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SECTION III: HOW TO MAKE MORE EFFECTIVE POLICIES AND FINANCING ARRANGEMENTS FOR RURAL BIOENERGY

Challenges and opportunities for financing rural bioenergy projects

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Introduction

Through earlier activities jointly developed by FAO and SNV in Lao PDR and Viet Nam in 2009, the lack of affordable and accessible financing was identified as a key obstacle to the development of the bioenergy sector in these two countries. Therefore FAO commissioned two studies to further investigate the financing of bioenergy. The studies were conducted simultaneously by the Lao Institute for Renewable Energy (LIRE) and the Asian Institute of Technology in Vietnam (AIT-VN).

The objectives of these studies were to:

- Review the institutional and policy framework;
- Review financing options for bioenergy projects;
- Identify barriers to bioenergy financing and potential solutions to overcome them; and
- Provide recommendations for policy interventions.

This paper summarizes the main findings of the two studies, highlighting common issues and constraints in the two countries.

Methodology

The study's methodology involved four main steps:

a. A desk study of relevant documentation and secondary data review to provide a picture of the current policy and institutional framework, as well as projects in place and under development.

b. Interviews with selected key stakeholders from government agencies, development groups and financial institutions to gather information on existing investment channels including opportunities and constraints.

c. Interaction between the two study teams to discuss common issues and approaches.

d. Stakeholder consultation workshops in each country to consult government agencies, public and private banks, investment groups, project developers and other stakeholders on the status of bioenergy development and solutions to improve access to financing.

Environment for bioenergy financing

This section provides an overview of the overall situation of renewable energy (RE) financing in each country, reviewing policies, key actors and available financing mechanisms.

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Policies and strategies

As of yet, strategies for developing RE are generally part of overall policies and strategies for energy, the environment and rural development. Currently both countries are in the process of developing a specific strategy for RE development.

Table 1. Strategies for RE development

Lao PDR	Viet Nam
National Socio-Economic Development Plan (NSEDP) 2006-2010: RE not clearly defined as a priority, but the plan highlights the need for "promoting the development of environment-friendly private sector products such as (...) technologies that are energy efficient and clean". The NSEDP focuses mostly on electricity generation for export, as a source of revenue, and to achieve 90% electrification by 2020. The draft NSEDP 2011-2015 reiterates the objective to "develop hydropower sources and renewable energy in order to supply energy to production sectors and society, and become the battery of ASEAN" (MPI 2010). **Renewable Energy Development Strategy (October 2011):** Refers to biofuels, biomass, biogas, solar and wind power also with a strong emphasis on hydropower of less than 15 MW in size. ▪ Objective of 30% share of RE in energy consumption by 2025; ▪ Substitute tentatively 10% of the transportation fuel demand from biofuels by 2025; ▪ Financial incentives for RE projects, e.g. import tax exemption, tax reduction/exemption on profits, VAT, and repatriation of profits, and possible subsidies on unit product price, and longer land leasing term; ▪ Creation of a public Renewable Energy Fund; ▪ Small hydropower: Exemption from concessional agreements and royalties, competitive bidding, non-discriminatory connection to national grid, and preferential loans from state-owned commercial banks; ▪ Proposed establishment of a new division at the Department of Electricity (DOE), in the Ministry of Energy and Mines (MEM) called Institute for Renewable Energy Promotion (IREP)	**National Strategy on Energy Development** up to 2020 with a vision towards 2050: ▪ RE as share of total commercial primary energy to 5% in 2020 and 11% by 2050; ▪ Diversify investment and business models to develop a competitive energy market. **National Power Development Master Plan** 2006-2015 with outlook to 2025: ▪ Additional electricity capacity from RE of 2 451 MW by 2015 + 1 600 MW by 2025; ▪ 400 remote communes in northern and central highlands and islands as target recipients of electricity from RE; ▪ Import tax exemption for wind turbines and solar panels. **Strategy and Master Plan for Renewable Energy Development** up to 2015 with an outlook to 2025 (draft): ▪ Incentives for small hydro, wind, solar, geothermal power, biomass and biofuels; ▪ Creation of a Renewable Energy Development Fund (REDF); **Scheme for Biofuel Development** up to 2015 with a vision to 2025: ▪ Priority loans and land support to international and domestic investors; ▪ By 2025: Target of 1.8 million tonnes of ethanol and vegetable oil output or 5% of oil and gasoline demand. **National Rural Electrification Program:** ▪ Diversify ownership forms and promote decentralized RE electricity generation offered to rural households ▪ Programme has triggered small hydropower development since 2005.

Key actors

The main actors in RE are government agencies, state-owned energy companies, international organizations and private sector developers and investors.

Table 2. Government agencies

Lao PDR	Viet Nam
Ministry of Energy and Mines (MEM): Key government body for RE. At the national level, MEM has primary responsibility for policy formulation and strategic planning, as well as the preparation and implementation of legislation and regulations related to the power sector and RE. **MEM departments working on RE:** ▪ Department of Electricity: Main roles are to prepare strategic planning for the power sector and regulate the electricity sector; ▪ Department of Energy Promotion and Development (DEPD): Supports the development of power plants and coordinates with Independent Power Producers (IPPs), mainly large hydropower and large-scale foreign investment. **The former Sciences Technology and Environment Agency (STEA) has been divided into two separate institutions:** **Ministry of Natural Resources and Environment (MONRE)** Responsible for water use and environmental permits, as well as the implementation of the National Strategy and Action Plan on Climate Change (NSAPCC). Designated National Authority (DNA) for CDM projects. **Ministry of Science and Technology (MOST):** Recently established this ministry works on policy formulation and planning across all sectors. Under its umbrella are regrouped different research institutions, but coordination among them is low (Technology Research Institute, Engineering and Renewable Energy Centre, and Renewable Energy and Materials Institute (REMI)).	**Ministry of Industry and Trade (MOIT):** Responsible for preparing laws, policies and regulations related to RE, as well as the appraisal and monitoring of RE investments through the issuance of licences and other legal documents. MOIT also has the task of supervising state-owned energy companies such as EVN and Petrovietnam. **Departments working on RE:** ▪ Department of Energy (DOE) develops and implements policies and programmes; ▪ Department of International Cooperation coordinates programmes with other countries and international organizations. **Ministry of Finance (MOF):** Borrows from international development funding organizations and then re-lends the money to public and private investors for energy project financing or re-financing, e.g. JICA's Energy Efficiency and Renewable Energy Program (EEREP) or the EIB's Climate Change Program. **(IE):** Key actor in RE policy with mandates of research, consultancy and promotion of international cooperation in power, gas, coal and RE. IE has been commissioned by MOIT to conduct studies on RE policies and strategies including feed-in tariffs and guarantee schemes as well as master plan formulation. IE is also active in assisting investors and financiers with assessment of RE potential, conducting feasibility studies and providing technology transfer assistance. IE is an investor through ownership in the Vietnam Renewable Energy Company (REVN).

Table 3. State-owned enterprises

Lao PDR	Viet Nam
<u>Electricité du Laos (EdL)</u>: 100% state-owned corporation under the jurisdiction of the Ministry of Energy and Mines. It owns and operates the country's main generation, transmission and distribution assets. It also manages electricity imports into its grids and exports from its stations, whilst promoting and developing sources of power supply. It implements government power projects, and represents the government as a shareholder in IPPs. It promotes a commercial approach to off-grid electrification, but the Rural Electrification Division directly manages off-grid RE. EdL recently established EDL-Generation to own and manage its generation assets. EDL-Gen is 75%-owned by EdL, while the rest of the shares were issued through an IPO in January 2011. EDL-Gen is the first security to be traded on Lao PDR's new stock exchange that started operating in 2011. **<u>Lao State Fuel Company (LSFC)</u>:** 100% state enterprise under the Ministry of Industry and Commerce. The company has more than 150 gas stations around the country and annual sales of 150 million litres of petroleum products. LSFC is mandated by the government to conduct research and integrate biofuel production in the national fuel distribution system. The company has research plantations in Vientiane to develop biofuel feedstock from Jatropha C. and other sources.	**<u>Electricity of (EVN)</u>:** Formerly a state-owned monopoly electricity producer and distributor, in 2004 EVN was spun off and is now a joint stock company called the Vietnam Electricity Group with subsidiary power plants, distribution and retaining companies. The majority of shares in EVN still belong to the government with primary supervision from the MOIT. As the main electricity authority, EVN is both a producer and a buyer for RE. EVN has invested in small hydropower schemes below 30 MW and buys electricity from other RE projects to supply remote areas. **<u>Oil and Gas Corporation (Petrovietnam)</u>:** Invests and implements activities related to petroleum. Related to these functions, Petrovietnam invests in biofuel projects as a producer, a buyer and a distributor. Biofuels are to be added to gasoline and diesel to partially replace the use of fossil fuels. The biofuel strategy includes three main activities: feedstock securing, production & blending, and transportation & distribution. As a producer, Petrovietnam established several biofuel production and distribution projects including feedstock farms, refinery plants throughout the country and three biofuel plants in North, Central and , built in cooperation with foreign companies. Petrovietnam is currently the largest domestic producer and distributor of biofuels in Viet Nam.

Note: The energy sectors in Lao PDR and Viet Nam remain dominated by public ownership. The main areas of RE activities are therefore led by public utilities.

International organizations and donor programmes

International assistance for RE development comes in the form of Official Development Assistance (ODA), grants and soft loans. The funding is either earmarked for specific RE programmes or for more general programmes linked to energy efficiency, energy for poverty reduction or climate change mitigation. A large part of international assistance is used to finance grid extension and rural electrification using RE.

In Lao PDR the most relevant programmes include the Rural Electrification Program (REP I & II), operating under the Ministry of Energy and Mines and supported by the World Bank, the Biogas Pilot Program (since 2007) operating under the Ministry of Agriculture and Forestry funded by the Netherlands with technical assistance provided by SNV, and the recently launched Energy and Environment Partnership Program With the Mekong Region (EEP Mekong) (2009-2012) funded by the Ministry of Foreign Affairs of Finland and the Nordic Development Fund. A new EEP three year Phase (up to 2015) is under planning.

In Viet Nam, the World Bank operates the Vietnam Renewable Energy Development Project in cooperation with MOIT and four commercial banks, while the Ministry of Agriculture and Rural Development (MARD) has been managing the Domestic Biogas Program since 2003 with funding from the Netherlands and technical assistance by SNV.

Financial institutions and investors

In Lao PDR, the banking sector is dominated by the four state-owned banks, accounting for more than 60 percent of all bank loans. Otherwise, there are a number of private commercial and international banks. None of the banks have a formal policy on RE but several banks have been involved in the financing of medium and large hydropower projects. The Agricultural Promotion Bank (state-owned) has been involved in financing biogas projects (such as household biogas biodigesters).

In Viet Nam, the four largest banks are state-owned or majority state-owned, accounting for 65 percent of domestic lending. They are involved in RE through the on-lending of a loan provided by the European Investment Bank. Commercial banks are involved in RE through the World Bank's Renewable Energy Development Project.

The Mekong Brahmaputra Clean Development Fund (MBCDF) is the first closed fund focused on clean technology (including RE) in the Mekong River Region. Launched in July 2010, it is managed by Dragon Capital and has attracted commitments from international development financing institutions such as the Dutch development finance company FMO, the Asian Development Bank (ADB), Finnfund and BIO. It invests in hydropower, biomass power, wind and solar energy, with investments ranging from US$1-7 million. In January 2011 it made a US$3.36 million investment in the newly listed EDL-Gen in Lao PDR.

Developers and entrepreneurs

In Lao PDR a number of foreign companies and funding agencies invest in large-scale projects (e.g. hydropower plants for export) or acquire equity in local small or medium projects such as solar power, biofuel and hydropower for domestic consumption. There are a few small local enterprises working on the provision of energy services using RE technologies, the main ones being Sunlabob and the Provincial Energy Services Company.

In Viet Nam private RE investors are foreign and domestic companies that invest in hydropower, biogas, wind, biofuel, solar water heating, geothermal and other schemes. Domestic enterprises invest in small hydropower based on the Build-Operate-Transfer (BOT) or Build-Operate (BO) models for selling electricity to the grid. Similar models are used for biofuel and biomass production. Some domestic companies include Solar Energy Co. Ltd., Hoang Khang Group (biofuel), Nguyen Chi Co. (biofuel, biomass), New Energy Co. Ltd. (solar), BK Investment and Development of Solar Energy, and Greenfield (biomass, biofuel, hydropower).

Financing mechanisms

Examples of the most typical and relevant forms of RE financing in both Lao PDR and Viet Nam, segregated between types of financing are described below.

Lao PDR

ODA is the most common form of financing for RE projects, with most of the funding directed towards hydropower development. There are a few private sector initiatives, particularly in industrial biogas, but as of yet they seem to be an exception.

Grant funding

- Hybrid PV/hydropower system in Oudomxay Province supplying electricity to ten villages and 520 households, with a photovoltaic (PV) component of 100 kW. Completed in March 2005, this project was funded by NEDO Japan.
- Household and community PV systems throughout the country installed by Sunlabob and others as part of rural development projects and typically financed by grants from various international development organizations.
- Several microhydropower (<100 kW) projects, either refurbished or newly built, for rural electrification or grid connection., implemented by companies including Sunlabob.
- Variety of solar-powered water pumping or purification and PV-based battery charging stations installed by Sunlabob. Furthermore this model was successfully extended by the same company to solar recharged battery lanterns, with the successful implementation of 2000 lanterns in Bottom of Pyramid (BOP) communities in Laos.

Public-private partnerships

- Rural Electrification Program (REP): Consisting of three phases and financed by the World Bank, and implemented jointly with EdL and MEM, one of the objectives is to provide rural households with a Solar Home System (SHS) on a hire-purchase basis (i.e. rent-to-buy) with a repayment period of five to ten years. The first two phases connected around 15 000 households.
- Rural Electrification Fund (REF): A component of the REP, the fund aims to finance IPP projects, but so far no IPP projects have been financed by the fund. In order to overcome institutional and financial risks, the IFC and MEM are developing a lease-purchase mechanism for microhydropower, in which developers would make the upfront investment and would pay a fixed lease for five to ten years.
- Biogas Pilot Program (BPP): Aims to establish a sustainable market for household biogas digesters as a substitute for fuelwood and charcoal. The programme is funded by the Netherlands, financing the technical assistance and advisory role of SNV and a fixed subsidy to households for the installation of a digester. The Agricultural Promotion Bank has recently approved loans to households for the initial capital cost of the biodigester systems.

Private financing

- Industrial Biogas: Several projects have been developed to generate biogas from wastewater at industrial facilities. The Lao Brewery Company (LBC) project, which is the first CDM project in the country, uses biogas to substitute for Heavy Fuel Oil (HFO) for steam generation. The project was privately financed by LBC with support from International Finance Corporation (IFC), which is part of the World Bank Group. Other projects include the Thai Biogas Energy Company (TBEC) BOOT project at a starch plant operated by the Laos-Indochina Group, and projects at a feed mill and piggery of C.P. Laos Co. Ltd., a subsidiary of the Thai company Charoen Pokphand Foods PCL.
- Biofuel: Several companies are active in developing plantations for biofuel production, mostly based on Jatropha curcas, either for export or local use. So far, production is limited and some companies face issues with yields and establishing relations with farmers.
- Solar Home Systems (SHS) rental: Between 2003 and 2009 Sunlabob offered solar home systems to rural households through a rental scheme under which end users paid a monthly fee to rent the PV system. Largely financed by the company, around 4 800 SHS were installed, of which around 3 000 units were returned after the rental scheme was terminated. The scheme was discontinued due to competition from the REP, as well as households' limited ability to pay for the service and the high cost of the training of village energy committees and technicians.

Viet Nam

RE investment is on the rise due to the government's determination to stimulate RE development and global trends on securing a more sustainable energy supply. The number of projects, investors and financiers in Viet Nam has increased and financing channels have become more diverse. One noticeable trend has been the increasing participation of the private sector. As an indication of the pace of development, the monetary value of currently planned projects in aggregate exceeds the total investment to date in Viet Nam's RE sector.

Grant funding

Several projects have been developed with grant funding from foreign donors, in particular using PV. For example, PV systems ranging in capacity from 500 to 1 500 Wp have been installed in the southern region in households, hospitals, schools and village communities (ABCSE 2005). Other activities include the Fondem-Solarlab rural electrification project (1990-2000), a rural electrification programme conducted by Solarlab in cooperation with Atersa (2006-2009) and a hybrid system with 100 kWp of PV and 25 kW of microhydropower in Central Viet Nam funded by Japan (Trinh Quang Dung 2010).

Public-private partnerships

- Domestic Biogas Program (2003-2012): Implemented by MARD and SNV, with funding from MARD and the Netherlands, as well as contributions from households. Farmers installing a biodigester receive a fixed subsidy of about US$60 regardless of system size, equivalent to 12 percent of the total cost, with the farmers investing the rest. The payback period of a digester is about two to three years. The programme celebrated the milestone of 100 000 units in December 2010.

- The World Bank's Renewable Energy Development Project (REDP, 2009-2014): Debt financing for RE projects which generate electricity to connect to the national grid including small hydropower (< 30MW), wind power, biomass and other schemes. Loans are provided via participating commercial banks. The interest rate and other details are negotiated between the bank and the project and most often follow market interest rates rather than a subsidized one. The maximum funding period is 12 years and up to 80 percent of total investment capital, with an expected IRR of ≥ 10 percent. So far, hydropower seems to be the only technology that can satisfy the banks' commercial viability requirements.

- Credit Program for Energy Efficiency and Renewable Energy, Vietnam Development Bank (VDB): A three-year programme to provide debt financing to clean energy projects, supported by a loan from the Japanese Government. The total budget is US$40 million, with US$30 million for energy-saving projects and US$10 million for RE, including small and medium hydropower, wind, solar, geothermal and biomass schemes. Loans constitute up to 85 percent of total investment with a maximum term of 20 years with a five-year grace period. Interest rates are 6.9 percent per annum for loans in Vietnamese dong, and 5.4 percent for US dollar loans. The Vietnamese Government owns 100 percent of the VDB, under the Ministry of Finance.

- The European Investment Bank (EIB) has provided a €100 million framework loan that will make available long-term loans at attractive interest rates to RE and energy efficiency projects. Loans are provided via four state-owned banks.

Private financing

- Biomass power: Several biomass power generation projects have been developed at privately owned facilities, such as bagasse cogeneration at around 40 sugar companies throughout the country, and rice husk co-generation and gasification in Southern Viet Nam.

- Industrial biogas: Several companies are active in developing industrial biogas, either as turn-key or BOOT, and often involving revenues from CDM or other carbon-offset mechanisms. Two projects under development include the Dong Xanh Joint Stock Co.'s project at an ethanol plant in Quang Nam Province with an investment of US$5.3 million, and CDM-based projects in An Giang Province by Hoai Nam Hoai Bac.

- Biofuel: Investments in biofuel come from both public and private sectors, but so far investments from Petrovietnam surpass private sector investments. The latter include the Green Field ethanol plant in Quang Nam Province, the first bioethanol production plant in Viet Nam, operational since 2008 (Nguyen Phu Cuong 2009), and Saigon Petro's cassava-based ethanol plant operational since 2009. In addition, more than 50 000 hectares of dedicated Jatropha plantation are under development (AITVN 2010).

- Solar water heating: Commercially viable with households and businesses willing to invest in solar water heaters due to savings on electricity bills. Heaters are produced locally by more than ten small and medium enterprises (SMEs).

Main findings

Overall, the studies identified several positive trends and it can be concluded that the outlook for RE is fairly positive in both countries. However, it should be noted that the focus is on power generation and rural electrification and that there is limited interest in bioenergy.

In Lao PDR there is increasing interest on the part of the government and its international partners in developing the RE sector as shown by recent and upcoming improvements to the regulatory and legislative framework. The government is currently in the process of approving the 'Renewable Energy Development Strategy' (revised in October 2011), which provides an action plan to promote RE use and production.

Viet Nam is clearly ahead of Lao PDR in terms of RE policies and regulations and liberalization of the energy sector, and has already attracted significant interest from developers and investors.

Main constraints to bioenergy financing

Despite positive trends in both countries, the growth of the sector continues to encounter many challenges. This section outlines the main constraints that were identified during the studies. Even though the RE sector in the two countries differs in many aspects, they share the main constraints, albeit at different levels.

Regulatory environment

All stakeholders consulted agree that a transparent and consistent regulatory environment is the most crucial factor for further bioenergy development. Because of the evolving nature of RE policies and regulations in each country, there are shortcomings in transparency, uniformity and consistency among ministries, departments and local agencies.

While both countries, in particular Viet Nam, have developed RE targets and strategies, many supporting regulations are still lacking or inadequate. The development and implementation of policies and regulations usually takes a long time, due to limited information and awareness, as well as a lack of staff working on RE and bioenergy. In addition, administrative procedures and policies may change, sometimes with little advance notice. There are also delays in obtaining licences and permits, and procedures in different provinces are not always consistent.

In the energy sector overall, there is a bias towards hydropower, large-scale power infrastructure and grid extension, putting other technologies and small-scale applications at a disadvantage. Furthermore, certain energy policies are conflicting and present an obstacle to RE development. In particular, subsidies on fossil fuels and grid electricity are still in place in both countries, which sometimes makes bioenergy more expensive. In the case of Lao PDR, it is reported that because of this, people in remote areas are reluctant to pay higher prices for RE solutions and prefer to wait for grid connection.

For Lao PDR in particular, energy development seems to focus on the construction of large hydropower plants, mainly for electricity export. Stakeholders consulted lament a lack of proactive leadership by the government to remove barriers and set a comprehensive and constructive regulatory framework for bioenergy financing. As for international investors and developers, they perceive a high political risk and an unattractive investment environment. This leads them to commonly prefer to explore opportunities in neighbouring countries such as Thailand and Viet Nam.

Access to financing

While RE is often capital-intensive and requires long-term investment, access to long-term financing is difficult. Interest rates are considered high, as well as the requirements for guarantees and high collateral often difficult to meet for bioenergy developers with small assets and cash flow. Loan applications are reviewed mainly considering assets owned by the applicant, and project financing, where assets to be financed are treated as collateral and projected revenue as the guarantee, is still uncommon.

This situation is partly due to the unawareness of financing institutions with commercially viable technologies and business models. Banks have limited understanding of RE investment needs and their financial products are generally not tailored towards RE. They also lack the capacity to advise RE entrepreneurs about their business plans, feasibility studies, fund-raising mechanisms and the completion of loan applications.

Particularly in Viet Nam, international support programmes are in place to provide financing through local banks, but it is reported that procedures are often cumbersome and bureaucratic, leading to delays and high transactions costs to project developers.

Low electricity tariff

For power-generating projects, project developers and financiers consider a profitable selling price a decisive factor in attracting investment from the private sector. Tariffs currently paid to RE projects are low and there are no standard formats for Power Purchase Agreements or clear subsidy systems such as feed-in tariffs to streamline and support RE project development.

Lao PDR: Because of the reliance on large-scale hydropower, electricity prices are low. Some large and medium hydropower power producers have been able to negotiate highly competitive feed-in tariffs, but there is no clear regulation to set feed-in tariffs, which is a constraint for developers of small hydropower schemes and other technologies. The large hydropower development sector has been able to reliably access extremely competitive financing rates and terms, with support from a range of international development project financing such as from World Bank, IFC, and KfW and this extends also to low cost of financing for the related infrastructure, including soft-loans.

Viet Nam: The purchase price of electricity paid by the EVN is set by the central government. At present, the maximum price is US$0.053/kWh, too low for many projects. The government is developing a feed-in tariff scheme but it is unclear when this will be in place.

Capacity of local entrepreneurs

Since RE is a relatively new field, most local enterprises have a limited track record and lack developing and operating experience. They often have a broad investment portfolio in which RE is only one activity among many others. The diverse portfolio helps them to reduce investment risk but investors and financiers consider this a weakness and would prefer to work with dedicated RE developers that focus on a specific technology and business model.

The experience in both countries also shows that most domestic enterprises do not have the experience to approach international investors, let alone obtain financing from them. They are reluctant to face international procedures and standards, such as background checks, need for licences and permits, and strict rules for transparency and corruption.

Policy recommendations

Based on the stakeholder consultations and main constraints identified, the studies formulated policy recommendations to improve the environment for RE investment and financing. This section lists the main common items for both countries.

Stronger policies and regulations

Although the governments of Lao PDR and Viet Nam have set broad orientations and targets, further deployment of RE calls for stronger support policies, to assure developers, investors and financiers of an attractive and stable environment for RE development.

Policies and targets should be supported by concrete measures. In particular, there is a need for financial instruments and incentives to support the private sector. These would include tax exemptions during the initial years of operation, import duty exemptions for RE equipment and feed-in tariffs and other subsidies. While some of these support measures are already in place, in practice information provided is not always clear and it can be cumbersome to obtain these benefits.

Improved coordination and transparency

Limited coordination and transparency among different agencies, both at national and local levels, creates uncertainty and frustration among developers and investors. Entrepreneurs and investors have to deal with different types and levels of government agencies to obtain permits and licences. Requirements for applications and approval are not always clear and consistent, and they sometimes get stuck in bureaucratic and unclear appraisal procedures. It is recommended to streamline the coordination between different agencies, simplify and clarify procedures and to improve the information on requirements and processes.

It is also recommended to disseminate information of RE master plans and related policies from central and local governments clearly and in a timely fashion to project developers and investors to ensure transparency and facilitate their investment plans.

In the case of Lao PDR, it is recommended to set up an overall coordinating RE agency that assumes overall governmental responsibility for the sector (in line with the RE agency under the Ministry of Energy and Mines proposed in the draft Renewable Energy Development Strategy).

Tailored financing mechanisms

To facilitate access to financing, adequate financing mechanisms should be further developed. Each country has already proposed to set up a public renewable energy fund. While developing these funds and other mechanisms, the different nature of technologies and applications should be taken into account, to allow for the broad development of bioenergy, including household-level applications and energy services in remote areas.

To increase the effectiveness of these financing mechanisms, they should be accompanied by activities to strengthen the capacity of local entrepreneurs and project developers. Particular focus should be given to business development, management, accounting and financing.

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Challenges associated with replicating successful bioenergy projects in Thailand

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Introduction

In rural areas of Thailand, household use of traditional forms of bioenergy such as fuelwood and charcoal is still common, despite the fact that modern energy forms such as LPG and electricity are commonly available throughout the country. The reasons for this may be that the cost of mainstream energy is considered high for many rural households and that fuelwood and charcoal are preferred fuel sources for cooking certain dishes.

Traditional forms of bioenergy are often produced and used inefficiently, using poor and outdated technologies. However, technologies are available that greatly enhance the quality and efficiency of bioenergy, and can provide several benefits to rural Thai communities including reduced cost and improved health.

In Thailand many communities make efficient and innovative use of bioenergy to produce energy. Some of these communities have had particular success with these technologies and have attracted interest from other communities who are looking for ways to replicate these successes.

Unfortunately, the stories of these 'best practice' bioenergy communities are not well publicized and not widely known to the rest of the country.

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Thus there is considerable potential for rural Thai communities to learn from these examples and broaden the choice of energy options available to them. Despite successful cases and the potential benefits to be gained, replicating successful best practice bioenergy cases presents a significant challenge.

The purpose of this study is to identify the key success factors and barriers in replicating best practices.

Methodology

In order to identify the key success factors for community-level bioenergy projects, different community bioenergy projects were studied at two levels. First, three communities that were considered highly successful in developing bioenergy (best practice communities, BPCs) were studied in detail. Secondly, the study team investigated communities that had learned from the best practice communities and tried to replicate the bioenergy projects (replicating communities, RCs).

For the first level, the three BPCs were selected using the following criteria:

a. The technology(s) used must have been adopted for a period of over 12 months.

b. The community has received wide recognition for best practice in adopting bioenergy technology.

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c. The communities selected should have diversity both in terms of location and technologies adopted.

d. The selected communities must be self-reliant and financially viable up to a certain level.

Three communities met all these criteria, namely:

- Don Phing Dad village (Petchaburi Province, central region): high-efficiency charcoal making and biodiesel;

- Lao Khwan subdistrict (Kanchanaburi Province, western region): biogas; and

- Ta-Ong subdistrict (Surin Province, northeastern region): biogas, high-efficiency charcoal making.

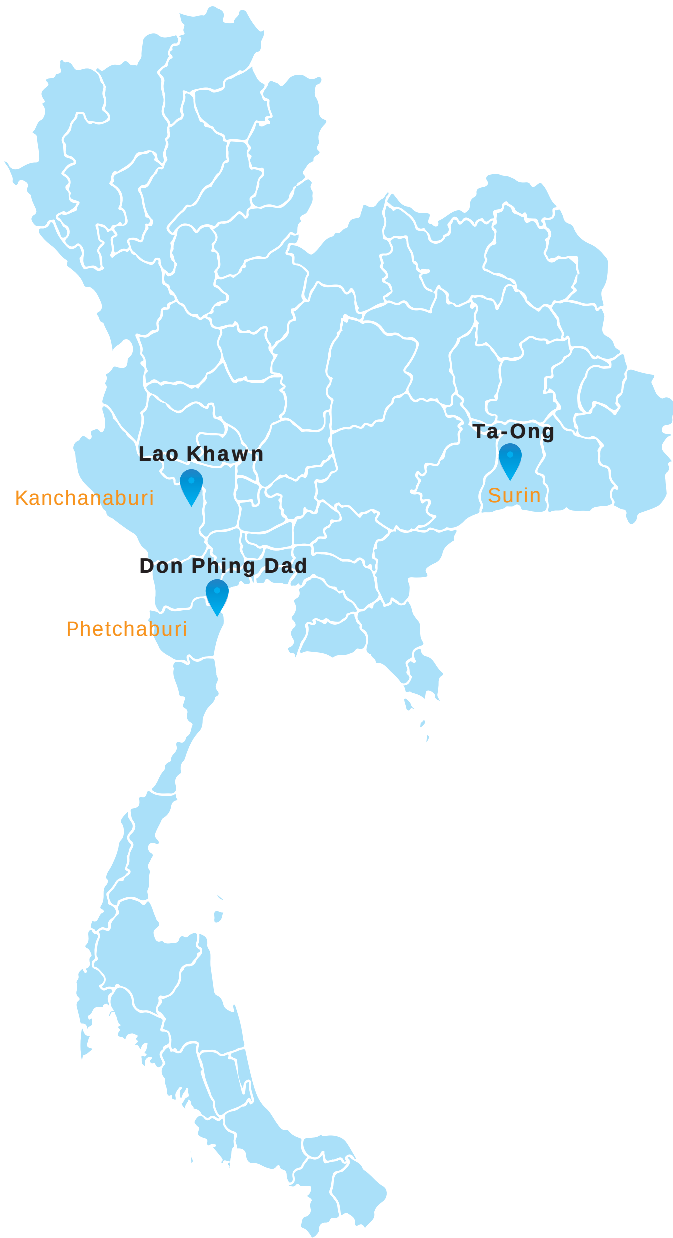
Apart from the aforesaid criteria, these three communities also show a difference with regard to project development. The projects at Don Phing Dad village and Lao Khwan subdistrict were mainly developed by people in the community with limited support from external sources. In contrast, the projects at Ta-Ong subdistrict received significant external support, mainly from a local NGO and the local administrative office.

The study used two main methods. First, in-depth interviews were conducted with key stakeholders in each community, such as community leaders, villagers, government officials and local NGOs. In addition, field surveys and non-participatory observation techniques were employed to observe how the technologies are used by villagers as well as community-level management practices. After the raw data and information were collected they were synthesized and all information was classified into specific aspects such as project characteristics, technology transfer and impacts.

Following assessment of the BPCs, the RCs were identified in consultation with key stakeholders from the best practice projects. Subsequently, the RCs to be studied further were chosen using a purposive sampling method so that only communities which could provide information relevant to the study were selected.

It should be noted that the identification process for the RCs was different from that of the three BPCs. In the case of Don Phing Dad, key members provided a

Figure 1. Map of Communities Assessed



list of registered trainees and replicating projects they had followed up with earlier, and they also helped to make contact before giving their personal opinion. In contrast, in Lao Khwan and Ta-Ong, the management system of the learning centres is not as organized and no written information on RCs was available. Key members rarely followed up with replicating projects and could only give some names of communities from personal memory. Eventually, nine RCs for Don Phing Dad, and four each for Lao Khwan and Ta-Ong were selected.

In order to provide further insight into the elements of success and obstacles affecting the replication process, the selected RCs were divided into three groups, namely most successful, moderately successful and least successful (Table 1).

Table 1. Criteria for success among replicating communities

Level of success	Description
Most successful	The community has established a learning centre that has held many informal and formal training sessions for more than a year with some obvious replication successes.
Moderately successful	The community has established a learning centre and has implemented bioenergy projects successfully but there is no evidence of successful replication to other communities.
Least successful	A centre has not been established and there are only a few or no users of bioenergy technology.

Main findings

This section provides an overview of the bioenergy projects in the three best practice and corresponding replicating communities.

Don Phing Dad

Don Phing Dad is a farming community in Petchaburi Province in the central region of Thailand on the cusp of the southern provinces. Most villagers are not landowners and are constrained by degrading soil.

In an effort to reverse growing degradation of local soils, in 2005 the community requested the assistance of the Research and Development Institute of Silpakorn University with regard to adopting organic farming techniques. Together with the organic farming processes, the institute advocated the use of high-efficiency charcoal kilns and biodiesel production from waste cooking oil. The bioenergy operation that was subsequently adopted at Don Phing Dad involves a wide range of actors including 70 farmer households. The community now produces 1 500 litres of biodiesel and approximately 9 600 kilograms of high-efficiency charcoal per month. They also produce wood vinegar, a by-product of the charring process that is used for pest control instead of chemical pesticides.

Among the three BPCs, Don Phing Dad is considered the best example of successful implementation of a small-scale, community bioenergy project. The community has also established a training centre where people from surrounding communities can learn about the project implemented in Don Phing Dad and purchase the community's outputs of wood vinegar, biodiesel and charcoal. This centre trains more than a 1 000 people per year and has been recognized as a Ministry of Energy biodiesel learning centre and has received financial support from the Thai Government.

At the centre trainees not only learn the theory, but also how to apply this in practice in order to assure successful replication in their own communities. The trainees subsequently created a network in their communities and link with Don Phing Dad for follow-up support.

Replicating communities

Communities that have attempted to replicate the Don Phing Dad case are numerous and spread over Phetchaburi Province. For the purpose of the survey nine communities were studied. These communities consist mainly of rice and fruit farmers.

While most communities surveyed were supported by government funds, some relied on their own resources, especially those that witnessed firsthand the economic and health benefits of bioenergy. The production of biodiesel in the RCs was very limited due to insufficient availability of waste cooking oil feedstock. However, these communities successfully produced high-efficiency charcoal and wood vinegar. Interestingly, the least successful cases identified limited financial support from government sources and lack of waste oil as key barriers to success.

In general the communities surveyed were satisfied with their attempts to replicate the Don Phing Dad case noting that their outputs of high-efficiency charcoal have reduced household expenditures on LPG, improved their health and helped to restore the environment in their communities. Some farmers have also had some success in selling high-efficiency charcoal, wood vinegar and biodiesel products.

Lao Khwan

Lao Khwan District is located in Kanchanaburi Province in the west of Thailand. In the past the community suffered from low agricultural productivity and lack of collaboration between local farmers. In 2007 a group of farmers formed the Connecting Wisdom group. The group has four main activities, namely growing herbs, producing organic fertilizer, raising fish and generating biogas. The community installed a biogas digester at a cost of approximately US$2 300 and now produces 336 cubic metres of gas per month.

In terms of generating bioenergy from biogas a key factor behind the success of the Lao Khwan case is that this subdistrict has the largest number of cattle in Kanchanaburi Province. Animal waste is the key input for the biogas plant. With the help of the Lao Khwan District Office and the Thai Health Foundation, the community in Lao Khwan established a learning centre to educate other communities about the benefits of cooperation and bioenergy. The Connecting Wisdom group subsequently expanded its network to nearby subdistricts and neighbouring provinces.

Replicating communities

While four communities are attempting to replicate the Lao Khwan model, so far only one community is successfully producing a regular supply of biogas. However, the projects surveyed are still at an early stage of development.

Of the four RCs studied, two communities received support from the Thai Health Foundation and two from the Lao Khwan District Office. Projects supported by the Thai Health Foundation are more organized, because staff from the foundation is working more closely with villagers. Unfortunately, only one community successfully developed the use of bioenergy in the community and established a bioenergy learning centre. Another community successfully established a learning centre but the topics are not relevant to bioenergy.

Ta-Ong

Ta-Ong subdistrict has a population of 20 000, most of whom are farmers. It has the highest number of cattle in the province of Surin.

In 2007 Ta-Ong subdistrict was selected as one of 80 communities to be part of the Ministry of Energy's sustainable energy communities' programme. With the assistance of the North Eastern Thailand Development (NET) Foundation and the provincial energy office the community established biogas, high-efficiency charcoal and energy-efficient stove initiatives.

Although the community energy planning project has been completed, energy projects are still ongoing, and at present there are more than 250 high-efficiency charcoal kiln and nine biogas systems in operation, producing 24 000 kilograms of charcoal and 108 cubic metres of biogas per month. The community has received a grant from the Global Environment Facility (GEF) with the assistance of the United Nations Development Programme (UNDP) to expand the number of biogas systems in the community to 80 units.

Replicating communities

A number of communities from the surrounding area has approached the Ta-Ong community to replicate its biogas and high-efficiency charcoal facilities. At this stage, the technologies are mostly transferred through informal training. To date two communities have installed biogas facilities and small high-efficiency charcoal kilns with the support of the provincial energy office.

High-efficient charcoal making has been widely adopted in nearby communities. However this has not been the case for biogas systems, mostly due to the lack of financial support. In the communities studied, biogas systems are only used at the learning centres.

Conclusions: conditions for successful replication

Based on the three BPCs and their corresponding RCs, several conditions were identified that are considered crucial for the successful replication of bioenergy projects.

Desire to improve livelihoods

Many farmers and rural households face a range of pressures such as degradation of the environment, high farming debt, heavy reliance on purchased chemical fertilizer, degrading soil quality, poor health, decreasing farming output, bad economic conditions and high oil prices.

All initiators of bioenergy projects, both best practice and replicating, had a strong desire to improve their livelihoods. When they learned about the benefits of bioenergy, they invested time and money in learning about technologies, experimenting and problem solving, and seeking outside assistance. Driven by different pressures they adopted bioenergy as a way to reduce their energy costs, improve their health and practise alternative ways to farming.

Where such pressures were not considered particularly strong, communities lacked sustained interest in maintaining their bioenergy projects. Therefore, while villagers may have a certain interest in learning about these technologies, a stressful environment can be considered a necessary condition for the project to be successful in the long run.

Availability of external support

This condition covers several levels of support. First, villagers need to be motivated by examples of success and benefits to be gained from the bioenergy technologies. These can come from public media, a facilitator or even word of mouth. Under stressful conditions, farmers who are shown the benefit of alternative approaches will be keen to implement them.

Second, communities often lack the technical expertise to build bioenergy systems and to properly operate and maintain them; the study showed that external support is crucial in this regard. As shown by the case studies, this can come from a variety of sources, such as local administrative offices, NGOs or nearby universities.

Finally, while some villagers are able to implement projects using their own resources, most require additional financial support, because many have debts or high farming expenses. Apart from project implementation, financial support is also used to cover training (including travel and accommodation), as well as compensation for lost opportunities to generate income.

Economic benefit

In all of the projects people wanted to lower their energy costs in farming or household use. Even though most projects were developed for self-reliance purposes and not for commercial reasons, many villagers mentioned that 'go' or 'no-go' decisions were based on a monetary cost-benefit analysis.

In a few cases where people already had invested in a bioenergy project, they doubted whether they could gain sufficient benefits, and they hesitated to continue. For example, in the case of biodiesel, the higher the difference in price for oil and biodiesel, the stronger the motivation was to produce biodiesel, while the production would be low or even halted whenever the diesel price was low. This shows that economic benefit is a necessary condition for a long-term operation.

Adequate supply of feedstock

For all technologies the quantity and quality of the feedstock material significantly affects the success of a bioenergy project. For instance, biogas systems were widely and successfully adopted in Lao Khwan and Ta-Ong because of the large number of cattle, whereas in Don Phing Dad cattle raising is uncommon so biogas is not used. In the case of biodiesel from used cooking oil, several producers face supply problem because of multiple buyers and competing uses, causing production to be limited and intermittent.

This shows that a proper study of available feedstock and its continuous availability is crucial for the long-term success of a project and indiscriminate promotion of bioenergy technologies without looking into locally available materials should be avoided.

Local champions and management

Every community that successfully implemented a bioenergy project had a key person or a group of people who took the lead in organizing the community to develop bioenergy activities. Apart from enthusiastic key people within the community, any successful project also sources outside experts who support the community in terms of technology and management.

While key people are crucial, a structured management system plays an important role, particularly for the ability to replicate projects. All best practice communities and some of the most successful ones have a structured management system where each group committee has a clear role and responsibility. In contrast, some of the successful RCs have determined leaders, unfortunately without a clear management system, and they are not successful in expanding bioenergy activities throughout their community as much as they originally anticipated.

Policy recommendations

Promotion of rural bioenergy solutions

Bioenergy promotion will raise awareness among communities of its use and benefits, showing ways to use local resources to reduce their expenses and improve their livelihoods. This can be done at several levels, starting with public media such as national television and newspapers.

Information should also be made available to relevant government agencies, in particular local units such as district offices, to allow them to support communities under their jurisdiction. The same applies to existing training centres, educational institutions and rural networks, so they can further promote bioenergy locally. Additionally, mobile demonstration units that travel to communities could be used to expose communities directly to bioenergy and provide on-the-ground learning.

The study found in particular that local learning centres and networks play an important role in developing bioenergy and many successful project developers have used them to overcome obstacles in implementing their projects. Therefore the government should strive to strengthen the capacity of learning centres related to rural development, organic farming and bioenergy, in terms of funding, management and technology. Subsequently, they can be instrumental in supporting community management systems, helping villagers to conduct financial management, strategy development and implementation.

Coordinated and sustained support by government agencies

Many different government agencies are providing support to communities, both in terms of funding and technical assistance. These include district offices, the Department of Alternative Energy Development and Efficiency (DEDE), the Thai Health Promotion Foundation and the Ministry of Agriculture and Cooperatives.

While such support is essential, it is not always effective. Villagers mention that activities conducted by different agencies often cause confusion and create a certain degree of redundancy, resulting from a lack of coordination among government agencies. In addition, government support is often intermittent and sometimes seems to be related to political activities, creating distrust of government officials among villagers.
Therefore, there is a need for better coordination and planning of community bioenergy activities, possibly under a central coordinating body. In this regard there has been a recommendation to establish a National Alternative Energy Office (NAEO), with provincial branches, as the host to drive all bioenergy and other alternative energy activities at national and local levels. The NAEO could be developed from the alternative energy task group that already exists within DEDE.

Potential for social indicators to guide bioenergy policies

Sittha Sukkasi[1]

Introduction

Bioenergy is essentially a form of development, a technological pathway that can help people leverage their natural resources and lead them to a better quality of life. Like other forms of development, bioenergy development may or may not be sustainable, and its sustainability can be assessed by economic, institutional, social and environmental aspects. Sustainability assessment is especially critical for development that is based on currently evolving technologies. While such technologies have potential to bring people a better standard of living, they may also have unforeseeable and negative side effects, which can undermine the sustainability of the development itself. Indicators are key tools for planning and monitoring the sustainability of development. There are many sustainability indicators including the *Triple Bottom Line,* the *UN's Indicators of Sustainable Development,* the *Dashboard of Sustainability* and the *Human Development Index.*

However, these indicators are unsuitable for small-scale and context-specific applications. The present work proposes a way to formulate indicators that are tailored to bioenergy development in specific settings. The method involves interaction with the stakeholders to identify the dimensions of the development, to analyse the issues associated with each dimension and to choose indicators that can quantitatively measure the development's impact with respect to each issue. While there are many well-known economic and environmental indicators that are readily applicable to small-scale and context-specific development, those in the social aspect are harder to define. This paper focuses on the formulation of social indicators. Biodiesel development in the Greater Mekong Subregion is used as a case study.

Development as a pathway

The concept of sustainable development has been given many different descriptions. The most well known was given by Gro Harlem Brundtland, the chair of the World Commission on Environment and Development (Brundtland 1987):

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

There are two key concepts embedded in Brundtland's description. First, there is the concept of *needs*. People have needs, and they can be fulfilled by development. Second, there is the concept of *limitation of resources*. Development requires

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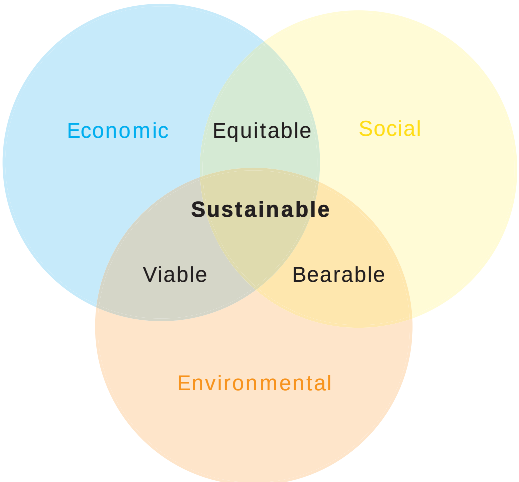
resources, which are finite, and one generation's overexploitation of resources might jeopardize the availability of these resources to future generations.

Other descriptions similarly revolve around these key concepts. For example, *Caring for the earth: a strategy for sustainable living* (IUCN *al.* 1991)). Additionally, many descriptions also specify the key economic, environmental and social aspects for sustainable development as depicted in Figure 1.

Development can also be viewed as a pathway that can help people leverage their natural resources

Figure 1. Key aspects of sustainable development



Source: Consultative Group on Sustainable Development Indicators. 2002

and lead them to a better state (Figure 2). There are many technological means, or pathways, that can potentially lead people to the same developmental goal. Nonetheless, some pathways may be convoluted, and some may create problems as side effects. Many pathways also involve technologies that are still evolving and whose directions and side impacts are still unclear. Sustainable developmental pathways can lead people to developed states without causing economic, social and environmental problems.

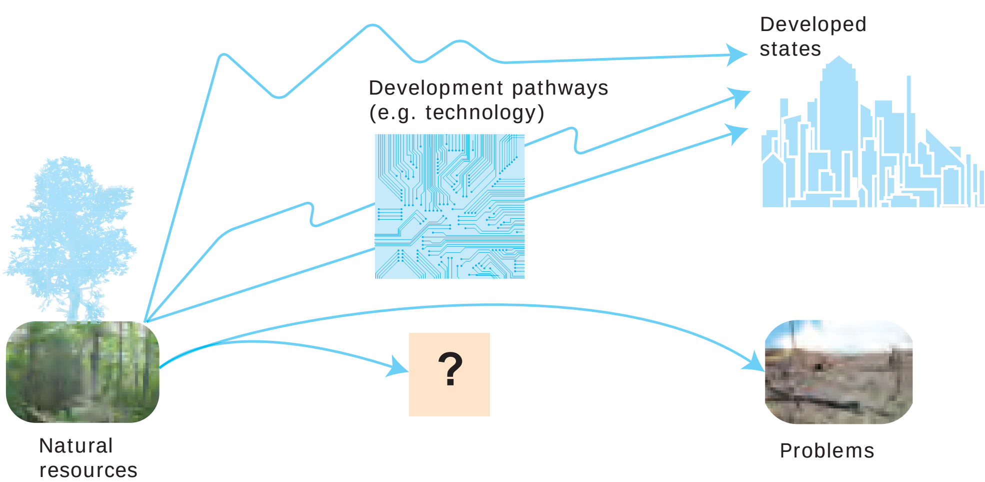
In this regard, bioenergy could be considered as a set of developmental pathways. Each bioenergy technology can help people utilize biological resources and lead them to a state of optimized energy needs. Some bioenergy technologies are more straight-forward than others, and some could easily create negative side impacts without proper planning and management. There are also many fledgling bioenergy technologies whose impacts are still equivocal.

Sustainability indicators

Sustainability indicators can provide information on the state of specific aspects of the development. In other words, they can help people gauge whether a pathway is leading them towards the goal and whether they are headed in a sustainable direction.

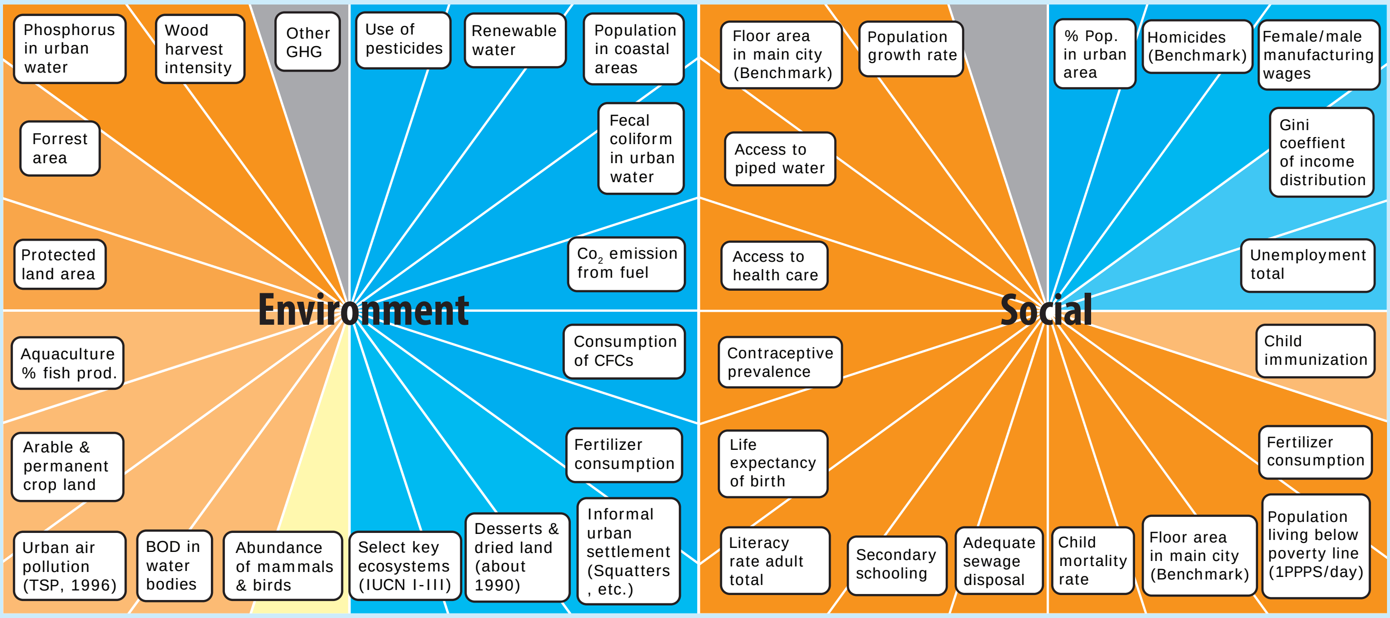
There are many sustainability indicators. John Elkington proposed the concept of *Triple Bottom Line* (Elkington 1998), suggesting that companies need to evaluate their performances not only in terms of profit, but also with respect to their impacts on people and the planet. The Commission on Sustainable Development (CSD) developed *Indicators of Sustainable Development* to help countries measure their progress on achieving sustainable development at the national and international levels (United Nations 2007). There are 96 indicators in the themes of poverty, governance, health, education, demographics, natural hazards, economics, atmosphere, land, oceans, seas and coasts, freshwater, biodiversity development, global economic partnership, and consumption and production

Figure 2. Developmental pathways



Source: Sittha Sukkasi

Figure 3. The Dashboard of Sustainability



very good
good
ok
medium
bad
very bad
critical
No data available

Source: UNDP. 2010

patterns. Another set of sustainability indicators is the *Dashboard of Sustainability*, aiming to allow policy-makers and interested parties to see complex relationships between economic, social and environmental issues in a highly communicative format (Consultative Group on Sustainable Development Indicators *et al.* 2002). Examples of the social and environmental aspects of the Dashboard are shown in Figure 3. Another measurement commonly used to gauge the social aspect of sustainable development is the *Human Development Index*. It is derived from four indicators in the areas of health, education and living standards (UNDP 2010).

While the aforementioned indicators are suitable for measuring the progress of development on a large scale, they are not practical for development in very specific contexts.

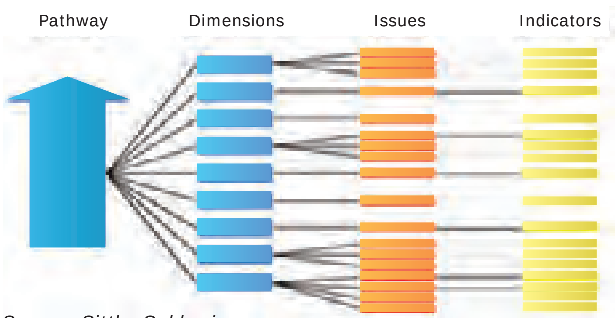
Customized sustainability indicators for context-specific development

For development in a very specific context, such as bioenergy development in a particular region, sustainability indicators could be customized to measure more meaningful, context-appropriate states of the development. The customized indicators could be more useful than generic indicators for guiding related policies and monitoring development.

The extended version of this paper (Sukkasi *et al.* 2010) proposes a framework for developing customized sustainability indicators for context-specific development, outlined in Figure 4. First, the development is regarded as a pathway, and the relevant stakeholders, resources and goals are identified. The different dimensions of the pathway are identified, and the different issues within the dimensions are determined and evaluated. If possible, the analysis of the dimensions and issues should involve the stakeholders. Related indicators are then proposed for each issue, in order to quantitatively measure the development's impact with respect to the issue.

While there are many well-known economic and environmental indicators that are readily applicable to small-scale and context-specific development, those in the social aspect are harder to define.

Figure 4. Framework for developing customized sustainability indicators for context-specific development



Source: Sittha Sukkasi

Social sustainability indicators for biodiesel development in the Greater Mekong Subregion

The dimensions and related issues of biodiesel development in the Greater Mekong Subregion (GMS) have been analysed (Sukkasi *et al.* 2010). The process involved site visits and interviews with stakeholders consisting of local energy companies, investors, international banks, environmental organizations, development agencies, research institutes, universities and local governmental offices of industry, energy, forestry, environment, agriculture, transportation, commerce, rural development and policy. The identified dimensions of the pathway were policies, governance and management, infrastructure, technology and feedstock, impacts on the poor and rural livelihood, and climate change and the environment. Within these dimensions, 19 key issues were identified and analysed.

Building upon these issues, the extended version of this paper proposes sustainability indicators for GMS biodiesel development. With regard to the harder-to-define indicators in the social aspect, the following are proposed:

Technology and feedstock

- The percentage of population whose access to and capability to afford food is negatively affected by the chosen feedstock crops (related to the issue of feedstock choice and competition with food production).
- The percentage of unproductive land utilized for activities related to the chosen feedstock crops (related to the issue of feedstock choice and productive land).
- The income generated from secondary uses of the chosen biofuel feedstock crops (related to the issue of potentials to generate additional revenue streams from biofuel feedstock crops).
- The percentage of population who work on producing or maintaining the chosen biofuel technologies locally (related to the issue of locally appropriate technologies).

Impacts on the poor and rural livelihoods

- The percentage increase in income from planting biofuel crops on marginal land (related to the issue of enhanced rural incomes at individual and community levels from small-scale biofuel operations).
- The proportion of biofuel-related jobs (also related to the issue of enhanced rural incomes at individual and community levels from small-scale biofuel operations).
- The number of different kinds of feedstock crops (related to the risk that all farmers in one area will follow short-term price increases and rush to grow the same crops).

Many indicators can also be proposed in this dimension to gauge the issue of exploitation of land concession schemes:

- The percentage of agricultural land that is affected by biofuel land concession.
- The percentage of landownership that is lost due to biofuel land concession.
- The percentage of population whose access to water resources is affected by biofuel land concession.
- The percentage of population whose access to roads is affected by biofuel land concession.
- The percentage of population whose income is affected by biofuel land concession.
- The percentage of population that is displaced by biofuel land concession.

Conclusions

A framework for developing customized sustainability indicators for context-specific development is proposed. By systematically analysing the dimensions and related issues of a developmental pathway, indicators for measuring specific issues pertaining to the sustainability of the development can be formulated. These customized indicators can facilitate quantitative assessment in a more meaningful way than generic sustainability indicators.

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Using microfinance for farm/household-level bioenergy technologies

Riaz Khan[1]

Introduction

If we look at the Earth City Lights layer in Google Earth© we see a very uneven distribution of electric lights across the South Asia and Southeast Asia regions (Plate 1).

There are vast areas which are known to be populated but have limited access to electricity. The cities are well lit, yet many rural areas are completely dark. This lack of access is due to the lack of capacity of the national and sub-national grids.

Plate 1. South and South East Asia Earth City Lights *Source: Google Earth*

Lack of access

Approximately 41 percent of the population of Bangladesh did not have access to electricity from the grid in 2009 (International Energy Agency, 2012). This translated into 95.7 million people without access to electricity. The situation is even worse when we look at the urban-rural divide. In Bangladesh in 2008, while 76 percent of urban dwellers had access to electricity, only 28 percent of the rural population had similar access (International Energy Agency, n.d.).

Neither the public sector nor the private sector has been able to provide comprehensive power supply. Solutions to this problem have started to emerge from social enterprises relying on off-grid technologies.

Social business

In order to solve social problems we need to look at organizations that combine the idealism of the grassroots sector with the efficiency of the business sector. People are therefore increasingly looking to social enterprises and social businesses to solve social problems. But what do we mean by these terms?

In order to better understand this context, it is useful to visualize organizations functioning in a space where we measure not only financial returns but also social returns. In Figure 1 the horizontal line measures financial returns whereas the vertical line measures social returns.

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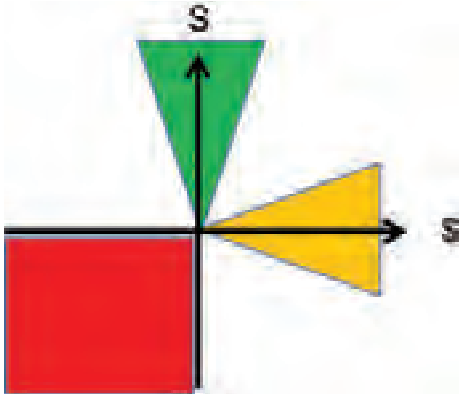
1 Yunus Center at the Asian Institute of Technology.

Figure 1. Social and financial returns in the corporate context



S = Social Returns, $ = Financial Returns

We divide organizations into two broad categories: conventional companies and non-profit institutions. Most conventional companies are concerned with increasing their earnings and profits. As they provide a service, there is a social component to their work, but they aim to provide maximum value to their shareholders, in the form of profits. Therefore, when we think of such companies we think of their performance primarily in terms of their financial returns. In Figure 1 the horizontal axis represents the financial performance of a company. Most profit-making companies would be working within the yellow triangle that lies along the horizontal axis. If a company is operating in the upper half of the triangle then the company is making a profit and contributes positively to society. However, if there is a conflict between social goals and financial goals the financial goals will usually trump the social goals.

On the other hand, non-profit, charitable and social enterprises work along the vertical axis that represents social goals. They aim to work within the green triangle that lies along the vertical axis in Figure 1. Charities for instance do not usually make money from the services that they offer, but are dependent on donations to fund their operations. Social enterprises are also operating within the green triangle that lies along the vertical axis. Once again the main goal of these organizations is to do social good and they look for money from grants and donations. If a social enterprise is able to provide a service for which it can charge, then it may be able to cover its cost of operations. This will make the initiative economically viable. In that case the enterprise will be in the happy position of financial sustainability and positive social returns. Naturally all enterprises want to stay out of the red zone where they are neither profitable nor are they doing any social good.

Social businesses are entities that aim to function within the right half of the green triangle. We will briefly discuss the concept of social business as defined by Nobel laureate Professor Muhammad Yunus. There are two types of social businesses. Type I is defined as a non-loss, non-dividend company dedicated to a social cause. Non-loss means that the company covers its cost of operations and can even make a profit. Non-dividend means that the investors cannot take any profit out of the company. They can only take back their original amount of investment. After that any further profit must be put back into the company. The investors cannot even adjust their investment for inflation. Finally the company must be dedicated to solving a social problem. The most publicized example of this is the Grameen Danone joint venture in Bangladesh that is dedicated to supplying yoghurt fortified with vitamins and minerals to combat malnutrition among poor children (Yunus & Weber, 2010).

The other type of social business or a Type II social business is a business that is profit making, owned by the poor and dedicated to solving a social problem. The best known example is the Grameen Bank that has been providing credit and savings for the poor for over 30 years.

Application to renewable energy technology

Grameen Shakti is a non-profit organization that is part of the Grameen family of organizations. The company works using the network that has been built up by the Grameen Bank and provides a variety of renewable technology solutions to poor households. In particular, the company sets up loans for its customers so that they can buy the systems on a staggered payment system.

The major energy requirements of poor households are for lighting and cooking. Lighting is being tackled through solar energy and cooking through biogas and energy efficient stoves. Grameen Shakti installs solar home systems, biogas plants and improved cook stoves. Solar household systems are the largest and oldest of the services. Solar home systems are provided in a variety of packages. Rural solar home systems range from US$120 to US$900. The capacity of these systems vary from lighting one compact fluorescent lamp (CFL) to systems that can power two 20 watt lights, two fans and a 21" colour TV. In urban areas, Grameen Shakti provides even larger systems with the most expensive system costing over US$2,000. This system can power two CFLs (20 watts), two ceiling fans, a 21″ colour TV and a computer for four hours.

The range of systems means that customers have a large choice in what they can buy. Grameen Shakti has built up a large country-wide logistical network that allows it to provide services to rural and urban households. It has a good after sales service to ensure that once the solar home system is installed it can handle any after sales issues. It has worked on bringing down the cost of the technology and has trained people in rural areas at its Grameen Shakti technology centres.

In addition, Grameen Shakti provides its customers with financing options so that they can pay for their loans through monthly installments. Table 1 shows the payment options that are available to customers.

Plate 2. Installing a solar panel

Plate 3. A Grameen Shakti technician training centre

Women are trained at the various Grameen Shakti technology centres and are then employed as technicians to help in after sales service. By 2010 Grameen Shakti had installed over 0.5 million solar home systems in the country. Figure 2 shows the exponential growth of installations of solar home systems by Grameen Shakti.

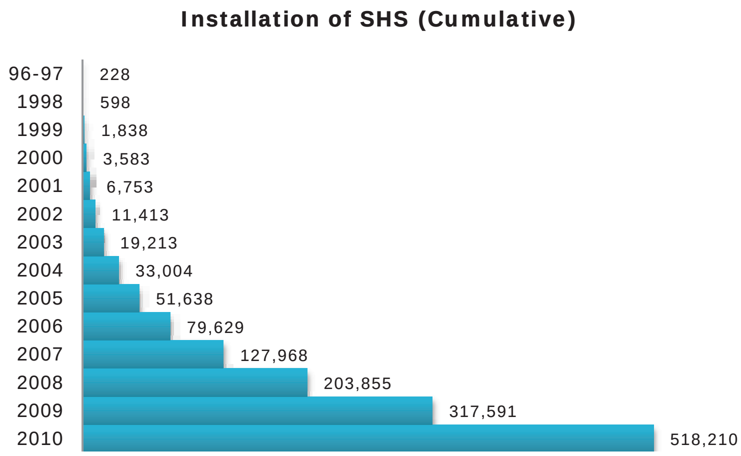
Table 1. Financing options for solar home systems

Mode of repayment	Down payment	Installment	Service charge (flat rate)
Option 1	25%	24 months	6%
Option 2	15%	36 months	8%
Option 3		100% cash payment with 4% discount.	

Source: Grameen Shakti (www.gshakti.org)

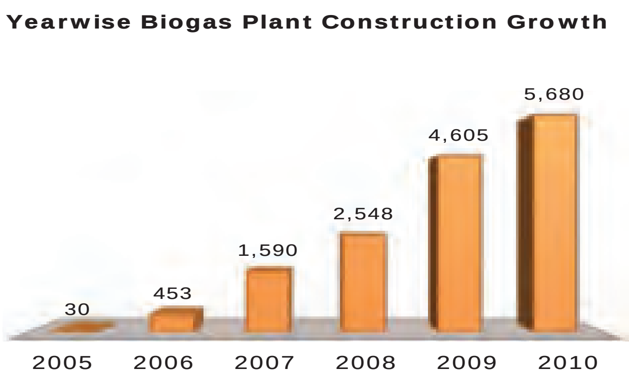
Besides solar home systems Grameen Shakti is also involved in building small household-level biogas plants and installing improved cooking stoves in villages. Although these programmes are relatively new compared to the solar energy programme, Figures 3 and 4 show that they have enjoyed robust growth over the last few years.

Figure 2. Total number of solar home system installations



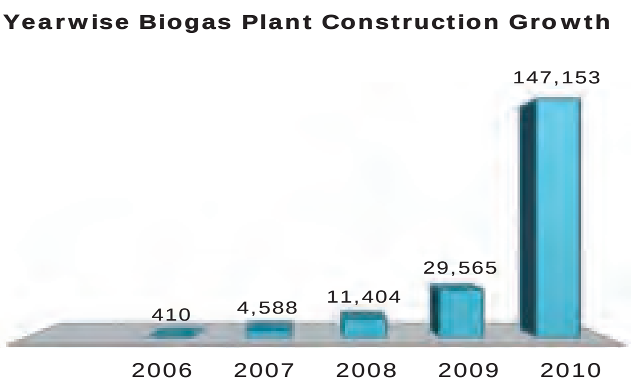
Source: www.gshakti.org

Figure 3. Grameen Shakti biogas plant construction



Source: www.gshakti.org

Figure 4. Grameen Shakti improved cook stoves



Source: www.gshakti.org

Conclusion

This paper argues that supply of clean energy is too important a matter to be left alone to conventional, profit-seeking companies. There is a need to widen our thinking to include social parameters of returns, in addition to the purely financial ones, and non-profit organizations can play an important role in this respect. Over recent years in Bangladesh there have been many schemes for microfinance credits tied to installment and use of small-scale renewable energy devices. So far these arrangements seem to provide benefits to household-level consumers at an affordable price, where traditional market forces would not have been interested in providing funding.

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SECTION IV: CLIMATE FRIENDLY BIOENERGY

Food, fuel and climate change: policy performance and prospects for biofuels in Thailand

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Overview
Biofuels have been strongly promoted in Thailand over the past few years and they also form a part of the long-term strategy to increase the use of alternative sources of energy. As the feedstocks for biofuels are agricultural products, they could compete with food unless adequate precautions are taken. The apparent greenhouse gas (GHG) benefits of substituting fossil fuels with biomass-based fuels could also be negated if there are large-scale conversions of land, especially tropical rainforests. This paper looks at the biofuels policy in Thailand and analyses its implication to food security and climate change inducing GHGs. Conditions are proposed under which the biofuel policy in Thailand could be adequately met without compromising food supply as well as reducing GHG emissions.

Introduction

Thailand has been promoting the use of agriculture-based liquid transportation fuels, referred to as biofueThailand has been promoting the use of agriculture-based liquid transportation fuels, referred to as biofuels in this paper, for several years. They comprise ethanol or gasohol (a blend of ethanol with gasoline) and biodiesel. One of the major reasons for the promotion of biofuels is that they are based on feedstocks that are available in Thailand – bioethanol is mainly being produced from sugar-cane molasses and cassava, and biodiesel from palm oil. This leads to a decrease in the importation of crude oil which is the main source of fossil-based liquid transportation fuels, resulting in a saving of foreign exchange as well as contributing to an increase in energy security (Silalertruksa and Gheewala 2010; Bell et al. 2011). It is also anticipated that the use of local feedstocks will provide benefits to the rural economy by stabilizing the prices of certain agricultural produce. Biofuels are also anticipated to help in mitigating climate change as they may release fewer greenhouse gases (GHGs) than their fossil energy counterparts (Nguyen et al. 2007a,b; Pleanjai et al. 2009a,b).

The last point was almost taken for granted initially when biofuels were assumed to be 'carbon neutral'; the carbon dioxide released from the combustion of biofuels is equivalent to that taken up from the atmosphere by the plants used as feedstocks, during photosynthesis. This idea was quickly seen to be inaccurate when the whole life cycle of the biofuel was considered. Thus, GHG emissions

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from feedstock cultivation (particularly from the manufacture and application of nitrogen fertilizers), feedstock processing and transportation between the various life cycle phases are outside the scope of carbon neutrality, which is limited to plant growth and biofuel combustion only. More recently, it was observed that change of land use, especially from forests and other areas of high carbon stocks, to agriculture results in the release of a huge amount of GHGs which could far outweigh the GHG benefits compared to fossil fuels (Danielsen et al. 2008; Fargione et al. 2008).

This is an issue that needs to be considered in any evaluation of the GHG implications of biofuels. Further still, concerns have been raised on indirect land-use change, which refers to the change in use of land as a consequence of direct land-use change elsewhere.

Change in the use of land from cultivation of food to feedstocks for biofuels causes competition with food if food crops are directly diverted for production of biofuels (Daniel et al. 2010). Competition is not limited only to land but also to another limited resource – freshwater (Gheewala et al. 2011a).

This paper examines the biofuel policy in Thailand with respect to feedstock security and GHG emissions when the policy targets are to be met. The results are based on studies carried out over several years under the Life Cycle Sustainability Assessment Laboratory at the Joint Graduate School of Energy and Environment in Bangkok.

Biofuel policy in Thailand

There is a strong policy drive in Thailand for the increase of renewables in the energy mix, particularly the use of biomass. The most recent 15-year alternative energy development plan from the Ministry of Energy lays particular emphasis on the promotion of biomass (DEDE 2009). In the short term (2008-2011), it focuses on promotion of biofuels, heat and power generation from biomass and biogas as the major alternative energy sources. In the medium term (2012-2016), it focuses on developing new technologies for alternative energy, including biofuel production. In the long term (2017-2022), it proposes to make Thailand a hub of biofuel export in the Association of Southeast Asia Nations (ASEAN) region. The plan includes a target of 20.4 percent alternative energy in the final national energy mix by 2022, biomass for heat, power and transportation fuels playing a key role.

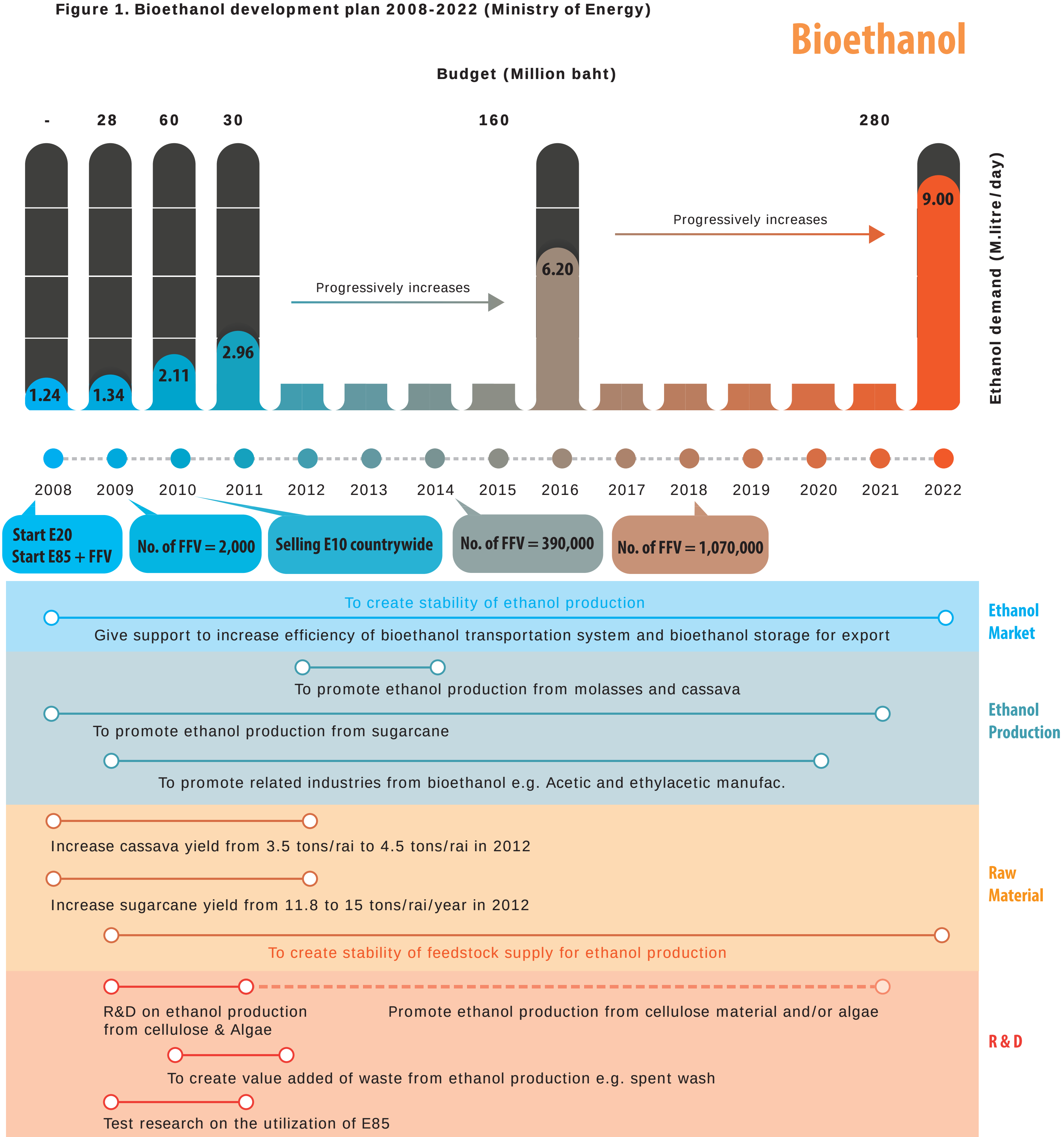
Bioethanol development plan

According to the Ministry of Energy, bioethanol production targets for 2011, 2016 and 2022 were 2.96, 6.2 and 9.0 million litres/day, respectively (Figure 1) (DEDE 2009). Ethanol is currently being produced from sugar-cane molasses and cassava. Ethanol production directly from sugar-cane juice is also planned for the future. Sugar cane and cassava are both well-established agricultural products and important for the domestic market as well as export. The increasing demands on sugar cane and molasses for ethanol are to be met by increasing the yields of sugar cane and cassava as indicated in Figure 1. Research is also planned for production of ethanol from cellulosic materials (particularly agricultural residues) as well as algae. A 10 percent blend of ethanol with gasoline, E10, has been available for several years since 2005 and has well-established usage; prices of E10 are maintained lower than gasoline through government incentives to encourage its use. Since 2008, E20 (a 20 percent blend of ethanol with gasoline) has been available once again with government incentives to maintain an attractive price. Many automobile companies are producing vehicles which can use E20. E85 (an 85 percent blend of ethanol with gasoline) has also been introduced since late 2008 on a very limited scale although vehicles that can use this blend are not readily available in Thailand.

Biodiesel development plan

The 15-year alternative energy plan from the Ministry of Energy has proposed targets of 3.02, 3.64 and 4.50 ML/d biodiesel for the years 2011, 2016 and 2022 respectively [11]. This plan has been adjusted from a previous target of 9 ML/d biodiesel in 2022. The biodiesel is mainly produced from palm oil and stearin, both products of oil palm. Palm oil is widely used for cooking, thus care must be taken to avoid the food versus fuel conflict. The government has proposed an improvement in yield of oil palm trees and also an additional plantation of 2.5 million rai (0.4 million ha) to meet the increasing demand (Figure 2). Jatropha is another plant which can be used as a feedstock for biodiesel production; it has been under research for several years and community scale applications are anticipated. Biomass-to-liquid (BTL) and algal biodiesel are also planned on a longer term. Pure diesel has been entirely phased out of the market and currently the fuel being sold as diesel is actually B3 (3% blend of biodiesel with diesel); B5 (5% blend of biodiesel with diesel) is planned by the end of 2011. B5 is also already available in the market as an option.

Figure 1. Bioethanol development plan 2008-2022 (Ministry of Energy)



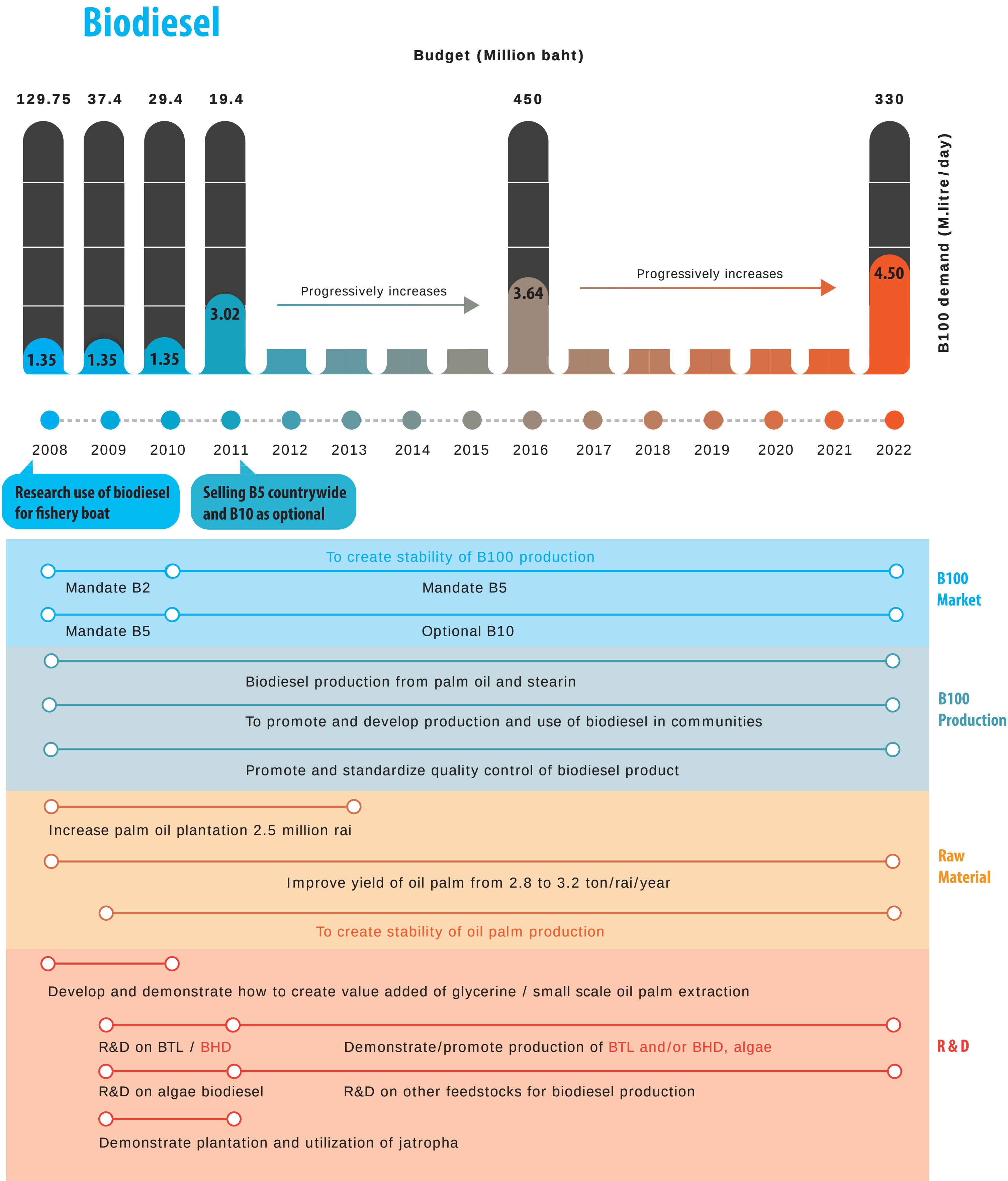
Biofuels performance and prospects

Several energy balance and life cycle assessment (LCA) studies, particularly dealing with life cycle GHG emissions have been performed on biofuels from various feedstocks in Thailand. Bioethanol from sugarcane molasses and cassava and biodiesel from palm oil, used cooking oil and jatropha have been studied (Nguyen et al. 2007a,b,c; Nguyen and Gheewala 2008a,b,c; Pleanjai et al. 2009, a,b; Prueksakorn and Gheewala 2008; Prueksakorn et al. 2010). The studies were conducted over several years with changing conditions. The findings from the most recent studies are discussed in this paper.

Performance and prospects of bioethanol

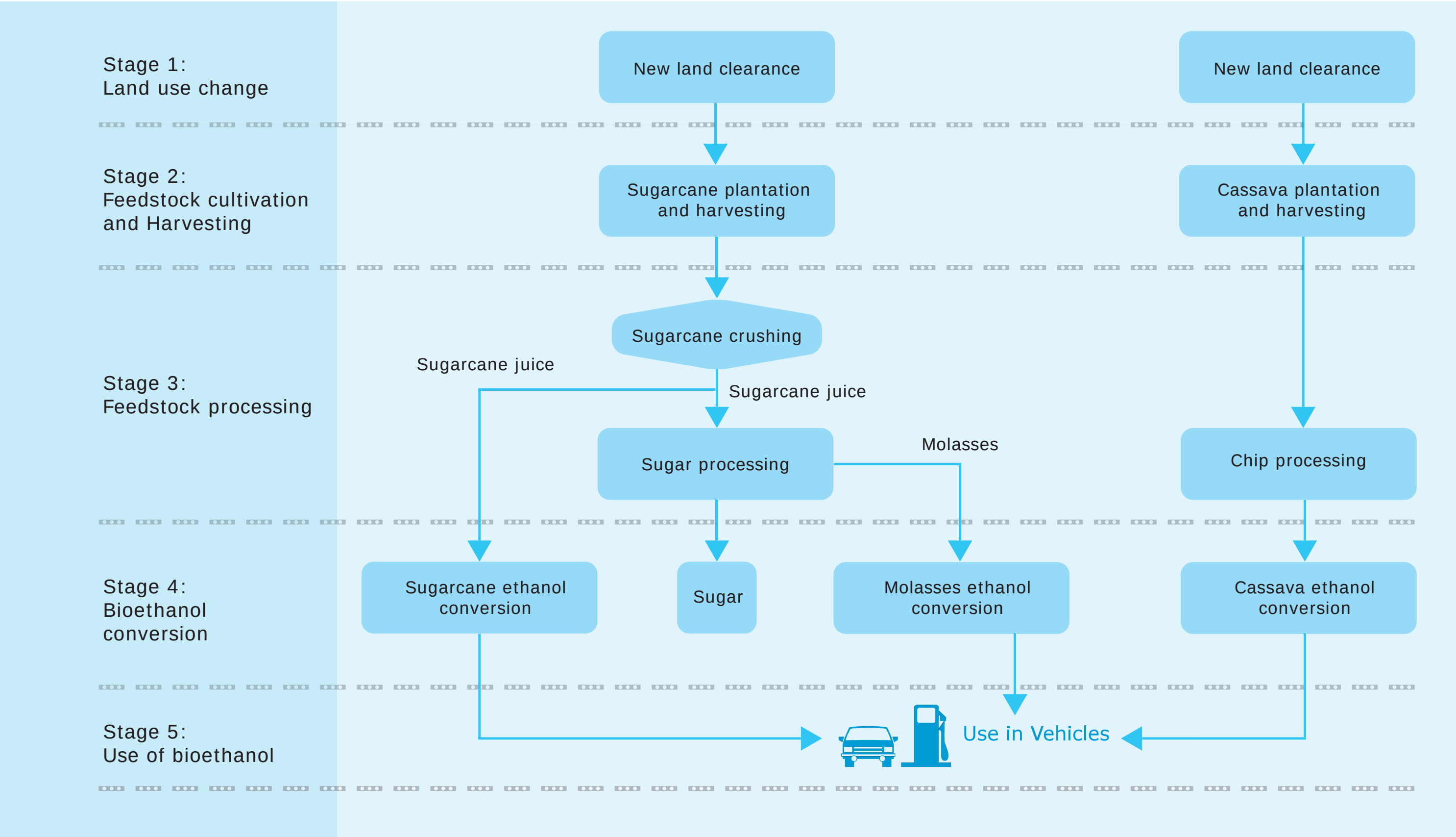
A summary of the results from the various studies on bioethanol from various feedstocks is provided in Table 1 below (Silalertruksa and Gheewala 2010). The

Figure 2. Biodiesel development plan 2008-2022 (Ministry of Energy)



system boundaries of the various chains are shown in Figure 3. It must be noted that these results are drawn based on the assumption of status quo vis-à-vis land use change as bioethanol production relies mainly on surplus feedstocks from the existing plantation areas. Also, both sugarcane and cassava are being planted traditionally in the same area for many decades; thus, there is no recent conversion of land. So Stage 1 in Figure 3 is not included for the results presented in Table 1.

Figure 3. Life cycle stages of palm biodiesel



As none of the ethanol plants are using sugar-cane juice directly for ethanol production (only sugar-cane molasses), the values for that feedstock are from Brazil. A range of results has been obtained due to the various operating conditions and energy carriers in the different plants as explained in the footnotes of Table 1.

a. Average GHG emissions of three molasses ethanol plants, Allocation factor (AF) of sugar: molasses = 4:1.

b. A molasses ethanol plant which used bagasse as fuel.

c. A molasses ethanol plant which used coal as fuel; AF of sugar:molasses = 8.6:1.

d. Ethanol produced from dried cassava chips in Thailand; ranges of GHG emisission were reviewed from various studies (Nguyen et al. 2009a; Silalertruka and Gheewala 2009; Hue et al. 2004).

e. Cassava ethanol plant that used biomass as fuel.

f. Cassava ethanol plant that used coal as fuel.

g. Sugar cane in Brazil (sugar-cane juice) (Macedo et al. 2008).

h. Estimations based on energy content of ethanol = 21.2 MJ/L; energy content of gasoline = 32.4 MJ/L.

Thus, a litre of ethanol will produce the same performance as 0.65 L of gasoline. Gasoline fuel-cycle GHG emissions = 2.9 kg CO_2eq./L gasoline.

Source: Silalertruksa and Gheewala (2010)

Table 1. Life cycle GHG performance of bioethanol from various feedstocks

Feedstock	Estimated GHG emissions (kg CO_2eq / L biofuel)		Net avoided GHG emissions compared to gasoline[h]	
	Baseline	Range	Baseline	Range
Molasses	0.68[a]	0.65[b]-3.46[c]	64%	66%-(-82%)
Cassava/dried chips	0.96[d]	0.77[e]-1.92[f]	49%	59%-(-1%)
Sugar-cane juice	0.5	0.26[g]-0.5	72%	82%[c]-76%

The implications of the policy targets on feedstocks are presented in Table 2 (Silalertruksa and Gheewala 2010). Three scenarios are defined considering varying yield improvements. The low yield improvement scenario is the business-as-usual where yields are projected to increase as shown by the historical data as if there is no policy promoting biofuel development. In the moderate yield improvement scenario, crop yields are anticipated to be improved according to the government's short-term policy targets in Thailand's 15 years renewable development plan. In the high yield scenario, the crop yields are projected to reach the genetic potential of the cassava and sugar-cane varieties. Table 2 clearly shows that cassava feedstock will run out at some point in all the scenarios considered (indicated by the numbers in parentheses). The deficit could be made up by decreasing the export of cassava chips but that itself is an indicator of supply insecurity. Sugar-cane juice may play an increasingly important role in meeting the ethanol demand in the future as indicated by the high surplus availability of this feedstock.

One of implications of the results in Table 2 is that even if the ambitious moderate yield improvement scenario is achieved, there will still be a shortall of cassava by 2016 and molasses by 2022. Therefore, expansion of both cassava as well as sugar-cane plantation areas needs to be considered if reduction of exports, which may in turn induce indirect effects of increased production elsewhere, is to be avoided. To produce bioethanol according to the government's targets and thus considering an expansion of cultivation areas for sugar cane and cassava, five scenarios are postulated:

Case 1: New plantations for both cassava and sugar cane will take place on grassland.

Case 2: New plantations for both cassava and sugar cane will take place on forest land.

Case 3: Same as Case 1 but ethanol systems widely adopt sustainability measures such as waste utilization and biomass energy (Gheewala et al. 2011b).

Case 4: Same as Case 3 but new plantations of cassava and sugar cane take place on forest land.

Case 5: No expansion of new cultivated areas as cassava and sugar-cane yields are projected to increase to reach the genetic potentials of the current varieties. Sustainability measures adopted.

The results of the analysis are summarized in Table 3. It can clearly be seen that if no land area expansion takes place due to high yields (Case 5) or expansion takes place on grasslands (Cases 1 and 3), then bioethanol does better than gasoline even after inclusion of GHG emissions from direct land-use change. However, if forest land is converted to sugar-cane and cassava plantations (Cases 2 and 4), then the GHG benefits of bioethanol are lost due to the large emissions taking place due to land-use change (LUC). The GHG emissions per litre of ethanol range between 0.49-3.7 kg CO_2-eq. The wide range is due to the effects of LUC as well as various production factors (waste utilization and biomass energy).

Table 2. Net feedstock balances for bioethanol (after accounting for the projected demand)

Net balance (Million tonnes feedstock / year)		2008	2009	2010	2011	2016	2022
Low yield improvement	Molasses	0.13	0.54	0.65	0.62	0.23	(0.17)
	Cassava	3.50	0.54	(2.11)	(3.61)	(13.00)	(20.95)
	Sugar cane		4.33	8.26	8.49	7.03	6.24
Moderate yield improvement	Molasses	0.13	0.81	1.13	1.31	0.81	(0.08)
	Cassava	3.50	1.23	0.64	1.19	(6.95)	(20.63)
	Sugar cane		10.24	18.75	23.55	19.60	8.23
High yield improvement	Molasses	0.13	0.81	1.13	1.31	1.42	1.44
	Cassava	3.50	1.23	0.64	1.19	(0.23)	(0.48)
	Sugar cane		10.24	18.75	23.55	32.79	41.18

Source: Silalertruksa and Gheewala (2010)
Note: Numbers in parentheses indicate shortfall.

Table 3. GHG emissions of future bioethanol production systems in Thailand including LUC

GHG indicator	Year	Case 1	Case 2	Case 3	Case 4	Case 5
Average GHG emissions from bioethanol (kg CO_2-eq/L ethanol)	2011	1.39	1.39	0.48	0.48	0.48
	2016	1.75	3.16	0.76	2.18	0.49
	2022	1.84	3.7	0.85	2.71	0.49
GHG emission reduction compared to gasoline (%)	2011	27	27	74	74	74
	2016	8	(67)	60	(15)	74
	2022	3	(95)	55	(43)	74

Source: Silalertruksa and Gheewala (2011)

For the case of no new cultivated area (Case 5), in 2022, GHG reductions of 4.6 million tonnes CO_2-eq (74 percent reduction compared to gasoline) are possible provided improvement options such as those suggested below are also encouraged:

- Increasing feedstock productivity by improving soil quality with organic fertilizers.
- Implementing energy conservation measures that promote use of renewable fuels in ethanol plants.
- Preventing cane trash burning during harvesting by using it as fuel in sugar milling.
- Enhancing waste utilization from ethanol plants such as biogas recovery, organic fertilizers and animal feed.
- Providing technical knowledge associated with cassava ethanol production to industry.

Performance and prospects of biodiesel

Accounting studies of life cycle GHG emissions from biodiesel produced from palm oil and used cooking oil in Thailand have yielded values of 0.6-1.2 and 0.23 kg CO_2-eq/L respectively which are much lower than an equivalent amount of conventional diesel (Pleanjai et al. 2009a; Pleanjai et al. 2009b; Silalertruksa and Gheewala 2012). The life cycle stages of the palm biodiesel chain are shown in Figure 4. The range of values for life cycle GHG emissions from palm biodiesel are due to variations in the production systems (energy carriers and waste/by-product utilization). The biodiesel produced from palm oil considered in the above study does not include land-use change (Stage 1) as the palm plantations in the southern region of Thailand have been in existence for over three decades. On the other hand, palm biodiesel in Southeast Asia has come under a lot of scrutiny due to conversion of tropical forests and peatlands, lands with high carbon

Table 4. Net feedstock balances for biodiesel (after accounting for food and stocks)

Net balance (million tonnes feedstock/year)	2008	2009	2010	2011	2016	2022
Feedstock supply potentials						
Planted area (million hectares)	0.58	0.67	0.75	0.83	0.91	0.91
Harvested area (million hectares)	0.46	0.51	0.55	0.59	0.91	0.91
Yield (tonnes/hectare)	20.2	18.6	19.7	20.8	21.9	21.9
FFB production (million tonnes FFB)	9.27	9.57	10.78	12.20	19.95	19.95
CPO production (million tonnes CPO)	1.68	1.74	1.96	2.22	3.63	3.63
Feedstock requirements for biodiesel						
Biodiesel production targets (million litres/day)	1.23	1.56	2.28	3.00	3.64	4.50
CPO required (million tonnes/year)	0.42	0.54	0.78	1.03	1.25	1.54
FFB required (million tonnes FFB/year)	2.32	2.94	4.30	5.66	6.87	8.49
Net feedstock balances						
Net CPO balance (million tonnes CPO)	0.15	0.09	0.03	(0.01)	0.88	0.07

Source: Silalertruksa and Gheewala (2012)
Note: CPO = crude palm oil.

stock, to oil-palm plantations which results in large release of GHGs. However, the situation in Thailand is quite different from the other palm oil-producing countries in the region in that there are hardly any peatlands and conversion of organic soils to oil-palm plantations is almost non-existent. Nevertheless, there are plans to expand plantations of oil-palm. Hence, it is interesting to evaluate the security of palm oil supply as it is by far the major feedstock for biodiesel, which types of land will be converted and what would be the consequences of such LUC on the GHG performance of biodiesel.

Table 4 shows the analysis of feedstock for biodiesel; if the government plan of yield increase and additional plantations is followed, there will not be a supply shortfall (Silalertruksa and Gheewala 2012). However, there is a chance of a slight deficit in 2010 and 2011. This is because even with additional plantations, fresh fruit bunches (FFB) can, at the earliest, only be harvested three years after planting. Hence, increase in productivity will be very important if imports are to be avoided. These will have to supported by good agricultural practices such as application of appropriate amount of fertilizers, increased use of organic fertilizers and proper irrigation.

According to government plans, the expansion of oil-palm plantations will take place on abandoned rice fields, fruit orchards and reserved land. However, other site surveys have also shown conversion of rubber plantations, cassava and secondary forests to oil-palm (Siangjaeo et al. 2011). However, there is no evidence of tropical rain forests being converted to oil-palm plantations in Thailand. Five possible changes of land or cropping systems to oil-palm are presented in Table 5. The conversion of forest to oil-palm is included only as a reference. Five different production systems are considered based on utilization of empty fruit bunches (EFB) and the wastewater from palm milling, termed palm oil mill effluent (POME), as follows:

Case 1: EFB is dumped in the plantation; POME is treated in open ponds with CH_4 leakage.

Case 2: EFB is dumped in the plantation; POME is treated with biogas recovery.

Case 3: EFB is co-composted with POME; POME is treated in open ponds with CH_4 leakage.

Case 4: EFB is co-composted with POME; POME is treated with biogas recovery.

Case 5: EFB is sold as fuel or other purposes; POME is treated with biogas recovery.

Compared to the life cycle GHG emissions from diesel (72 g CO_2-eq/MJ), most of the scenarios even including LUC have GHG benefits. The conversion of forests to oil-palm have higher GHG emissions than diesel for every case indicating that utilization of waste/by-products cannot compensate for the GHG emissions from LUC. In fact, comparing the results with those excluding LUC indicates that conversion of field crops, rubber, paddy fields and reserved land to oil-palm actually has GHG benefits due to increase in biomass carbon stock and/or soil organic carbon. Converting reserved land to oil-palm plantation would intuitively have the maximum benefit; but this is not so as the calculations were done based on the assumption that reserved land would stock carbon as a grassland. This in a way reflects the opportunity cost of leaving the land uncultivated.

Table 5. GHG emissions of future biodiesel systems in Thailand including LUC

Land-use change scenario	GHG emissions of palm biodiesel ($g\ CO_2$-eq / MJ biodiesel)				
	Case 1	Case 2	Case 3	Case 4	Case 5
Excluding LUC	38	20	21	18	20
Including LUC					
Rubber to oil-palm	25	6	8	5	6
Field crop to oil-palm	21	3	4	1	3
Paddy field to oil-palm	27	9	10	8	9
Reserved land to oil-palm	28	10	12	9	10
Forest land to oil-palm	248	230	231	228	230

Source: Silalertruksa and Gheewala (2012)

The above analysis shows that the government policy of expanding oil-palm plantation areas to non-forest lands and increase in yields can result in significant GHG benefits. Thus, the policy to promote suitable land as well as to encourage the implementation of recommended measures such as utilizing POME and EFB to produce biogas and co-compost and increasing FFB yield by promoting good agricultural practices to farmers is important and necessary for sustainable palm biodiesel production in Thailand.

Concluding remarks

The analysis of feedstock availability in Thailand for bioethanol from cassava and sugar cane (including molasses) and biodiesel from palm oil has shown that if the government's targets on yield increases can be achieved along with careful expansion of cultivation areas, the planned targets for bioethanol (9 million litres /day) and biodiesel (4.5 million litres/day) in 2022 can be met. In addition, substantial GHG reductions can be achieved as compared to the gasoline and diesel that would be replaced in vehicles. Thus good agricultural practices must be urgently promoted by the responsible agencies and efforts made to utilize by-products from all the supply chains. The importance of by-product utilization to achieve the benefits points also to the need for developing the appropriate infrastructure (powerplants, biogas production facilities, fertilizer factories, etc.) so that the by-products can actually be utilized in practice.

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Linking energy, bioslurry and composting

M. Fokhrul Islam[1]

Introduction

Most Asian countries have largely agrarian societies. Therefore, any technology that can influence agriculture becomes a subject of concern, particularly in the domain of biogas.

In many Asian countries, the annual removal of soil nutrients is higher than what is added to the soil and with expanding areas under improved varieties and high-yielding crops, this removal is expected to continue at a higher rate in the future. As a result, the productivity of soils is declining due to this continuous over-mining.

To compensate for this development, the use of fertilizers has become the leading means to increase agricultural production. Yet it has not been possible to supply chemical fertilizer on time and at sites where it is required. In some cases, import of low-quality fertilizers has been reported. Continuous use of chemical fertilizer alone, without the addition of organic manure, has detrimental effects on soil quality in the long run mainly because of the constant loss of humus and micronutrients. Thus reliance on chemical fertilizer alone does not ensure sustainable agricultural development.

By-products of agriculture, mainly animal wastes and crop residues, are the primary inputs for biogas plants. Bioslurry, a biogas plant output, can be returned to the agricultural system. Proper application of bioslurry as organic manure/ fertilizer improves soil fertility and thereby increases agricultural production because it contains elements of soil organic matter, plant nutrients, growth hormones and enzymes. Bioslurry can also safely replace part of animal and fish feed concentrates. Furthermore, bioslurry treatment increases the feed value of fodder with low protein content. When bioslurry is placed into the food chain of crops and animals, it leads to a sustainable increase in farm income.

Bioslurry is linked with mitigation of natural resource use such as natural gas and is used for production of urea; in turn this saves natural gas used for production of electricity. Bioslurry use also reduces the need for mineral resources required for other fertilizers like triple super phosphate (TSP) and muriate of potash (MoP).

However bioslurry production needs energy for its drying, transportation and production of organic fertilizer and animal feed.

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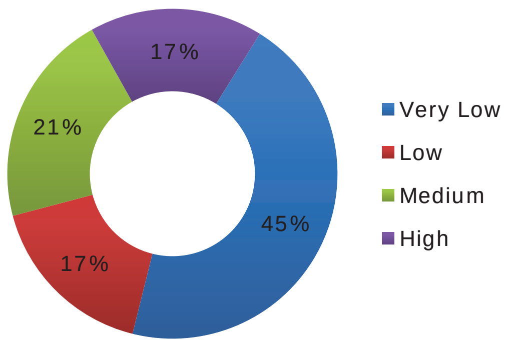
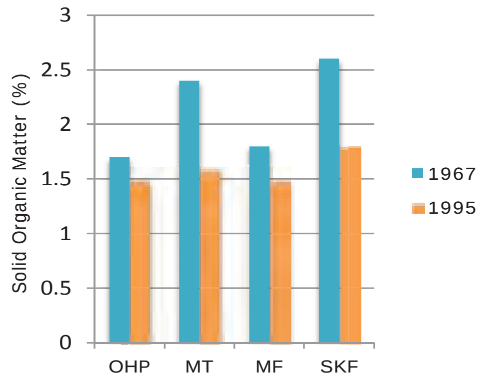
Figures 1a, b. Organic matter content and its change over time in Bangladesh





Soil fertility in Bangladesh

Soil organic matter is the most important factor in soil fertility management. A good soil under Bangladeshi conditions should have organic matter content of 3.5 percent. But soil analysis shows that most soils (62 percent) have less than 1.5 percent and some even less than 1 percent (Figure 1a). One of the main reasons why crop productivity is declining in some areas is the depletion of soil organic matter over time (Figure 1b). This is caused by high cropping intensity, intensive tillage and removal of all straw and other crop residues from the field and practice of low organic manure application or none at all. Efforts must be made to educate farmers about the importance of soil organic matter, and the possibility of long-term soil improvement through application of more organic materials on fields.

The nutrient content of plants in Bangladeshi soil typically decreases over time. As time elapses, the nutrient balance is becoming more negative (Figure 2). Again, land use with higher cropping intensity may show higher negative balances. On the other hand, the addition of organic manure may help to reduce negative balances; the magnitude depends on the types and amounts of manure.

Bioslurry

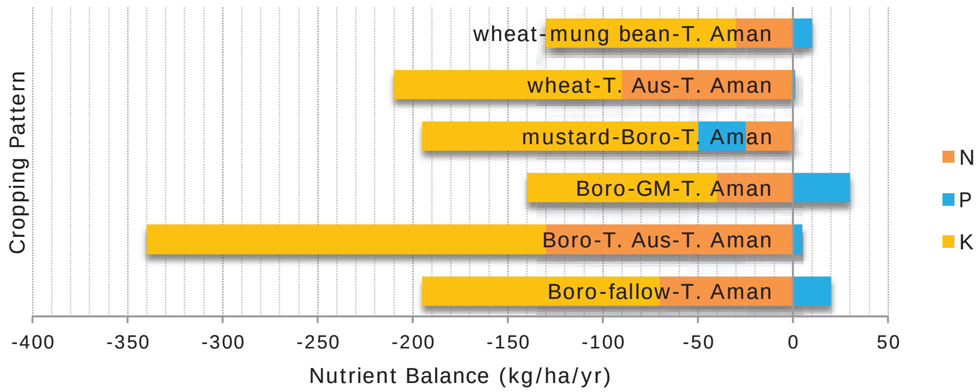
Bioslurry is the decomposed product of organic materials; it is derived from a reduction process in presence of anaerobic microbes in the digester of a biogas plant. It comes out through the hydraulic chamber of the biogas digester.

During digestion, about 25-30 percent of the total dry matter (total solids content of fresh dung) of animal/human wastes will be converted into a combustible gas, and a residue of 70-75 percent of the total solids content of the fresh dung comes out as sludge. It is this sludge that is known as digested slurry or bioslurry. Various names given for the digested slurry include: slurry, digested slurry, sludge, bioslurry, effluent slurry or biogas effluent, biomanure, organic fertilizers and organic manure.

Source and form of bioslurry

The main sources of bioslurry are cow dung, poultry manure, buffalo dung and biodegradable agricultural waste. Bioslurry can appear in liquid, semi-dry and powder form.

Figure 2. Nutrient balance in different cropping patterns



Characteristics of bioslurry

Some of the main traits and features of bioslurry are listed below:

- When fully digested, bioslurry is odourless and does not attract insects or flies in the open.
- Bioslurry repels termites but raw dung attracts them.
- Bioslurry reduces weed growth as biogas plants either destroy weed seeds or make them less fertile through anaerobic digestion.
- Bioslurry is excellent nutrient and feed material for algae, earthworms, livestock and fishponds.
- Bioslurry manure has greater fertilizer value than composted manure or fresh dung.
- Bioslurry is an excellent soil conditioner as it adds humus and supports the microbiological activity in the soil, increasing the soil porosity and water-holding capacity.
- Bioslurry has residual value (whereas most chemical fertilizer is effective for one crop only).
- Bioslurry is pathogen-free. The complete digestion of dung in a biogas plant kills the pathogens present in it.
- Bioslurry can be used to compost other raw materials and this provides larger quantities of manure.
- Loss of nitrogen is lower in the case of bioslurry compared to fertilizers and compost due to anaerobic conditions in the biogas plant.
- If night soil (toilet attached) and cattle urine is added, N and P availability in the bioslurry manure can be increased.

Potential of bioslurry use

For the promotion of biogas technology, besides gas, the potential of bioslurry use has to be taken into consideration. There is a need to understand and assess the potential of bioslurry in terms of maintaining soil fertility, reduction of inorganic fertilizers and agricultural production.

Maintaining/improving soil fertility

Decline in soil fertility is a common scenario in most countries though magnitudes vary in different agro-ecological zones (AEZ) within a country. Decline in soil fertility describes deterioration in physical, chemical and biological properties. It occurs through a combination of lowering of soil organic matter and loss of nutrients. The average organic matter content of topsoil in Bangladesh has declined by 20-46 percent over the past 20 years, due to intensive cultivation of the land. To arrest further decline of soil fertility, proper use of bioslurry alone or in combinations with inorganic fertilizers may be good options.

Bioslurry obtained as a result of anaerobic decomposition from a biogas plant may be considered as a high-quality organic fertilizer. This organic fertilizer is environmentally friendly, has no toxic or harmful effects and can help to a great extent to rejuvenate soils by supplying considerable amounts of macro- and micronutrients and organic matter, which can also improve the physical and biological conditions of the soil.

This organic fertilizer also has liming effects. Poultry litter-fermented organic fertilizer is more effective in acid soils to reduce acidity, and thereby protects crops from the harmful effects of aluminium. Cowdung, poultry bioslurry and bioslurry compost can be fitted into the modern Integrated Plant Nutrition System (IPNS), which combines the use of organic and chemical fertilizers. Thus, the use of bioslurry will improve the physical, chemical and biological conditions of the soil.

Reduction of inorganic fertilizer use

There is potential for establishing about 3 million biogas plants in Bangladesh and the possibility of producing 18 million tonnes of dry bioslurry (15 percent moisture) per year from family-sized (2.4 m^3) biogas plants. If calculated in terms of nutrients, 207 000 tonnes of nitrogen, 111 000 tonnes of phosphorus and 28 518 tonnes of potassium would be available each year as fertilizer.

A family-sized biogas plant produces 6 tonnes (dry basis) of bioslurry per year, which can supply nutrients to the equivalent amount of 163 kilograms of urea, 280 kilograms of TSP, 162 kilograms of potash and 245 kilograms of gypsum.

If properly managed, bioslurry could play a major role in supplementing the use of expensive inorganic fertilizers. However, in the present context in Asia, the focus has been only to increase the number of biogas plants for its gas use and little attention has been paid to the proper utilization of bioslurry as organic fertilizer.

Increasing agricultural production

Bioslurry can be used successfully for crop production owing to its good quality plant nutrient value. But its effectiveness depends on cropping systems, crop variety to be used, soil types and agro-ecological regions. Neither bioslurry nor inorganic fertilizer alone is enough to meet the demands of soil-crop systems.

The farmer needs to use chemical fertilizer to increase crop production. However, if only mineral fertilizers are continuously applied to the soil without adding organic manure, the productivity of the land will decline. On the other hand, if only organic manure is added to the soil, desired increase in crop yield cannot be achieved. Fertility trials carried out in Bangladesh and elsewhere have revealed that optimum results can be achieved through the combined application of both chemical and organic fertilizers following the IPNS approach.

In countries where biogas technology is well developed, for instance in China, there is evidence that productivity of agricultural land can be increased to a remarkable extent with the use of bioslurry produced from a biogas plant.

In Bangladesh, the Bangladesh Agricultural Research Institute (BARI) with support from the SNV (Netherlands Development Organisation) conducted on-station and on-farm trials with bioslurry on different crops in major AEZs; average crop yield increases are given in Table 1.

Agribusiness

Bioslurry can be used effectively for all high-value fields and horticultural crops including vegetables, fruit, flowering as well as ornamental plants and roof-top gardens. This organic fertilizer can also profitably be used for forest nurseries, public parks and roadside plantations.

Organically-produced crops and fruits are healthy and nutritious, and have better shelf-life as well as higher market value. Demand for organically-produced crops is increasing in Bangladesh and elsewhere in the world.

Quality organic fertilizer

A part of the total content of plant nutrients in bioslurry is converted to available form and if liquid bioslurry is applied to a standing crop, it can immediately absorb these nutrients. Bioslurry can be applied directly to the fruit or vegetable crops grown close to the house or biogas plant with the help of a bucket or pail.

Bioslurry for composting

Using dry forms of bioslurry is not recommended. The transportation of fresh slurry is not that practical because farmers want to fertilize all their fields at several sites. The slurry comes daily from the biodigester but cannot be used daily because farmers use manure according to cropping seasons. Thus it needs to be preserved and used as and when needed. However it is also noted that crop yields are decreasing because not enough organic manure is being added. Similarly, much agricultural waste such as weeds, straw and crop residues are being burned and not used properly. One remedy is to make compost. Bioslurry is the best material to make compost as it contains micro-organisms that are very helpful in the decomposition of organic wastes. The slurry need not be decomposed as it has already been digested during gas formation, and can thus be used directly. However, to use it when needed, and to increase the quantity of manure, it should be composted and stored safely. Composting can done be via pit or heap methods.

Table 1. Crop yield increases with bioslurry in Bangladesh

Crop	% yield increase with IPNS over inorganic fertilizer	
	Cowdung bioslurry	Poultrymanure bioslurry
Boro rice	9	-
Wheat	17	-
Maize	17	-
Cabbage	16	-
Cauliflower	21	-
Tomato	-	19
Potato	12	-
Mustard	8	-
Jute	4	-

Source: BARI project report 2008 & 2009

Material for composting

Material with a high C: N ratio such as sawdust (Table 2) should not be used for composting. Composting increases the nutrient content (Table 3) and quantity of biomanure. The amount of compost depends on the amount and type of organic materials added. Generally the amount of compost is three times higher than that of bioslurry.

Potential use of bioslurry or other purposes

In addition to its application as manure/fertilizer or compost preparation, bioslurry has many other uses such as for:

- Soil conditioning;
- Feed;
- Pesticide;
- Seed pelleting;
- Animal feed;
- Fish culture;
- Mushroom cultivation; and
- Earthworm rearing (vermiculture).

Table 2. Material for composting

Items	C: N ratio
Dry leaves	-
Kitchen waste	-
Animal bedding	-
Water hyacinth	25
Maize stalks	60
Rice straw	70
Wheat straw	90
Sawdust	200
Paddy husks	250

Table 3. Nutrient content of bioslurry and its compost

Compost materials	Nutrient content (%)			
	N	P	K	S
Cowdung slurry	1.42	0.68	0.32	0.33
Cowdung slurry compost	1.73	0.85	0.37	0.46
Poultry manure slurry	1.85	0.88	0.52	0.40
Poultry manure slurry compost	2.38	0.95	0.77	0.38

Bangladesh Government Gazette for Organic Fertilizer

The Government of Bangladesh has approved permissible limits for organic fertilizer (Table 4).

Table 4a. Permissible limits of different nutrients in organic manure

	pH	%	N	P	K	S	Cu	Fe	Mn	Zn
			%							
Minimum	6.0	17	0.50	0.5	1	0.1	0	-	-	0
Maximum	8.5	43	4.00	1.5	3	0.5	0.050	-	-	0.10

Table 4b. Permissible limits of different heavy metals in organic manure

Permissible limit	% moisture	µg/g				
		Co	Ni	Cd	Pb	As
Minimum	0	-	0	0	0	0
Maximum	15	-	30	5	30	20

Bioslurry quantity and quality

Quantity of bioslurry in comparison with farmyard manure

The quantity of manure after processing through a biogas plant exceeds that of farmyard manure. About 25-30 percent of organic matter present in dung is converted into gas while about 50 percent of the organic matter is lost in open pit composting as carbon dioxide. Thus about 20 to 25 percent more manure is produced through a biogas plant. Secondly, the quantity of bioslurry manure can be increased up to three times its weight if composting is done at the rate of 1: 3 ratios of bioslurry and agricultural waste or dry materials. A research study has shown that the quantity of organic manure obtained from composting bioslurry out of biogas plant is 40-45 percent more than traditional pit manure. A threefold increase in the quantity of manure can be achieved if bioslurry is composted with organic dry materials available in and around the farm.

Plant nutrient value of bioslurry

The National Domestic Biogas and Manure Program supported by SNV outsourced its bioslurry research activities to BARI. An investigation was conducted by BARI to determine manure quality for bioslurry. Bioslurry samples were collected from biogas plants. Samples were analysed for moisture content, pH, organic matter, essential plant nutrients (N, P, K, Ca, Mg, S, B, Cu, Fe and Mn) and heavy metals like Co, Ni, Cd and Pb.

All samples contained more than 17 percent organic matter (Table 5). The nutrient content of poultry manure bioslurry was higher than that of cowdung bioslurry. The calcium content of poultry manure bioslurry was higher than cowdung and buffalo dung bioslurry because poultry feed contains more calcium. This high content of calcium is useful for decreasing the acidity of acidic soils.

Cobalt, nickel and cadmium contents of cowdung and poultry manure bioslurry were within the safe limit (Table 6). The lead concentration of poultry bioslurry was higher than that of cowdung bioslurry. Air-dried bioslurry contained higher organic matter and nitrogen than sun-dried bioslurry.

Bioslurry research and extension

On-station trials

Two separate experiments were conducted under irrigated conditions. Six treatments were replicated three times in a randomized complete block design for high yields:

- T_1: Soil test based (STB) inorganic fertilizer;
- T_2: IPNS with 5 tonnes/hectare cowdung plus inorganic fertilizer;
- T_3: IPNS with 5 tonnes/hectare cowdung bioslurry plus inorganic fertilizer;
- T_4: IPNS with 3 tonnes/hectare poultry manure plus inorganic fertilizer;
- T_5: IPNS with 3 tonnes/hectare poultry bioslurry plus inorganic fertilizer; and
- T_6: Natural fertility (no fertilizer used).

The details of the materials and methods used in the experiments are available in the project annual report 2009 and 2010.

Table 5. Organic matter and nutrient content of bioslurry

Manure	OM (%)	Nutrient concentration (%)					
		N	P	K	S	Ca	Mg
Cowdung bioslurry	27	1.42	0.68	0.32	0.33	1.41	0.85
Poultry manure bioslurry	29	1.85	0.88	0.52	0.40	5.72	1.98
Buffalo dung bioslurry	26	1.05	0.82	0.55	0.44	1.15	1.11

Table 6. Heavy metal status of different organic manure

Sources	µg/g			
	Co	Ni	Cd	Pb
Cowdung bioslurry	7.2	9.4	0.9	9.1
Poultry manure bioslurry	8.2	10.3	1.0	24.5
Buffalo dung bioslurry	5.3	7.9	0.4	4.8

The type of nutrient package significantly influenced the yield and yield components of cabbage and cauliflower. The highest head yield of cabbage (98.3 tonnes/hectare) and curd yield of cauliflower (56.8 tonnes/hectare) were obtained from T_5 which was close to T_3. The gross margin was higher where organic and inorganic fertilizer were used combined compared to that of T_1 while the marginal benefit-cost ratio (MBCR) was higher in T_4 (Table 9).

On-farm trials

On-farm trials were conducted with five vegetable crops (cabbage, cauliflower, brinjal, tomato and potato), three cereal crops (maize, wheat and rice), 1 fibre crop (cash crop) and 1 oilseed crop (mustard) in 110 farmers' fields in 30 locations of Bangladesh.

Four nutrient management packages – T_1 (STB inorganic fertilizers), T_2 (IPNS with poultry manure/cowdung), T_3 (IPNS with poultry bioslurry/cowdung bioslurry) as well as the farmers' dose (not in all locations) were tested on different crops (Table 10).

Use of bioslurry increased yield of:

- Energy-rich food crops: wheat, rice (9-16 percent);
- Biofuel-producing plants/crops: maize (17 percent), Jatropha, rubber;
- High-value vegetable crops: cabbage, cauliflower, tomato (11-48 percent); and
- Cash crops: jute (4 percent), tea

Bioslurry extension

Bioslurry extension activities are outsourced to the Department of Agriculture Extension (DAE). The following activities have been undertaken:

- Activity 1. Development of extension materials;
- Activity 2. Training; and
- Activity 3. Demonstration.

The following demonstrations were conducted:

- Slurry compost preparation and preservation;
- IPNS;
- Home garden management.

- Activity 4: Farmers' Field Day on Bioslurry Management and Utilization.

Linking bioslurry and energy

Bioslurry is a source of energy for soil micro-organisms to break down complex organic materials and release nutrients into the soil.

Use of bioslurry as organic manure or fertilizer saves a considerable amount of inorganic fertilizers and thereby saves on exploitation of natural resources for the production of fertilizer. It also saves on required for the production of inorganic fertilizers and natural resources like methane for the production of energy.

Table 7. Effect of different nutrient packages on the yield and MBCR of cabbage and cauliflower

Treatment	Cabbage		Cauliflower	
	Head yield (tonnes/ hectare)	MBCR	Curd yield (tonnes/ hectare)	MBCR
T_1: STB inorganic fertilizer	83.9c	24.83	41.9d	13.76
T_2 : IPNS with 5 tonnes/hectare cowdung	87.2bc	31.01	47.5cd	21.35
T_3 : IPNS with 5 tonnes/hectare cowdung slurry	96.1ab	16.83	54.1ab	11.03
T_4 : IPNS with 3 tonnes/hectare poultry manure	88.5bc	34.53	49.7bc	25.44
T_5 : IPNS with 3 tonnes/hectare poultry manure slurry	98.3a	20.51	56.8a	14.32
T_6 : Natural fertility	21.4d	-	15.4e	-

Table 8. Effect of nutrient management practices on various crops

Treatment	Cabbage	Cauliflower	Brinjal	Tomato	Maize	Wheat	Mustard	Rice[1]	Jute
	Yield (tonnes/hectare)								
Inorganic fertilizers	91.4	39.2	57.2	87.9	7.7	3.2	1.2	6.8	2.7
IPNS with manure	92.8	44.6	84.9	95.0	8.0	3.5	1.2	6.9	2.7
IPNS with bioslurry	106.3	47.3	108.9	104.6	9.0	3.8	1.3	7.5	2.8
Farmers' practice	78.8	37.4	49.9	77.8	7.6	3.1	1.0	6.2	2.6

- Bangladesh has potential (in terms of input sources) of establishing 3 million domestic biogas plants;
- 1 plant (size 2.4 m^3) produces 6 tonnes of dry bioslurry annually;
- Bangladesh can produces 18 million tonnes of dry bioslurry annually;
- 18 million tonnes of dry bioslurry can supply nutrients equivalent to 0.57 million tonnes of urea, 0.61 million tonnes of TSP, 0.12 million tonnes of MoP and 0.33 million tonnes of gypsum annually;
- Producing 0.57 million tonnes of urea in factories requires 19 380 mmcf CH_4;
- 19 380 mmcf CH_4 gas can generate 200-220 MW;
- 18 million tonnes of dry bioslurry can save US$643 million annually on the cost of fertilizers (non-subsidized basis);
- If a Bangladeshi farm household has a biodigester (2.4 m^3) it can save US$148 by using bioslurry.

The use of bioslurry can save draught power and energy for land preparation by decreasing the soil bulk density.

Bioslurry needs energy via sun-drying or mechanical/electrical driers. Sun-drying is not advisable because of loss of quality, such as loss of nitrogen.

Bioslurry as organic manure or organic fertilizer needs energy for transport to remote locations.

Future needs

Research

Further research needs to be conducted on:

- Bioslurry quality;
- Mineralization and nutrient-release patterns;
- Residual value;
- Storage;
- Energy needs for transportation and drying;
- Use of bioslurry as fish and animal feed;
- Standardization of liquid bioslurry for use in crop and fish culture; and
- Exploration of the commercial potential for using bioslurry as organic fertilizer.

Extension

Strengthen extension (public, NGO and private) activities to increase the capacity building of biogas plant owners and bioslurry users in relation to proper bioslurry management and utilization.

Conclusion

Bioslurry is important for maintaining soil health and thereby increasing crop yield. It has salient environmental traits as it draws heavily upon by-products of biogas production that otherwise would largely remain unused. Bioslurry can mitigate the use of natural resources and energy and represent a source of income for farm households. Bioslurry needs energy for drying and transportation. The use of bioslurry in Asia is still at a nascent stage and different aspects of its values still need further investigation.

Biochar potential for Asia and the Pacific

Yoshiyuki Shinogi[1]

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Introduction

Biochar is a carbon product obtained from biomass. Wood-char has been widely used as a solid fuel worldwide, and for many other purposes in Japan, mainly for soil amendment and as a humidity control resource and as an ornament in houses. Recently, biochar has been used as a stable carbon sink in farm fields. However, there is little solid evidence that it is a stable, long-lasting carbon sequester. This needs rectification to allow it to reach its full potential. In Southeast Asia, the possibility for viable biomass production is considerable, but this has yet to be fully realized. Promotion in this context is necessary for sustainable agricultural production and rural development.

The nature of biochar

Characteristics

Biochar is light and highly absorbent. During pyrolysis, reduction of weight and volume, noxious odours such as ammonium fumes and dioxin emissions occurs in greater volume compared to usual incineration, depending on the feed material and manufacturing conditions, such as, temperature and furnace conditions.

Wood-char is reported to contain potassium, which is an essential nutrient for crops; some kinds of biochar, mainly from cattle waste and sewage sludge, contain nutrients. Shingyoji et al. (2009) reported that citric phosphorus and potassium are contained in biochar from sewage and cattle waste(sludge); thus, it can replace or reduce chemical fertilizer applications on farmland.

Use

Application of biochar can improve the soil's physical and mechanical properties such as water-holding capacity, hydraulic conductivity, and soil compaction. Thus, we can expect to improve root zone conditions not only for crops, but also, for microorganisms in adjacent crop root zones.

It can also be used as an effective deodorant to absorb various noxious odors, such as; ammonium fumes from livestock manure and for moisture control in humid areas.

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Carbon sequestration

Biochar, mainly wood-char, has been employed in Japan since ancient times. Evidence of this has been found at archeological sites and in historical records. It is believed that under certain conditions it does not decompose easily; consequently, it provides long lasting benefits. However, there are currently no precise methods for analyzing carbon that does not decompose easily.

Pyrolysis during biochar production fixes carbon; therefore, biochar can act as a stable carbon sink on farmland. It improves the productivity of the farmland as it facilitates the absorption of CO2 by crops from the atmosphere through photosynthesis. We can expect more CO2 to be absorbed by plants that grow in fields applied with biochar. Recent research indicates that it can be considered a stable and effective carbon sink.

However energy is needed to produce biochar, so how can carbon can be sequestered in a stable and sustainably manor, with little or no energy input, is a major issue to be addressed.

Carbon sequestration programmes in Japan

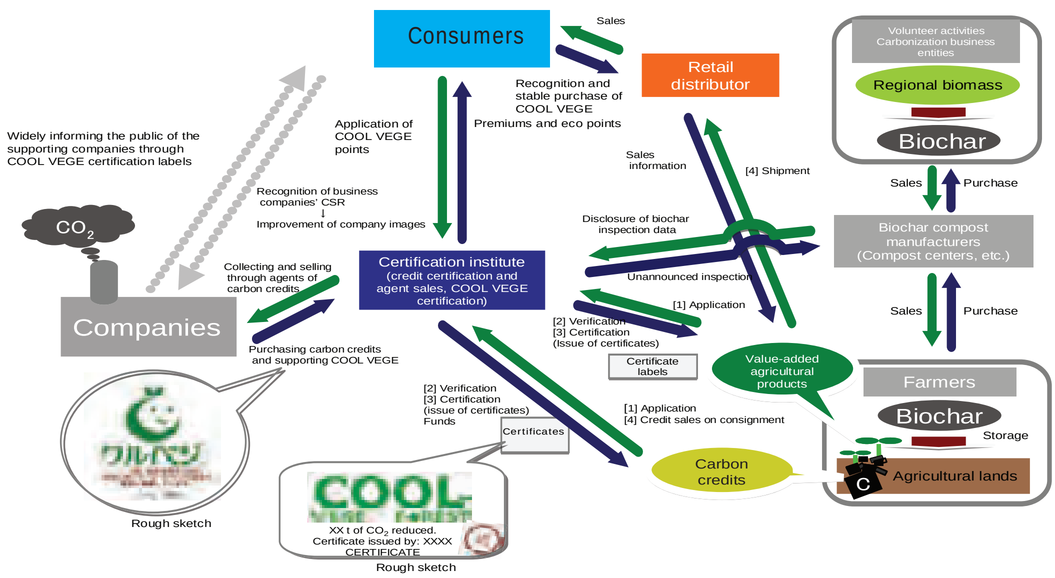
The Ministry of Agriculture, Forestry and Fisheries in Japan has launched carbon sequestration programmes from 2009 for three years. Sixteen programmes have been approved nationwide. Six programmes deal with carbon products such as biochar, namely Aomori, Akiruno (Tokyo), Hozu (Kyoto), Higashiomi (Shiga), Kochi, and Miyako (Okinawa).

Figure 1 illustrates an innovative example of carbon stably sequestrated by applying biochar in fields according to a standard, and selling them as certified carbon minus vegetables to revitalize a local economy.

This certified vegetable is sold under the trade marked name 'Cool Vege', and is accompanied by a 'Cool Vege' certification label. Participating private companies provide funding as a means to promote their Corporate Social Responsibility (CSR) activities, and in return receive feedback from Cool Vege customers that have purchased those products. The farmers who applied biochar to their fields also benefit through subsidies from the private fund. This programme has been extended to other regions and to other companies. This is the first programme in which biochar use has been activated to support rural regions.

The most important task is acquiring official certification. In this context The Japan Biochar Association (JBA) has been striving to achieve biochar certification, biochar inputs, and product quality. Environmental education is also included in this programme. Farmers' associations invite elementary schools to send pupils to participate in farming activities, such as, treading wheat in winter. Environmental conservation is thus promoted, and the children enjoy the activity as well.

Figure 1. The Carbon Minus Project at Hozu (Kyoto)



Source: McGreevy and Shibata (2010)

Conclusion

Much remains to be done for biochar to be approved as a sustainable carbon sink by the international community, so further research is required to support stability, standardization, and quality.

In September 2011 the Asia and the Pacific Biochar Conference was held in Kyoto, organized by the JBA. In-depth discussion and information was exchanged, and it is hoped that future exchanges will promote consolidation of biochar research and its use on a global scale.

Acknowledgement

The author gives special appreciation to Dr. Akira Shibara (Ritsumeikan University, Kyoto, Japan) and Dr. Michael Hall (Kyushu University, Fukuoka, Japan) for information and assistance in writing this article.

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SECTION V: ANNEXES

Annex 1

Programme - Sustainable Bioenergy Symposium: Improving resilience to high food prices and climate change

June 2, 2011

Renewable Energy Asia 2011, BITEC, Bang Na.

Objective

The objectives of the Symposium are:

a. To share experiences with initiatives around the region designed to improve the sustainability of regional bioenergy production;

b. To identify suitable technologies and strategies to foster more sustainable and effective bioenergy systems in Asia; and

c. To create opportunities for more effective future collaboration in the development of sustainable bioenergy technologies and policies.

Participants

The Symposium will include presentations from over 35 technical and policy experts from the Asian bioenergy sector. The Symposium is open to all registered participants at Renewable Energy Asia 2011.

Theme and format

The theme for the symposium is 'Improving resilience to high food prices and climate change'. As part of the program the organizers will showcase a number of emerging approaches to ensure that bioenergy developments in Asia avoid conflicts with food security and deliver on their potential benefits for rural development, the environment and the climate. By combining the Symposium with the annual Renewable Energy Asia event, FAO is looking to create a unique forum for government representatives, the development community and the private renewable energy sector to identify ways to provide more sustainable and effective bioenergy systems and policies in Asia.

The Symposium will be organized into five sessions to encourage more focused discussion on issues related to the central theme. As some sessions will be convened simultaneously, participants are encouraged to identify sessions where they feel their particular knowledge and expertise will be most relevant to the discussions. However, it will be possible to also float between sessions depending on where each individual participant's interests lie.

The Symposium sessions are:

Session 1:	Opening and Keynote address
Session 2:	Plenary session on 'Ensuring bioenergy is not a threat to food security and the climate in Asia'
Session 3:	Group session on 'Sustainable bioenergy feedstock production in Asia'
Session 4:	Group session on 'Expanding the reach of sustainable rural bioenergy solutions in Asia'
Session 5:	Group session on 'Climate friendly bioenergy'

Final Programme

Time	Item and Speaker / Organization
Session 1	**Welcome**
09:00 – 09:10	Welcome Address – Mr. Hiroyuki Konuma, FAO Regional Representative for Asia and the Pacific and Assistant Director-General, FAO RAP
09:10 – 09:20	Welcome Address – Dr. Bundit Fungtammasan, JGSEE
09:20 – 09:40	Bioenergy outlook in Asia and the FAO integrated approach/tool on bioenergy and food security by Mr. Beau Damen, FAO Asia Pacific
09:40 – 10:00	A regional framework for bioenergy and food security in Southeast Asia and East Asia by Ms. Pouchamarn Wongsanga, ASEAN Secretariat
10:00 – 10: 30	Coffee Break
Session 2	**Panel debate**
10:30 – 11:30	**Topic: Ensuring bioenergy is not a threat to food security and the climate in Asia** **Moderator: Mr. Beau Damen, FAO** **Speakers discuss topic for 10-15 minutes followed by questions from the moderator and the audience.** **Possible selection of speaker topics:** The potential of bioenergy to benefit the environment and food production systems by Dr. Boonrod Sajjakulnukit, JGSEE Small-scale bioenergy systems: Finding a local way to generate energy, strengthen communities and benefit the environment by Mr. Bastiaan Teune, SNV Linking bioenergy, natural resource management and climate change by Dr. Sitanon Jesdapipat, SEA START

	Investigating the links between bioenergy and food security by Professor Sudip Rakshit, Asian Institute of Technology
11:30 – 12:00	Question and answer session by Panel Speakers
12:00 – 13:00	Lunch
Session 3	**Parallel breakout sessions** **Topic 1: Bioenergy & food security: Using our resources more sustainably** **Moderator: Ms. Delgermaa Chuluunbatar, FAO**
13:00 – 13:30	Integrated food and energy systems: A local way to improve food security by Ms. Delgermaa Chuluunbatar, FAO
13:30 – 14:00	Tropical agriculture and bioenergy in Asia by Mr. Rod Lefroy, International Centre for Tropical Agriculture (CIAT)
14:00 – 14:30	Biofuels and consumptive water use by Mr. Upali Amarasinghe, International Water Management Institute
14:30 – 15:00	Coffee break
	Breakout Group Panel Session
15:00 – 16:00	**Topic: Sustainable bioenergy feedstock production – examples from the region** **Moderator: Ms. Delgermaa Chuluunbatar, FAO** **Speakers discuss topic for 10-15 minutes followed by questions from the moderator and the audience.** **Selection of speaker topics:** Increasing cassava productivity for food and bioenergy production on small-holder farms by Thailand National Science and Technology Development Agency by Dr. Kuakoon Piyachomkwan, NSTDA Sustainable palm oil initiative in Thailand by Mr. Daniel May, GIZ Profitability of Social Investing – a case study in sustainable Jatropha production in Vietnam by Mr. Jamey Hadden, Green Energy Vietnam An assessment of different bioenergy feedstocks in Thailand by Dr. Suthiporn Chirapanda, Thai Tapioca Development Institute Sweet sorghum: A better feedstock for bioenergy in Asia? by Mr. Shi Zhong Li, Tsinghua University Technical and economic prospects of rice residues (husks and straw) for energy in Asia by Dr. Werner Siemers, CUTEC Institute
16:00 – 16:30	Question and answer session by Panel Speakers Session End
Session 4	**Topic 2: Expanding the reach of sustainable rural bioenergy solutions in Asia** **Moderator: Mr. Sverre Tvinnereim, FAO**
13:00 – 13:30	Enhancing the use of bioenergy to enrich rural livelihoods: Examples from Asia by Mr. Sverre Tvinnereim, FAO
13:30 – 14:00	A good start: Energy needs assessments for rural bioenergy projects by Dr. Kanchana Sethanan, Khon Kaen University
14:00 – 14:30	Making energy services work for the poor in Asia by Mr. Thiyagarajan Velumail, UNDP Regional Centre, Asia-Pacific
14:30 – 15:00	Coffee break
	Breakout Group Panel Session

15:00 – 16:00	**Topic: How to make more effective policies and financing arrangements for rural bioenergy** **Moderator: Mr. Sverre Tvinnereim, FAO** **Speakers discuss topic for 10-15 minutes followed by questions from the moderator and the audience.** **Selection of speaker topics:** Challenges and opportunities for financing rural bioenergy projects: Examples from Lao PDR by Ms. Aurelie Phimmasone, Lao Institute of Renewable Energy Potential for social indicators to guide bioenergy policies by Dr. Sittha Sukkasi, NSTDA Developing small-scale, environmentally sustainable bioenergy technologies in Myanmar by Mr. Htun Naing Aung, KKS Developing opportunities for public private partnerships in rural bioenergy by Eco-Asia by Mr. Suneel Parasnis, Eco-Asia Possibilities for using microfinance for farm/household level bioenergy technologies by Dr. Riaz Kahn, AIT Yunus Centre
16:00 – 16:30	Question and answer session by Panel Speakers Session End
Session 5	**Topic 3: Climate friendly bioenergy** **Moderator: Mr. Beau Damen, FAO**
13:00 – 13:30	Climate friendly bioenergy and food security in the Greater Mekong Sub-region by Ms. Sununtar Setboonsarng, Asia Development Bank
13:30 – 14:00	Current status and prospect of biofuels in Thailand by Professor Shabbir Gheewala, Joint Graduate School of Energy and Environment
14:00 – 14:30	Integrating Feed-in-Tariff Policy into a PoA: Case Study from Thailand by Mr. Ingo Puhl, South-Pole Carbon
14:30 – 15:00	Coffee break **Breakout Group Panel Session**
15:00 – 16:00	**Topic: Innovative, climate friendly bioenergy** **Moderator: Mr. Beau Damen, FAO** **Speakers discuss topic for 10-15 minutes followed by questions from the moderator and the audience.** **Selection of speaker topics:** Linking bioenergy, bioslurry and composting by Dr. Fokhrul Islam, SNV Zero Waste Concept in Cassava Starch Industry: Implementation of biogas technology and Improvement of production process efficiency by Dr. Warinthorn Songkasiri, NSTDA Biogenious Waste to Biogas – Challanges and Solutions by Dr. Gert Morscheck, Rostock University Potential for biochar from bioenergy in Asia and the Pacific by Dr. Shinogi Yoshiyuki, International Biochar Institute Accessing carbon markets with small-scale biogas technologies by Mr. Oliver Lefebvre, ID China
16:00 – 16:30	Question and answer session by Panel Speakers Session End

Patterns in the use of bioenergy have been a key indicator of changing fortunes in Asia. Formerly the key source of energy for the region's largely agrarian societies, rapid economic development over the past 50 years has resulted in a significant decline in bioenergy's share of total primary energy and replacement with fossil energy. This transition has opened up even further opportunities for development and change.

Despite the overall trend toward fossil energy in the region, high fossil energy prices and a growing need for more environmentally sustainable energy sources have encouraged many governments in the region to adopt policies to support the development of modern bioenergy sectors. But, the recent resurgence of agricultural commodity prices in the region has given renewed cause to question whether a sustainable expansion of biomass feedstock to satisfy both the regional energy needs of growing economies and food requirements of growing populations is, in fact, possible. The region's capacity to produce increased biomass resources for food and fuel over the long-term will be further complicated by the anticipated impacts of climate change.

This publication documents recent experience with sustainable bioenergy in Asia. It highlights a number of approaches to strengthen the resilience of the region's biomass production systems, improve the contribution of bioenergy to rural development and avoid harmful trade-offs.

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