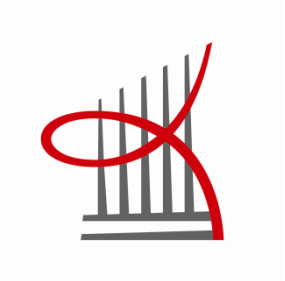

HOUSEHOLD BIOGAS DIGESTER IN RURAL ENERGY PRODUCTION

Case comparison in Cambodia, Ethiopia and Lao People's Democratic Republic

Heikki Lindfors

Bachelor's Thesis
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Degree Programme in Environmental Engineering
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ABSTRACT

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LINDFORS, HEIKKI: Household Biodigester in Rural Energy Production. Case Comparison in Cambodia, Ethiopia and Lao People's Democratic Republic

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The demand for energy is increasing globally. People of developed countries usually see the situation as future shortage of electricity and oil, but this is not the case everywhere; according to UN about 1,6 billion people live out of reach of electricity network. For these people, biomass is often the only energy resource for cooking and lightning. This has led to forest loss in many regions. Still, also these people demand energy in future; staple foods, like grains, are boiled, fried or cooked in an oven. These staple foods are essential source of nutrition for majority of world's people.

In this work the biogas digester programme of SNV (Netherlands Development Organization), and its role in energy production of Cambodia, Ethiopia and Laos, is evaluated. Biogas digester requires 20 kg (droppings of four cows) of fresh dung daily to operate. If this input is available, biogas digester provides cooking and lightning energy, as well as nutrition-rich slurry which can be used as fertilizer in farming activities. The digester reduces the need for fuel wood, candles, kerosene and similar energy sources which are used commonly in off-grid areas. However, it should be noted, that in many cases the digester is not sufficient as the sole energy source for a household. Some cooking methods require use of wood. Even though if household is not able to completely replace its use of fuel wood, the need for wood is significantly reduced, and money and workload is reduced, as less wood needs to be purchased or collected.

I found out that the digester plant is very beneficial for the user, saving money, due less fuels and fertilizer are needed to support household and farming activities. I found out no major reservations towards the technology. However, lack of promotion of such technology is major obstacle for further expansion of the programme. The plant is easy to operate, it saves time and effort, and as most SNV biodigester users live in rural areas, they are able to apply the bio-slurry as a fertilizer, or sell it to another farmer. The price for plant is around $500, depending on area. SNV provides subsidy for the investment, leading to reduced price. In some areas micro-credit system is available for biogas digesters. If people choose to fund the investment by loan, the reduced need for fuel wood creates so much saving for users, that generally people are able to pay back the investment within 1-2 years.

Key words: biogas, development, renewable energy

TIIVISTELMÄ

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Environmental Engineering

LINDFORS, HEIKKI: Kotitalouksien biokaasulaitos maaseudun energiantuotannossa – vertaileva tapaustutkimus Kambodžassa, Ethiopiassa ja Laosissa

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Energian tarve kasvaa kaikkialla maailmassa. Kehittyneissä maissa tämä energiantarpeen kasvu mielletään sähkön- ja öljyn tarpeen lisääntymiseksi, mutta tämä ei ole koko totuus; YK: n mukaan noin 1,6 miljardia ihmistä elää ilman sähköä. Näille ihmisille biomassa on usein ainoa energian lähde ruoanlaittoon ja valaistukseen. Tämä on monilla alueilla johtanut metsien häviämiseen. Kuitenkin kaikki ihmiset tarvitsevat energiaa; kuivat ruoka-aineet (kuten viljat) valmistetaan keittämällä, uunissa ja paistamalla. Nämä ruoka-aineet ovat vättämättömiä suurimmalle osalle maailman väestöstä.

Tässä työssä kasitellään SNV:n (Alankomaiden kehitysyhteistyöjärjestö) biokaasulaitosten roolia Etiopian, Kambozhan ja Laosin energiahuollossa. Biokaasulaitos tarvitsee toimiakseen 20 kg lantaa, eli vaikkapa neljän lehmän ulosteet. Jos tämä määrä on saatavilla, tuottaa biokaasulaitos energiaa ruoanlaittoon ja valaistukseen, sekä ravinteikasta lietettä jota voidaan käyttää lannoitteena. Tämä vähentää tarvetta polttopuuhun, kynttilöihin, kerosiiniin ym. sähköverkon ulkopuolella käytettäviin energianlähteisiin. Pitää tosin ottaa huomioon, että monissa tapauksissa biokaasu ei riitä ainoaksi ruokakunnan energianlähteeksi. Jotkin ruoanvalmistustavat tarvitsevat polttoaineeksi puuta. Vaikka biokaasu ei välttämättä korvaa täysin polttopuuta energianlähteenä, se kuitenkin korvaa puun tarpeesta huomattavan osan ja vähentää sekä aikaa että rahaa, mitä ruokakunta tarvitsi energiantarpeensa tyydyttämiseen ennen biokaasulaitoksen rakentamista.

Työn tuloksista päättelen laitos on erittäin hyödyllinen käyttäjälle. Rahaa säästyy polttoaineiden ja lannoitteen tarpeen vähetessä. Käyttäjien keskuudessa en havainnut mitään varauksellisuutta teknologiaa vastaan. Mutta tietoisuus teknologiasta on heikkoa ja tämä rajoittaa teknologian leviämistä tulevaisuudessa. Laitos on suhteelisen helppokäyttöinen, se säästää aikaa ja rahaa, ja koska useimmat biokaasulaitosten käyttäjät asuvat maaseudulla, he käyttävät myös laitoksesta saatavaa lietettä lannoitteena, tai myyvät sen lannoitteeksi viljelijöille. Laitos maksaa noin 500 Yhdysvaltain dollaria, alueesta riippuen. Monille kehitysmaassa asuvalle tämä on korkea hinta, mutta joka maassa on jonkin verran hieman varakkaampia viljelijöitä jotka voivat tämän hinnan maksaa. SNV tarjoaa investoinnille tukea, jolloin hinta laskee hieman. Joillain alueilla on lisäksi saatavilla mikrolainoja investointiin. Jos lainaa otetaan rakentamista varten, laitos tuottaa sen verran säästöjä, että investointi maksaa yleensä itsensä takaisin 1-2 vuoden aikana.

Avainsanat: biokaasu, kehitysyhteistyö, uusiutuva energia

Foreword

This thesis was done while I was participating in Finland Futures Research Centre projects ”Why Renewable Energy Projects Fail or Succeed? Design and Implementation of Energy Assistance Projects in Cambodia and Lao PDR” (DREAM) as well as “Knowledge for development: Creating rural resource database for sustainable livelihoods in Cambodia and Laos” (SURVEY), funded by the Academy of Finland. More information on these projects can be found at the internet at: www.mekong.fi and www.ffrc.utu.fi

I got more hands-on approach to biogas technology when I was doing my internship with Lem Ethiopia in Bahir Dar in July-September 2010. In this internship I was involved with construction of a biogas toilet solution for the new marketplace of Bahir Dar, coordinated by Lem Ethiopia and Kestävä Tulevaisuus ry, and funded by the foreign ministry of Finland.

This work was supervised by head of Environmental Engineering study programme, Mrs. Eeva-Liisa Viskari.

Acknowledgements

My thesis process started at Finnish Future’s Research Centre, where I was given the task as well as motivation to study household biogas energy. I want to thank FFRC researchers Hanna Kaisti and Mira Käkönen for guidance for better understanding biogas technology in developing countries’ energy production, and Mika Korkeakoski for his advice how to conduct academic research effectively in a developing country. I also want to thank TAMK SAWE 2 –project manager Aino-Maija Kyykoski for giving me the opportunity to continue my research in more practical way in Bahir Dar, Ethiopia. In Ethiopia I got invaluable help from Mikyas Getnet, Dessalew Asmare, and Girma Menelik. And finally I want to thank Eeva-Liisa Viskari for giving the guidance in the thesis writing process methodology, and for helping me finalize this long project.

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Acronyms

$ (or USD)	US dollar
ABPP	Africa Biogas Partnership Programme
ASEAN	Association of Southeast Asian Nations
Birr (abbr. ETB)	Currency of Ethiopia. ($1 ≈ 17 ETB)
CDM	Clean Development Mechanism
CIA	Central Intelligence Agency
ESMAP	Sector Management Assistance Program
FFRC	Finnish Futures Research Centre
GDP	Gross Domestic Product
Kip (abbr. LAK)	Currency of Laos. ($1 ≈ 8000 LAK)
Lao PDR	Lao People's Democratic Republic
LIRE	Lao Institute for Renewable Energy
MDG	Millennium Development Goal
NGO	Non-governmental organization
Riel (abbr. KHR)	Currency of Cambodia. ($1 ≈ 4100 KHR)
UK	United Kingdom
UN	United Nations
UNDP	United Nations Development Programme
US	United States
SNNP	Southern Nations, Nationalities and the People's Region (Ethiopia)
SNV	Stichting Nederlandse Vrijwilligers (Foundation of Netherlands Volunteers), Netherlands Development Organization
WB	World Bank

1. Aim of the work and background information

Personal motivation

My personal motivation to study this topic came from my interest in developing projects and other cultures. While doing my practical training in Finland Futures Research Centre, I was proposed the topic, and soon I came to realize how I can apply my knowledge about renewable energy, energy politics, environmental politics, sanitation, and development aid to the some of the very poorest people in this world, all under one topic. The biodigester seemed to me to be a good solution to energy issue of some people who live outside the electricity grid and its benefits, with minimum harmful impacts. When I continued my internship in Ethiopia with Lem Ethiopia I got more hands-on approach to biogas digesters, and learned some good practices in the production and usage. From experts, masons and users I learned also the technical difficulties, limitations and other problems related to biodigesters.

After this practical work I still strongly feel that biogas technology is beneficial in both urban and rural energy production in developing countries, despite its limitations and difficulties in construction. I hope that my work can work as a guideline for any technical or cultural perspectives for anyone, whose work is related to biodigesters.

Research questions

The aim of this work was to research following questions in the case study countries.

How the SNV operates, and how is the SNV biodigester programme funded?

SNV biogas programme has been well received where it has been implemented so far. As a development programme, SNV biogas programme can be considered successful, in both user and expert opinion. Operational model of SNV is evaluated in general, and more precise information of funding model is investigated in this work.

Biogas technology in socio-cultural context: which different benefits people in different countries want? What are the main differences of case study countries in their socio-cultural context? Which kind of socio-cultural limitations have the programme encountered in case study countries?

The digester has many advantages, and people in different regions are interested in different things. Also, people in different areas have different reservations, regarding, for example, using humanure and dung for cooking energy and agriculture.

Who are the potential customers for biogas technology?

Areas, where the fuel wood is scarce, people have interest in alternative energy sources. However, biogas digester is a major investment, and not all can afford it. Who are the potential customers for this technology in case study countries? How the technology be made available to more people in the future?

How biogas compares as an energy source to other energy sources and how it serves the needs of rural people in on- and off-grid areas compared to fuel wood and grid electricity?

Biogas is remarkably different from fuel wood and grid electricity as an energy source. How the biogas serves the energy demand of the people? Is it effective enough to serve all energy needs of a household?

How have people received the biogas technology?

What are users' opinions on the plant? How has biogas technology changed their lives since their plant was installed? Have the time and money use changed since installing the digester plant?

1.1 Introduction to Cambodian, Ethiopian and Lao societies: historical, political, economic, and social context

The Kingdom of Cambodia and Lao People's Democratic Republic are Southeast Asian countries. The capital of Laos is Vientiane, and the capital of Cambodia is Phnom Penh. Ethiopia is a landlocked East African country. The capital of Ethiopia is Addis Abeba.

Table 1: Basic information on the case study countries (source: CIA 2010)

Full name of the country and flag	**Kingdom of Cambodia** 	**Federal Democratic Republic of Ethiopia** 	**Lao People's Democratic Republic** 
Capital	Phnom Penh	Addis Abeba	Vientiane
Population	14,5 million	88 million	6,8 million
Urban population	22 %	17 %	31 %
GDP	$30,2 billion (108th in the world)	$86,1 billion (76th)	$15,7 billion (135th)
GDP/capita	$2100 (189th)	$1000 (213rd)	$2500 (176th)
GDP composition per sector	Agriculture: 33% Industry: 22% Services: 45%	Agriculture: 43% Industry:14% Services: 43%	Agriculture: 30% Industry:32% Services: 38%
Major exports	clothing, timber, rubber, rice, fish, tobacco, footwear	coffee, khat, gold, leather products, live animals, oilseeds	timber, coffee, electricity, copper, gold,
HDI	0,593 (137th)	0,328 (157th)	0,619 (133rd)
Population below poverty line	31 %	39 %	26 %

1.1.1 Recent history

1.1.1.1 Cambodia

In years 1975-1979, a communist government, known as "Khmer Rouge" ruled the country, led by Pol Pot. During his regime, it is estimated that 1,7 million Cambodians died from executions, starvation or forced hardships, about quarter of population in that time. The current generation is somewhat oblivious about Khmer Rouge era; Cambodia's population is notably young, and the history of Pol Pot's regime hasn't been taught in schools. This is about to change, however, as in 2009 Cambodian Education Ministry included a book called "A History of Democratic Kampuchea" in the study plan, describing the time of the regime. The trials of the high-ranking officers of the Khmer Rouge (excluding Pol Pot himself, who died in 1998) are currently underway. An UN-Cambodian tribunal acts as a court for crimes against humanity by some members of Khmer Rouge. (Hun Sen, et al. 2004; Washington Post, 2007)

1.1.1.2 Lao People's Democratic Republic

Since 1954 Lao PDR has been independent from the French rule. The royal government became the governing body in the country. However, during the 1950's and 60's conflicts were disturbing the country, as Laotian communists were in collaboration with North Vietnamese communist forces, and thus the country was a part in US involvement in southeast Asia during 1960's, even though the happenings in Laos were considered a sideshow to that what was happening in Vietnam.

A cease-fire agreement in Paris in 1973 ended the hostilities with US, and in February of that year a coalition government was elected. This government came to be somewhat short-lived; following the Vietnamese communist takeover in Saigon and Cambodian communist takeover in Phnom Penh, a bloodless communist coup took place in Laos in mid-1975. The Lao People's Democratic Republic was established in December 1975, ending 600-year monarchist regime. The new communist regime had close ties with

Vietnamese communist party, and the countries had similar interests in policy until late 1980's. In 1986, the Lao government established New Economics Mechanism, their own version of similar economic reform program that was happening in the Soviet Union at the time. After the collapse of communist power in Soviet Union and Eastern Europe the country moved towards liberating its economy further, this led to new constitution in 1991. This provided more economic and political freedom to the Lao citizens.

By mid-1990's significant economic growth was experienced in the country. Foreign aid was received from Japan, Western Europe and Australia, and Vietnam, as well as international organizations such as World Bank and International Monetary Fund. In 1997 Laos became a full member of ASEAN. Until date, the government of Lao PDR stays committed to ideas of Marxism and Leninism, and this brings it close to ideological neighbors Vietnam and China, while some Laotians who pursue deeper economic freedom wish more close ties toward Thailand and the West. (Encyclopædia Britannica, Laos, 2011)

1.1.1.3 Federal Democratic Republic of Ethiopia

During colonial periods Ethiopian monarchy held it's independency from European powers, except short occupation by Italian forces between 1936 and 1941. Emperor Haile Selassie ruled the country from 1930 until, when he was overthrown by a socialist military junta called the Derg. This was followed by a long period of bloody coups and uprisings, famine caused by drought and massive refugee problems. In 1991 Ethiopian People's Revolutionary Democratic Front (EPRDF) overthrew the socialist regime. Constitution was instituted in and first multiparty elections were held in 1995. (CIA, 2010)

Since 1990's, Ethiopia has had border disputes with Eritrea. Full-scale war raged until 2000, when a peace treaty was signed. In 2007 Eritrea-Ethiopia Border Commission demarcated the border, but the demarcation on ground is currently on hold, because Ethiopia's objection to international commission's decision to surrender territory to Eritrea. (CIA, 2010)

1.1.2 Social development

Population of Cambodia is currently 14 494 293 people (June 2009 est.). In Laos, there are 6 834 345 people total.

31 per cent of the population lives in urban areas in Laos. This number is even lower in Cambodia - 22 per cent. Also, the amount of people moving to urban areas is slightly higher in Laos; the annual growth of urban population is 5,6 per cent, compared to 4,6 per cent in Cambodia. (CIA, 2010) This is changing, driven by development of industrial jobs and escaping poverty in rural areas. Often the urban areas where the rural people migrate lacks proper infrastructure, and are economically degraded. (Beeson, 2004)

Large portion of people in Laos are ethnic minorities. There are more than 100 ethnic groups in the country, while the largest group (Lao), consist of 55% of the total population. In Cambodia, the ethnic demographic is more homogenous: 90% of Cambodian population identifies themselves as Khmer. (CIA, 2010)

In Ethiopia the total population is 88 013 491, and the population is growing 3,2% annually. Thus it is 7th largest country in the world and 3rd in Africa by population. It should be noted, however, that precise population estimates are difficult in Ethiopia due high mortality rates caused by AIDS. The AIDS causes high infant mortality rate, lower life expectancy, lowered population growth rate and changes in distribution of population by sex. Only 17% of the population live in urban areas. The urban population grows 4,3% annually. 46% of the people are 14 years old or younger. There are some 80 ethnic groups in the country, largest being Oromo (32,1%), Amara (30,1%), Tigraway (6,2%), Somali (5,9%), Guragie (4,3%), Sidama (3,5%) and Welaita (2,4%). Country is religiously diverse: there are people who follow christian, muslim, jewish and traditional religion, with little conflict between groups. (CIA, 2010)

1.1.3 Politics

Kingdom of Cambodia is a constitutional democracy, operated as parliamentary multi-party representative democracy. The parliament is elected in elections every five years, last time being in July 2008.

People's Democratic Republic of Lao the political system is communist, and other political parties are proscribed. The National Assembly (parliament) of Laos is elected every five years (last in April 2006). The National Assembly elects the president, who in turn appoints the ministers. The ministers are approved by National Assembly. Currently, the head of the state is President Lt. Gen. Choummali Saignason.

Federal Democratic Republic of Ethiopia is constitutional parliamentary multi-party representative democracy. The parliamentary elections are held every five years, last time being 23rd of May 2010. (CIA, 2010)

1.1.4 Economics

In 1989 the government of Laos agreed with World Bank and International Monetary Fund to start promoting private entrepreneurship, support foreign investors and privatize state ownership. This resulted in fast economic growth for two decades, averaging 6% per year in 1988-2008. Even the current economic crisis hasn't reduced this growth (6,4% in 2009), one of the reasons being the amount of electricity exported is growing, and the electricity has quite steady demand. The main exports of the country include wood, coffee, tin and electricity, and the main partners in both export and import are Thailand, Vietnam and China. (CIA, 2010)

The growth in past decade has been even more rapid in Cambodia; in 2004-2007 the GDP grew about 10% per annum, but the depression had significant negative impact to Cambodian economy, the GDP declined 0,9% in 2009. The garment industry is a significant, and it has suffered from rising competition from cheaper labor countries (China,

India) in past years. Other larger industries are construction, mining and tourism. Main export in the country are clothing, timber, rubber, rice, fish, tobacco and footwear and the most important export partners are US, Germany, Canada, UK and Vietnam. (CIA, 2010)

Majority of the population (78%) in Cambodia live in rural areas, and more than half of the population is under 21 years old, and lack education and vocational skills, and employing all these people in near future might be too great a challenge for private sector. (CIA, 2010)

In Ethiopia the GDP per capita is $1000 (2010 est.). Despite the growth compared to previous years and the forgiving of Ethiopia's national debt in December 2005, it is still amongst the lowest per capita income in the world. (CIA, 2010)

In Ethiopia the state owns all land and provides long-term leases to tenants. The agriculture dominates employment and exports. 45% of GDP comes from agricultural products, and 85% of people are employed by agricultural activities. Coffee production is critical to Ethiopian economy, accounting $350 million in 2006, but more and more former coffee farmers changing to khat production due low prices of coffee in global markets. Coffee production is further negatively impacted by frequent drought and border conflicts with Eritrea; the border with Eritrea remain closed to date. The largest export products include coffee, khat, gold, leather products, live animals and oilseeds. Major export partners are Germany, Saudi-Arabia, Netherlands, USA, Switzerland, Italy, China, Sudan and Japan. (CIA, 2010)

The drought impacted the economy of Ethiopia in 2002, resulting in 3,3% decline in GDP. The fluctuating prices of agricultural products and global economic depression caused problems in balancing the budget. International Monetary Fund forgave all Ethiopia's debt in 2005, and has since helped by emergency funding to reduce budget shortage. (CIA, 2010)

1.1.5 Corruption

Corruption is widespread in Cambodia, and has a major negative impact to economic growth. It is so deeply rooted in the society that people mostly feel that it is pointless to fight it. Most public servants collect bribes from their daily duties, and portion of them is passed up to their superiors to ensure the job safety and future advancement of job position. This applies to law enforcement sector also; it is common routine of police to demand payment for their duties, and illegal activities of the military officials are reported by foreign press. Military is often paid to ignore illegal logging activities. (Maclean, et al. 2006)

In Laos the corruption has become more serious in past years. The 2007 "Persistent corruption in low-income countries requires global action" –report by Transparency International states that Laos was a country "with a significant worsening in perceived levels of corruption". The Corruption Perceptions Index of Laos was 1,9 in 2007, while it was 3,3 in 2005 (higher is better). Some views of corruption were expressed in *1997-98 Vientiane Social Survey Project*: "an accident was caused by a drunken motorcyclist traveling at speed. However, he came out of it free and without police report at the police station where he was taken, thanks to his connections with-known and influential families." Of the people questioned in this survey, 71 percent confirmed that they have heard similar stories. Most common opinion amongst the people who answered the survey stated that egoism, covetousness or greed was the reason for corruption. (CRI, 1998; Transparency International 2005; Transparency International 2007)

Transparency Ethiopia published its Diagnostic Survey baseline study in the capital on march 2009. According to the survey, the public ranked corruption as fourth worst socio-economic problem in the capital, after cost of living, unemployment and housing. The public regarded that the management of kebeles (smallest administrative unit) is the least reliable governing authority in the country, followed by Quality and Standards Authority and Sport Federation, ranked 2nd and 3rd, respectively. As per survey findings, 55% of people conside3red that the corruption has gone worse in last two years. However,

people feel optimistic about the future; 59% of the respondents expect the level of corruption to go down in the next two years. (Transparency Ethiopia, 2009)

1.1.6 Poverty

Economically Laos and Cambodia are developing countries. The HDI rankings of the countries are medium (Laos 0.619, 133rd place. Cambodia 0.593, 137th place). (UNDP,2009) This has rapidly increased in past decade; in 2002 Laos was in 143th place, just above the very poorest sub-Saharan countries. (UNDP, 2002) The economic growth in Laos has reduced amount of people living in extreme poverty from 46% in 1992 to 26% in 2009. The country is on the UNDP's list of least developed countries, but according to World Bank it is possible that Laos graduates from this list by 2020. (CIA, 2010)

Laos' poverty reduction strategies are developed in co-operation with the government of Laos and foreign donors, with aim to turn traditional rural barter economy to modern market-driven agriculture business. Poverty and environmental degradation are linked closely. Very commonly the poverty is caused by loss of land, fisheries or forest resources or soil degradation. Rural livelihoods are fragile: if a farmer loses his or her crop because of flood, drought, plant disease or pests, usually he or she has to compensate the loss by selling land assets or animals to buy food for that season. These kinds of rapid changes can be devastating to rural households. Furthermore, dam development, mining, and plantation projects are likely to produce negative effects to rural people, and thus these sorts of projects and their social and environmental impact should be carefully assessed. There is no reason to rush these kinds of projects, as the demand for mining resources, cash crops and clean, affordable electricity is likely to remain strong. (Turunen, et al. 2010; International Rivers, 2008)

So called "cash crops" are usually proposed to replace lost livelihoods for those people whose livelihoods are affected by dam or mining development, but while cultivating them might be beneficial for some, they tend to bring risks and uncertainties to poorest. They often have to take loans to invest on fertilizers and seeds, and when growing only one type of crop, the farmers become vulnerable to market price changes. (International Rivers, 2008)

In Ethiopia 39% of people live below poverty line. The communist Derg regime (1974-1991) nationalized land, housing, farms and industry. Disturbed by their lack of ownership over land, the farmers became unmotivated to produce surplus foodstuff for market. Since that time, the rural living conditions have improved, but the land question remains as an obstacle for wider and faster development. Ethiopia is one of the poorest countries in sub-Saharan Africa. In 2001 IMF and WB implemented debt reliefs for Highly Indebted Poor Countries, to which Ethiopia was included. This released Ethiopia from all debt to IMF, WB and ADB. (CIA 2010; Encyclopædia Britannica, Ethiopia, 2011)

As agriculture provides 85% of all employment and 45% of GDP, the rural development is the most important factor on way out of poverty. Frequent droughts, poor cultivation practices, the land ownership issue as well as low world market price of such commodities as coffee trouble the income activities of rural population. The growth of GDP is currently high, but the per capita income is still amongst the lowest in the world. (CIA, 2010)

1.1.7 Geography

1.1.7.1 Cambodia

Picture 1: Map of Cambodia

Cambodia covers an area of 181 035 km2 of the Lower Mekong basin. It is bordered by Thailand on the north and west, Laos in the northeast and Vietnam in east and southeast. Its topographical profile varies by the region: the Gulf of Thailand coast is in the south, the Cardamom Mountains are located in the southwest, the Dangrek

Mountains in the north, a hilly plateau in the east and a central plain. The central plain is dominated by Tonle Sap ("Great Lake") Lake and the Mekong River and its tributaries. This geographical diversity creates richness in ecosystems, and gives suitability to grow a variety of crops. The Mekong river is second in biodiversity in terms of fish species, and the annual catch is larger than most of other river basins. (CDRI, 2008)

1.1.7.2 Laos

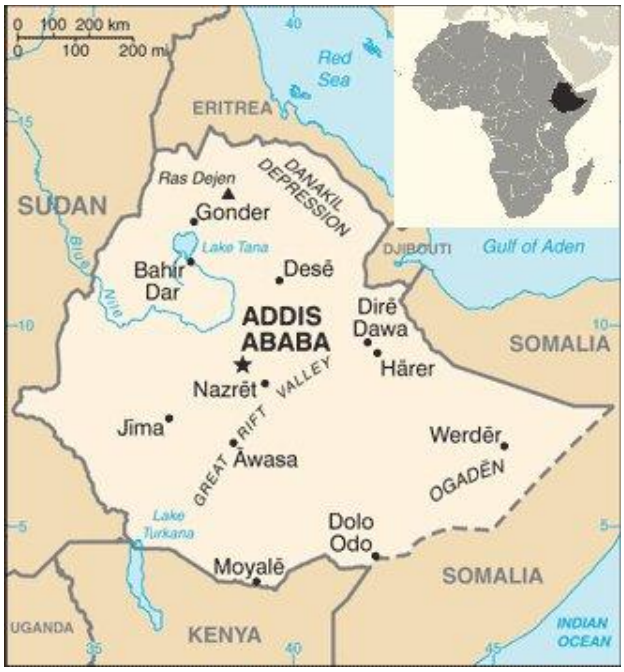
Picture 2: Map of Laos

Laos is a landlocked Southeast Asian country, bordered by China to the north, Vietnam to the northeast and east, by Cambodia to the south, by Thailand to the west and Myanmar (Burma) to the northwest. The topography is dominated by forest-covered mountain range of Annamese Cordillera, peaking at 2817m (Mount Bia). This mountainous landscape obstructs transportation all around the country and makes some areas inhospitable for habitation. Upland plateaus and lowland plains support agriculture especially rice production. Laos has tropical rainforests in the north and monsoon forests in the south. The varying landscape and forests support rich wildlife.

Mekong River dominates the drainage, running from China to northeast Laos, running along the country's border with Myanmar, and most of its border with Thailand. (Encyclopædia Britannica, Laos, 2011)

1.1.7.3 Ethiopia

Picture 3: Map of Ethiopia



Ethiopia is a landlocked east African country, bordered by Eritrea to the north, Djibouti to the northeast, Somalia to the east, Kenya to the south and Sudan to the west and northwest. The country can be divided to five dominant topographic features; the Western Highlands, the Western Lowlands, the Eastern Highlands, the Eastern Lowlands and the Rift Valley. The Western Highlands are dominated by mountainous topography, highest point being Ras Dashen (4533m), and the origin of the Blue Nile, Lake Tana, is located in the area, at elevation of about 1800 meters. Savanna is the dominant biome in Western Highlands. The Western Lowlands stretch from north to south along the border with Sudan. Around the elevation of 1000 meters the Western Lowlands are too hot for dense habitation. The Rift Valley is part of East African rift system, and consists of two parts: in the north the valley is very wide and topography is flat. The northern Rift Valley is hot and lacks water systems, making it unfriendly for habitation. The northern Rift Valley is dominated by desert biome. The southern Rift Valley on the other hand is located in higher elevation and contains many small rivers and lakes, and is one of the most productive and densely settled parts of Ethiopia. The Eastern Highlands are similar to Western Highlands, except being smaller, consisting mostly of savanna. The Eastern Lowlands roll down from narrow strip of Eastern Highlands towards Somalian border. (Encyclopædia Britannica, Ethiopia, 2011)

1.1.8 Land use issues

In rural areas of Cambodia resources like fuel wood and fresh water are common goods, free for anybody to exploit. Poor people tend to use these resources in sustainable way, collecting branches instead of cutting the whole tree down. But land ownership is often concentrated in hands of few people, and people who live or work on the land might not have ownership of it, and thus have little interest to manage the resources in sustainable way. (Beeson, 2004)

The US-Vietnam conflict in 1960's and early 1970 left amounts of unexploded bombs and mines remain in soil in Laos. In Cambodia, landmines are an issue with land-use in agricultural areas. (Beeson, 2004)

The food security is less problematic in Laos and Cambodia, compared to sub-Saharan Africa for example, but pressure to provide higher yields per area has pushed farmers to use additional fertilizers. (Beeson, 2004) The price of chemical fertilizers can be unexpectedly high: farmers might have to give away as much as 25% of their crop to pay for the fertilizers, and if the crop is ruined by plant disease, drought or flood, they still have to make the payment. In that case it happens often that the farmer has to sell livestock or land to make the payment for the fertilizer. Same might happen if the food crops are destroyed, and household has to buy food to cope; the land or livestock is sold. In such cases the payment is out of the rural people's future livelihood. It might happen also that the land is expropriated for mining, oil drilling or infrastructure building purposes. In these cases, the landowners might be compensated for their loss, but this compensation might come much later than promised or not come at all. (International Rivers 2008; Turunen et al. 2010)

In Ethiopia, the quality of land suitable for farming varies from region to region. The highlands, as well as plains and low foothills in west of the highlands are suitable for farming. Sandy desert soils in arid lowlands and in the Ogaden area allow only limited farming potential, due low rainfall. The soils in the Great Rift Valley allow farming activities if water is available. Soil erosion has been one of the country's major problems. Deforestation, overgrazing and practices such as cultivation on hillsides not suitable for farming have led to soil erosion, especially in Eritrea and Tigray regions. The farming

practices in highlands have not included conservation measures. In the dry lowlands high winds contribute to soil erosion. (Mongabay.com, 1991)

All land in Ethiopia is owned by the state, stated by the constitution in 1994. This has resulted in some food security issues, as the peasants do not own the land where they reside and farm. Ethiopia still faces the issue of self-sufficiency with food. (Mulatu, 1991)

1.1.9 Deforestation

The phase of deforestation in Cambodia is one of the fastest in the world. According to FAO, the country has 322 000 hectares of primary forest, and it has lost 29% of its primary forest between 2000 and 2005. Although the update of the report in 2010 showed that the rate of deforestation has dropped since 2005 by 22%, on average 126 400 hectares of forest was cut down per annum between 2005 and 2010. Currently, 59% of total land area is forest. There is legislation against logging, but it is widely ignored. (Butler, 2010 b; Beeson, 2004)

Laos doesn't suffer from deforestation as much as Cambodia, due more difficult terrain and poor condition of road system. The annual change in forest area was -0,6% between 2005 and 2010, which averages loss of 91 000 hectares of forest per annum. (Butler, 2010 a) In Laos logging and hydropower development are often related: harvesting occurs in planned reservoir areas for proposed dams. The aim of the government of Laos is to increase the forest area in the country from 40% to 70% by 2020. It should be noted though, that the increased forest area would not be native tree species, but instead fast-growing industrial varieties, like rubber tree, eucalyptus and acacia for paper production, and jatropha, sugarcane, oil palm and cassava for biofuel production. (International Rivers, 2008) Even though jatropha can be grown in degraded land also, it is sometimes grown in areas which would also be suitable for food production. (Kaisti, Käkönen, 2010 d) This kind of monoculture results in loss of biodiversity, habitat and species. Logging and intensifying of aquaculture have resulted in wide destruction of mangrove ecosystems, which in turn has resulted in reduction of fish in freshwater systems. Currently, 69% of total land area is forest. (Beeson 2004, Turunen et al. 2010)

Picture 4: Forest products in Oromia region, Ethiopia

The deforestation is continuous issue in Ethiopia, as forest area decreases every year due to firewood collection, conversion to farmland, overgrazing and using forest wood for building material. Between 1990 and 2010 the forest area has diminished by 141 000 hectares per annum. This will create difficulties in the future of the country, as the agriculture sector is depended on forest resources. Currently, 11% of total land area is forest. (Butler, 2010 a)

1.1.10 Mining and Oil

Laos' soil is rich with gold, copper, tin, gypsum and bauxite, and the economy relies strongly on these resources as exports. The gold and copper mines are in full production, and in 2007 60% of income from export came from gold and copper, while in 2004 this portion was only 10%. (CIA, 2010)

In 2005, oil deposits were discovered in a reservoir located under Cambodian national waters. Even small extra revenue from the oil would be a welcome boost to national economy. The income might be as high as $3-4 billion per year for the next 20 years, which would account to about 50% of Cambodia's GDP. The corruption and lack of transparency are problematic issues in regarding the oil findings. According to Al-Jazeera report, the government of Cambodia has concluded contractual negotiations with 13 foreign companies, but none of the details are released to either the public or the parliament, and there are no guarantees where the revenue from the oil goes to. When Al-Jazeera reporter Hamisgh MacDonald asks about corruption, Te Doung Dara from Cambodia National Petroleum Authority simply comments that: "I know people talk about anti-corruption law of something, but for me the most important is the spirit of the people." According to UNDP official, it is likely that the oil discovery won't increase overall wealth in Cambodia, but instead "only some rich people will get more rich." (Al-Jazeera 2010, Kaisti, Käkönen 2010 d)

Ethiopia has gold and tantalum deposits, but their effect to economy is small. There is potential for oil and natural gas production, but it has not started (Encyclopædia Britannica, Ethiopia, 2011)

1.1.11 Water issues

In Mekong region the water usage have often trans-boundary impacts. China and Laos use Mekong to produce electricity by damming the river, and it is likely to change the river's flooding and siltation, increase the salinity and have impact on freshwater fishing. (Beeson, 2004)

While the water shortage is less of a problem in Laos and Cambodia than in some other parts of Asia, the water pollution is extensive. Waste from industry, agriculture and untreated urban wastewaters have increased the heavy metal, bacterial, and e. coli levels to unsafe extents. This has resulted in reduction of fish stocks and that the water is not safe to use in agriculture. Especially Cambodia relies heavily on irrigation of rice fields. (Beeson, 2004) According to UNICEF, the low coverage is a main issue in water and sanitation safety in the country. In addition, water quality is another issue of concern. Cattle dung and human excreta contaminate the water supplies frequently, resulting in water-related epidemics. In many areas in Rift Valley regions, the concentration of fluoride is too high for drinking water. The social implication should also be noted: the women and children use several hours every day fetching the water. (UNICEF, 2011)

According to World Bank, in Ethiopia 13% of people in rural areas have access to safe drinking water and 6% have access to basic sanitation. In urban areas 73% of people has access to safe drinking water, and 62% of urban people have access to basic sanitation services. (World Bank, 2011)

Social impacts of unsustainable hydropower development can be significant. Fisheries contribute 6-8% to Laos' GDP, and dam building could block the fish migration, resulting in reduced yields. Eco-tourism is also a significant income source in Mekong region. Both of these livelihoods might have significant negative impact by hydropower development. (International Rivers, 2008)

1.1.12 Rural energy use profile in case study countries

According to encyclopedia Britannica, almost all total electricity is produced with hydropower in both Ethiopia and Laos. In Ethiopia this production is primarily for domestic use. In Laos electricity is one of the main exports of the country.

For cooking energy the households in rural areas use primarily firewood and charcoal at the moment in all case study countries. This has led to widespread forest loss in

many areas, especially in Cambodia and Ethiopia. (Encyclopædia Britannica, Etiopia, 2011; Encyclopædia Britannica, Cambodia, 2011)

A high-ranking World Bank official points out the problem in electrification of Cambodia; the biomass availability is too limited for large-scale electricity production. The availability of hydropower in Cambodia is more limited than in Laos and Ethiopia, but according to an UNDP official it is possible that energy generated with hydropower rises to as high as 50% by 2020. UNDP official continues that it as the electrification has only begun in Cambodia, and there is lot of possibilities to produce electricity in renewable and sustainable way, but it might reduce as much as 10% of economic growth. (Kaisti, Käkönen, 2010 d)

In agrarian societies the energy use is closely linked to livelihood activities and food security. If food energy supply is limited and/or energy price is high, the households prefer to primarily to cook foods that are fast to cook, and cook foods that take longer time less often, even those foodstuff might be nutritious and cheap, such as beans, which can lead to malnutrition. (Turunen, et al. 2010)

Common practices are to use kerosene, gasoline, car batteries and fire wood for provide lightning in off-grid areas. (Turunen, et al. 2010) According to the World Bank official, priority for grid extension In Laos and Cambodia are the villages, where electrification would support livelihood activities, where grid extension could create industry or other income activities. However, in rural areas most people get their income from agricultural activities and to some extent from small business activity, like handicraft or selling food products, so the electrification would create little livelihood supporting activity in short term. Usually electrification would create improved leisure time activity, like television or radio and lightning, which creates both extended leisure time and security at evening time. Those villages, which have a school or clinic within them, have higher priority in rural electrification. (Kaisti, Käkönen, 2010 a)

2 Materials and methods

The order for my thesis came from Finland Futures Research Centre, which was interested in this topic, to get additional information for their "Why Renewable Energy Projects Fail or Succeed? Design and Implementation of Energy Assistance Projects in Cambodia and Lao PDR." (DREAM) –research. At the time of writing, this research is ongoing at the time of writing this thesis, and is due to be completed in 2012.

For getting basic information about the livelihood situation in the case study countries a literature review was the main method. However, I participated in Finland Futures Research Centre's research "Knowledge for development: Creating rural resource database for sustainable livelihoods in Cambodia and Laos" (SURVEY), which was a very good resource in getting some up-to-date information on the livelihood, economic and environmental situation of some of the very poorest people living in Cambodia. Relevant information from SURVEY project is included in my thesis. As the SURVEY data was collected in 2009, it is very recent information.

I also participated on research called "Why Renewable Energy Projects Fail or Succeed? Design and Implementation of Energy Assistance Projects in Cambodia and Lao PDR." (DREAM), which studies SNV's biodigester program in Laos and Cambodia. Two researchers, Ph.M.(?) Hanna Kaisti and Ph.M.(?) Mira Käkönen visited Laos and Cambodia in January-March of 2010, and their interview data and notes were also a resource in my thesis. They interviewed number of people from SNV who are working on biogas projects, as well as people from the governments of Laos and Cambodia, World Bank and other NGOs, who provided information about current energy situation in mentioned countries.

3 Results of the study

In this chapter, the results of the study are presented. Sources of information are studies conducted by SNV and SNV expert interviews. Interviews were done by Heikki Lindfors in Ethiopia, and Hanna Kaisti, Mira Käkönen (both from FFRC) in Laos and Cambodia. It should be noted that as these sources are all from same organization, total biasness cannot be fully confirmed. This chapter also represents SNV experts' personal views of the programme, which might not be 100% the same as either SNV or FFRC.

3.1 Technical overview of SNV household biodigester

The SNV household biodigester needs at least four heads of cattle, stabled during the night, to get at least 20kg of fresh dung per day, for adequate cooking and lightning energy. Liquid input in 1:1 ratio with dung is needed for biogas production. Liquid can be either water or urine. There are many areas in case study countries, especially in Ethiopia, where this amount of excess water is not available. (Encyclopædia Britannica, Laos, 2011)

3.1.1 Biodigester as fuel

According to a survey made for the NBP in target provinces most households owns cows, 41% own pigs and 17,3% own buffalos. In average, the rural households own 8,33 animals, which produce enough dung to operate a biogas digester. According to NBP, production of at least 20 kg of dung on daily basis is the minimum requirement of biodigester operation. For example, two cows and five pigs would provide enough dung to operate a small plant. (UNDP, 2004; NBP Cambodia, 2009 b)

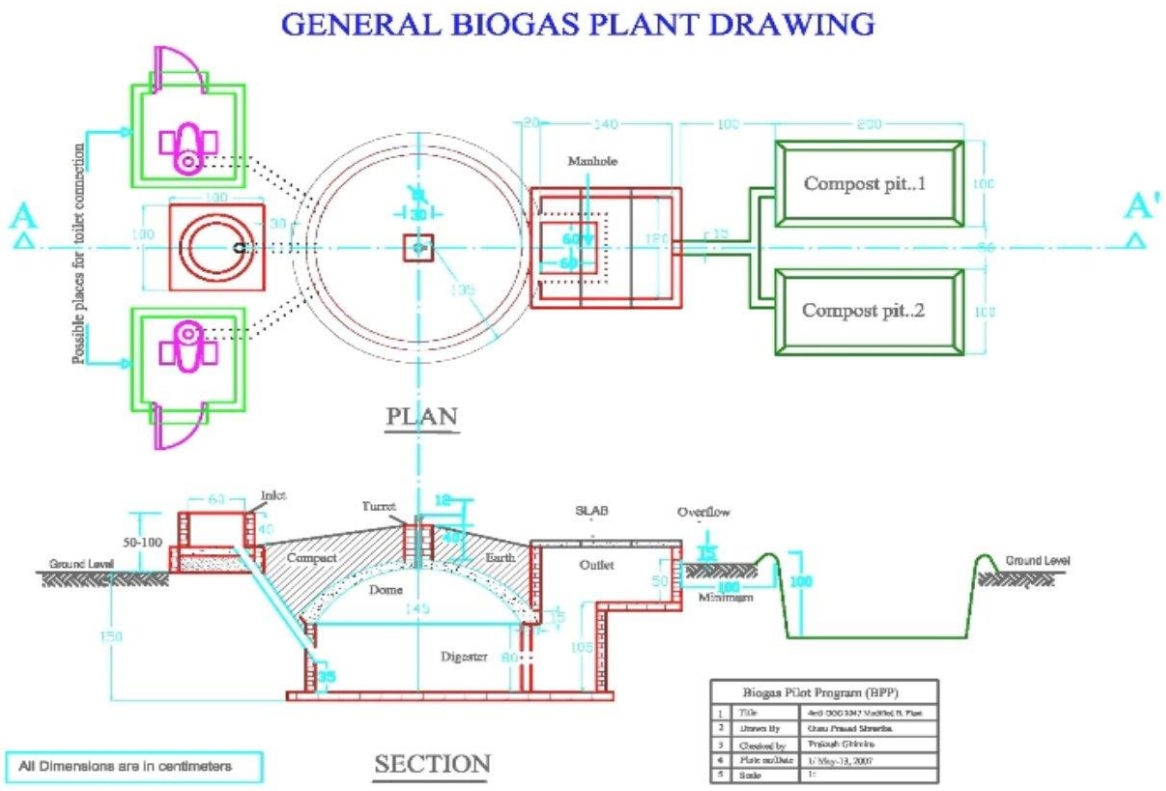
The plants come in four different sizes: 4, 6, 8 and 10 cubic meters. The required daily inputs are presented in the following table:

Table 2: Daily required input, gas production and fuel wood equivalent per plant volume. (Source: NBP Cambodia, 2009 b)

Biodigester size	Daily dung feeding (kg)	Daily gas production (m3)	Use of Biogas Stove (hour)	Use if Biogas Lamp (hour)	Fuel wood replacement value (kg)*
4	20 to 40	0.8 to 1.6	3.5 to 4	8-10	4 to 8
6	40 to 60	1.6 to 2.4	5.5 to 6	12-15	8 to 12
8	60 to 80	2.4 to 3.2	7.5 to 8	16-20	12 to 16
10	80 to 100	3.2 to 4.0	9.5 to 10	21-25	16 to 20

Note: * Based on a commonly used, low tech, woodstove with a 10% efficiency rate. 1 m^3 biogas will replace about 5kg of fuel wood.

Picture 5: SNV household biogas plant designs (Ghimire 2009)



Picture 6:Women & Children Development Organization urban biogas toilet in Awassa, Ethiopia. The toilet has input hole for kitchen waste in the foreground.

3.1.2 Bio-slurry as fertilizer

When completely digested, the slurry from biogas digester is odorless, doesn't attract insects, unlike farmyard manure, which attracts termites and other insects, which can damage the crop. It also reduces weed growth (again, unlike farmyard manure, which

increases the weed growth). The slurry has better fertilizing qualities than manure. The application of bio-slurry has increased the yields by 10-30%, and the slurry has been proven to have yield increase in growing of root vegetables (carrots, radish etc.), potatoes, fruits trees, rice, paddy field crops, wheat, maize, cabbages and tomatoes. (NBP Cambodia, 2009 b; NBP Ethiopia, 2008)

Bio-slurry is a product of biodigester plant. It is composed of animal and human waste (possibly also food residues and other organic matter). Besides fecal waste, compost matter can be introduced to digester, which would improve soil fertility, water-holding capacity, the physical characteristics of the soil, and increase activity of micro-organisms in the soil. In the digestion process, 25-30% of total dry matter, originating from dung, is turned to gas (CH4 (45-70%) and CO2 (25-50%), and O2, N2 H20) and the residual 70-75% is turned into bio-slurry. (NBP Ethiopia, 2008)

The bio-slurry consist 93% of water and 7% of dry matter, of which 4,5% is organic and 2,5% inorganic. The percentages for nitrogen, phosphorous, and potassium are 0,25-0,13-0,12 respectively on wet basis and 3,6-1,8-3,6 respectively. Trace amounts of zinc, iron, manganese and copper are also available in trace amounts.

Table 3: NPK values in different types of organic fertilizers (NBP Cambodia, 2009 a)

Nutrients	Compost manure		Farm yard manure		Digested bio-slurry	
	Value range (%)	Avg. Value (%)	Value range (%)	Avg. Value (%)	Value range (%)	Avg. Value (%)
Nitrogen	0,50-1,50	1,00	0,5-1,00	0,80	1,40-1,80	1,60
Phosporous	0,40-0,80	0,60	0,50-0,80	0,70	1,10-2,00	1,55
Potassium	0,50-1,90	1,20	0,50-0,80	0,70	0,80-1,20	1,00

The utilization of bio-slurry changes the properties of soil in various of ways. The physical soil structure, water holding capacity, soil fertility and microbiological activity are all improved. Bio-slurry is more effective as cereal crop fertilizer than farm yard manure;

production of paddy increased 10%, production of wheat increased 33% and production of maize increased 37%. (NBP Ethiopia, 2008)

3.1.3 Cost and payback time

Operational biogas digester reduces the need for fuel wood for 6-9 kg on average, and 0,2 liters of kerosene per household every day. It also reduces time needed for collecting the firewood, giving more time for livelihood or leisure activities. The need for using chemical fertilizers for agricultural activities is reduced, as the biodigester creates bio-slurry, which can be used as a chemical fertilizer. The bio-slurry enhances the soil quality, increasing the agricultural production. Building biodigesters creates work for local people, as masons and supervisors are needed for the building project and building material and equipment are needed for the project, supporting local construction industry. As of May 2009, 330 masons and 60 officers have been trained for construction and managing the biodigester programme in Cambodia. (NBP Cambodia, 2009 a)

3.1.4 Economic benefits

The SNV household biodigester plant cost varied around $400-$600 in 2010, depending on the market zone. Single investment to a biodigester plant provides cooking and lightning energy for operating time, expected to be 20 years.

While this cost is relatively high to most people in the rural areas in case study countries, there is always a proportion of rural population with stable enough income that they can afford the biodigester plant. If micro-credit system is made available for the program, rural people with smaller income can make an investment to the plant. (Lindfors, 2010 a)

Biodigester plant reduces household's need for firewood, and time used for firewood collection is saved to other household and leisure activities. Money is saved due less firewood and kerosene is needed for cooking and lightning activities. Domestic lightning promotes security, studying at home and economic activities at evening time. (UNDP, 2004; NBP Cambodia, 2010)

3.1.5 Social benefits

Energy services promote employment by providing people possibility to work outside daylight hours. Biogas digesters reduce the money paid for fuel for cooking and lightning. Rice is the single most important food resource to majority of world's population. Any other staple foods need cooking prior to consumption. Operational biodigester can provide cooking energy for 20 years or more. The very poorest cannot benefit from owning a biodigester, but it can be taken into consideration that more firewood is available for poorer households in the same village when a biodigester is constructed. (UNDP, 2004; NBP Cambodia, 2010)

3.1.6 Health benefits

Indoor smoke from using traditional energy fuels, like biomass, for cooking is a major health problem in developing countries. According to WHO indoor air pollution is responsible for 1,6 million deaths every year. (WHO, 2005) Soot and dust particles can go deep into lungs, causing inflammation of the airways and lungs, impairment the immune system, coronary diseases and cancer. Biogas stoves do not emit indoor smoke particulate matter. Switching cooking fuel from wood to gas reduces these health problems. (WHO, 2005) (Kaisti, Käkönen, 2010 b)Water contamination is responsible for 1,5 million deaths of children every year. Biogas digester reduces fresh water pollution as a result of improved management of fecal matter. Connecting toilet to the digester greatly improves the sanitary conditions, lowering the exposure of household members to infections related to poor sanitation. (UNDP, 2004; NBP Cambodia, 2010)

Picture 7: Woman cooking with biogas stoves in Awassa, Ethiopia. Burning biogas creates virtually no particulate matter, thus the kitchen walls and ceiling were clean of soot.

3.1.7 Environmental benefits

Renewable energy helps the sustainable use of environmental resources. Domestic biogas digester turns human and animal fecal matter into energy resource and organic fertilizer, while mitigating climate emissions due more harmful methane emissions are turned into less harmful carbon dioxide in the combustion process. Applying organic fertilizer improves soil fertility and reduces need for chemical fertilizers. Application of bio-slurry as a fertilizer will improve agricultural production, improving food security for the household and community. If a farmer uses chemical fertilizer, it might cause chemical imbalance in soil. If the amount of nitrogen in soil goes too high, cause by over-fertilization, the plant's phosphorous and potassium intakes might not be sufficient, leading to increased growth but reduced yield. In organic fertilizer this kind of unbalancing of chemicals is rarer, as most plants are used to use fecal matter as a resource for chemicals. (UNDP, 2004; NBP Cambodia, 2010)

3.2 SNV model of operation

3.2.1 SNV model of operation

SNV provides advisory services, with aim of improving basic services, production, income and employment for people in developing countries. The organization has activities in agriculture, renewable energy, water and sanitation, education, forestry, health, tourism and inclusive business. The organization is active in 36 countries in Africa, Asia, Europe, and Latin America. (SNV 2010)

SNV is committed in improving the energy situation in developing countries. The organization's main focus in energy sector is the biogas digester programme, and SNV has also projects related to biofuels, improved cook stoves and micro-hydropower. The first biogas programme was implemented in Nepal in 1989 and since then the program has been implemented in Vietnam (2003), Bangladesh (2006), Cambodia (2006), Lao PDR (2007), Pakistan (2009), Indonesia (2009) and Bhutan (2011) in Asia, as well as Senegal, Burkina Faso, Ethiopia, Tanzania, Uganda and Kenya under Africa Biogas Partnership Programme (ABPP). ABPP was started in 2008 and aims to build 70 000 plants by 2013. Cameroon

and Benin have been preparing to prepare their programme under ABPP. By 2010, 360 000 households have been equipped with SNV biogas plant globally. SNV together with Asian Development Bank aims to build additional one million plants by 2015 in their "Energy for All Partnership" -programme. (SNV 2010)

SNV calls its method of promoting biogas "multi-stakeholder sector development" -approach. The organization is active in policy level, providing promotion, materials, training for constructors and users, quality control and maintenance. The actual construction is made by local mason, trained by SNV. Ultimately, SNV's goal is that after some years of implementing the programme, the local biogas sector can implement the programme and construct plants without SNV's involvement. (SNV 2010)

3.2.2 Funding of the SNV biodigester project

The SNV biodigester programme is funded by Dutch government in collaboration with regional biogas programmes: African Biogas Partnership programme and Asia Biogas programme. The regional biogas programme provides 90% of funding, while national governments provide 10% of funding to national biogas programmes. (Lindfors, 2010 a)

3.2.2.1 Clean Development Mechanism and biodigesters

The United Nations Framework Convention on Climate Change was signed at the United Nations' World Summit in Rio de Janeiro in 1992. The involved parties signed Kyoto protocol in subsequent convention in Kyoto, which came into effect in 2005. The protocol aims to reduce greenhouse gas emissions. Under Kyoto protocol, an arrangement called Clean Development Mechanism allows Annex I countries(industrialized countries) to participate in greenhouse gas mitigation projects. The projects have to be evaluated for how much they reduce GHG emissions before approval. Once approved, Annex I countries have more options for reducing their emissions by buying offsets, and Annex II countries (developing countries) have access to these funds. To participate in CDM the country has to

participate the Kyoto protocol. To receive funding, a baseline study has to be made, and the reductions of GHG emissions have to be proven. In Cambodia such study has already been done by NBP and GERES. (GERES, 2006)

As biogas digesters can reduce CO_2 emissions from fuel wood burning, it is possible to apply for funding from CDM. CDM funding can be a substantial source for funding of the biogas digester program. In Vietnam, the Asian Development Bank is involved in developing CDM financing for the SNV biogas program there. This is also planned in Cambodia, but not yet implemented. Applying for carbon funding is a complex process; first a baseline situation has to be created, i.e. how much fuel wood would a household use before building a biogas digester. Also, the source of fuel wood has to be determined, would people get the wood in a sustainable way, like planting new trees or collecting only fallen braches from the ground. This baseline situation has to be done in pre-project phase. If it can be proved that building a biogas digester would reduce the deforestation in the area, thus lowering the carbon emissions, income from CDM funding can be applied for. In some areas, there is not much information on these kinds of baseline situations, so to get the CDM funding, investments have to be done to get it. Also, a buyer has to be found for the carbon credits, preferably one which is willing to participate the whole process to get the CDM funding from the beginning. CDM financing is possible to SNV's biogas digester programme, but it needs a lot of money and expertise invested in it. And while funding from CDM can be substantial source of income for SNV programmes, subsidies provided by European governments are still more essential source of funding to the national biogas programmes at the moment. (Kaisti, Käkönen, 2010 b)

3.3 National Biodigester programs in case study countries

3.3.1 National Biodigester Program Ethiopia

National Biodigester Programme was started in 2006 in co-operation of SNV and Government of Ethiopia. The NBPE is active in four areas currently: Amhara, Oromia, Tigray and The Southern Nations, Nationalities and the People's Region (SNNP), in which areas more than 70% of Ethiopian people and about 70% of cattle resides. In all these regions, the forest loss is especially problematic. (Lindfors, 2010 a)

Cattle manure is the main feedstock for SNV household biodigester, and availability for cattle manure in Ethiopia is high. In Ethiopian highlands, 77% of agricultural holders are cattle owners, although this portion varies greatly from region to region. The rate of mechanization and chemical fertilizer use is low and the soil quality is poor in many areas, and thus the agricultural production depends heavily on cattle production. Some reservation against using human waste as digester input; toilet connection is offered in SNNP region, but only one user wanted toilet connection installed. This seems to vary from region to region; such reservation has not been observed in Amhara region. (Lindfors, 2010 a)

Demo phase of the program started in 2008. The objective was to construct 25 digesters per region, and this objective was almost completed. NBP's target was to build 14 000 biodigester plants in this demo phase, and to ensure optimum and continuous operation of built plants. The method was from the beginning to start local companies and involve local actors for workforce and materials and such. The total cost of five year demonstration phase was projected to be 16,7 million €, or 208 million ETB (based on September 2007 exchange rate). Ethiopian government contributes 10% of this cost, foreign donors 90%. (Lindfors, 2010 a)

In the beginning of demo phase the goal was to build 100 digesters per region by the end of 2009 and 300 more in 2010, this was nearly completed in some regions, but it is uncertain if this goal of 300 digesters can be met in all areas. However, NBPE personnel in both Bahir Dar and Awassa point out, that public reception of biodigester technology has been generally positive. People like all benefits of digesters. Although the price of the digester is somewhat high for many Ethiopians (10 000 – 11 000 birr in August 2010),

there still exists 10-20% portion of rural population who are wealthy enough to construct a biogas plant, according to SNV Ethiopia official. (Lindfors, 2010 a)

Some reservation towards using human waste as input has been observed in SNNP, Ethiopia. Only one person has wanted toilet connected to his digester, as of August 2010. However, similar reservation has not been observed in Amhara region. (Lindfors, 2010 a)

After 2013, there are not yet definitive plans for continuity of the project, however according to interviewed SNV personnel both regional and national governments are supportive towards the biodigester programme. Public reception of biodigester technology is generally positive. However, public knowledge of the biodigester technology is somewhat limited. NBPE has used commercials on media in selected regions, but this is quite costly way to promote public interest. When asked about threats to the continuity of the programme, SNV official mentions lacks of knowledge of such product and programme is one of the major issues. SNV official continued saying that the cost of the material and labor is another limiting factor to the growth of the programme. To mitigate this large initial investment and make the digesters to become available to more people, NBP aims to organize a micro-credit system available to the consumers. On March 2011, SNV made a three-year contract for micro-credit financing for the biogas programme, together with Oromia Regional Bureau of Water, Mineral Energy/Regional Biogas Coordination Office and the Oromia Credit and Saving Share Company. (Lindfors, 2010 a; SNV, 2011)

3.3.2 Biogas Pilot Programme (Lao PDR)

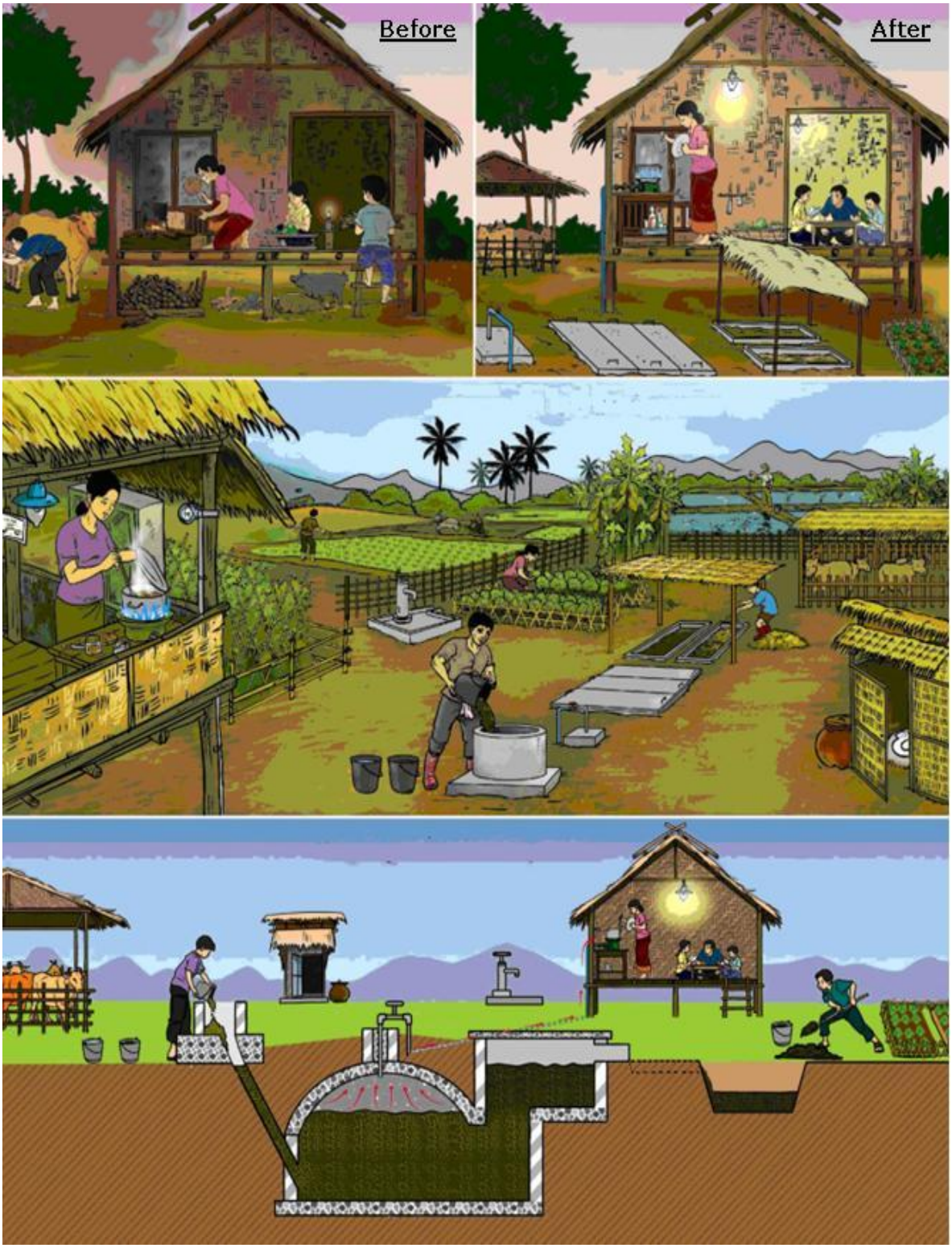
Biogas Pilot Programme implements the SNV biogas digester programme in Lao PDR. The programme started in 2007, and so far about 1425 plants have been constructed in Savannakhet, Khammuan, Vientiane and Xieng Khuang provinces. Target is to build 13000 more by 2015. However, as of spring 2010, the future funding for the programme was still undecided. (Kaisti, Käkönen, 2010 b; Vientiane Times, 2010)

According to survey made by LIRE, the average price of construction of the biogas plant was $380, and the average size 6m^3. The price varied from $350 to $500 and famers could get reduction if they provide construction materials. 81% of the respondents said that

the price of the construction is reasonable. 9% answered the plant was cheap and 9% considered it quite expensive. 92% responded that they have adequate savings and have no need for loan. Only two of the respondents borrowed money for the investment, and neither received the loan from a bank. (LIRE, 2008)

In Laos, the fuel wood and charcoal are well available. Wood resources have not been exploited in large scale due difficult terrain. Electricity is cheap, and is available for about 60% of the country population as of 2010. However, biodigester programme has had success and there is potential for future growth for biodigester programme in Lao PDR, due interest in fertilizer; soil quality is poor in many areas and farmers have to rely on chemical fertilizers, which can take up to one-fourth of income from crop production. It should be also noted, that the further expansion of electricity grid might prove difficult in near future. (Encyclopædia Britannica, Ethiopia; Kaisti, Käkönen, 2010 b)

Picture 8: A biogas instructional poster from BPP



For all households that responded to the SNV survey, cooking was the main function of the digester plant. 30% of the respondents had a biogas lamp installed. Average of the operational time of the biogas stoves was 116 minutes per day. Biogas was used in preparation of morning and evening meals, while at lunch time cooking many used traditional cook stoves. This is probably due most of the family members are working on the fields at that time. 56% of the respondents agreed that the output of the gas is sufficient for all household cooking activities. 26 respondents use biogas for primary cooking fuel, 12 use generally biogas, but occasionally other fuels, and 8 use other sources, because biogas output is not sufficient enough. (LIRE, 2008)

Of all households that used bio-slurry as a fertilizer, 47% estimated that slurry is better than farm yard manure as a fertilizer, 47% estimated it is as good, and 6% though it is less effective than farm yard manure. Farmers are making significant savings with slurry; on average 700 000 kip ($84, 2008) were saved on investments on chemical fertilizers. (LIRE, 2008)

Using humanure input in biodigester is not yet a common practice in Laos. So far BPP's attitude towards installing latrine has been as follows: 'The BPP digesters are designed and installed with two inlet pipes – one reserved for attaching to a human latrine. To date BPP has not promoted this practice due to the anticipation of negative customer perceptions that could affect general acceptance of biogas technology. SNV has learned in other countries to introduce the concept of attaching human latrines only after there is already good acceptance and awareness of the technology." (LIRE, 2008) However, the survey studied this aspect, and result was that 67% had no problem connecting a latrine to their digester. 13% considered "gas from toilet attached plants to be un-sacred". Another 13% considered that "people are hesitant to handle the bioslurry from toilet attached plants". 7% were "afraid of destroying biogas bacteria by toilet cleaner". 2/3 of surveyed people had no reservations against using latrine input in their digester. This suggests that latrine input is possible to be installed to some of new and existing digesters in Laos.

Table 4: Monthly savings from digester plant in Lao PDR. (Note: 1 kip = $0,00012, 2008) (Source: LIRE 2008)

Average monthly cooking expenses	Before (kip/month)	After (kip/month)	Saving (kip/month)
Fuel wood	48200 ($5,78)	21400 ($2,56)	26800 ($3,22)
LPG cylinder (gas tank)	300000 ($36)	150000 ($18)	150000 ($18)
Electricity	42200 ($5,06)	18800 ($2,26)	23400 ($2,81)
Charcoal	60800 ($7,02)	2900 ($0,35)	57900 ($6,95)

3.3.3 National Biodigester Programme Cambodia

The National Biodigester Programme (NBP), which implements the SNV's biodigester programme in Cambodia was started in 2006. It is part of the SNV's Asia Biogas Programme. National Biodigester Programme is operated jointly by Cambodia Ministry of Agriculture, Forestry and Fisheries (MAFF) and the SNV. The Dutch Ministry of Foreign Affairs has provided the funding and nowadays also German government financially support the programme. Normal procedure how SNV implements the biogas digester programme is to give the ownership of the programme to local governments quickly, while SNV works as an implementer. Besides local and Dutch and German governments SNV works with other organizations and companies on contract basis, like Groupe Energies Renouvables Environment and Solidarite, Consultant for rural energy related studies (GERES), Cambodia Institute of Development Study, Development Technology Workshop (DTW) and Consulting Engineers Mekong, Consultant for civil technical issues (iLi). According to NBP website, "the NBP is also open for new partnership with organizations who share the vision of the vision of the programme and that can contribute to achieving the programme's objectives." (Van Nes, 2005)

Picture 9: A biogas promotional poster by NBP Cambodia

The first phase of the programme was implemented in eight provinces: Takeo, Kandal, Kampot, Kampong Spoe, Kampong Chhnang, Kampong Cham, Prey Veng and Svay Rieng. Between 2010 and 2012, during the second phase, the aim is to expand the project in four more provinces around Tonle Sap lake: Kampong Thum, Siem Reap, Batdambang and Pouthisat. By the 2009 totally 6400 digesters have been constructed, and by 2012 NBP plans to construct 12000 more. So far, 400 masons have been trained in SNV training center to build biodigesters. According to NBP employee, about 300 biogas digesters were built per month in Cambodia in 2010. (Kaisti, Käkönen, 2010 c)

In Cambodia, building a normal-sized biogas digester costs about $500, and $150 subsidy is provided by the program. The remaining $350 is paid by the farmer. The largest digester's price is $1000. This price includes the building materials, appliances (stove, rice cooker and a lamp) and labor cost. The subsidy is always provided, regardless of income and possessions of the farmer. For financing this investment, the NBP channels the farmer cheap micro-loan, which has a payback period can be from four up to 24 months. NBP conducts a survey amongst biogas users, and according to this survey, 85% of the respondents to the NBP survey financed the biodigester with their "own savings", 7% paid the whole investment by loan, and 9% financed the investment with both savings and loan. Of those who took a loan for the investment, 75% repaid already or were making regular payments, while only 17% had late payments. The Chinese ministry of agriculture has a biogas digester program similar to that of NBP, but they provide a biogas digester free of charge. This distorts the market, and confuses the farmers; some might have problem understanding why the payment have to be arranged, when someone they know got theirs for no cost. The Chinese programme currently has 1500-2000 biogas digester plants in sub-Mekong region. (NBP Cambodia, 2008; Kaisti, Käkönen, 2010 c)

As NBP provides subsidy, the organization can control the quality in the building process. According to NBP employee, if no subsidy would be provided the farmer could use the cheapest materials, which might lead to problems when operating the plant. NBP makes sure that the decent quality bricks and other parts are used. NBP gives the plant a two year guarantee, and estimates that the total lifetime of the plant is 15-20 years. If anything goes wrong with the plant during guarantee period, a mason goes to the village and fixes it, and the farmer doesn't need to pay for this service. Only appliance that is not

included in the guarantee is the lamp, which farmer has to pay for himself ($3,50). The stoves are built in Cambodia by DTW. (Kaisti, Käkönen, 2010 c)

Based on user survey conducted by NBP Cambodia, 90% of the respondents agreed that output of the gas was "as expected" or "more than expected". However, when asked whether the gas output was sufficient at all times, only 63% agreed while 18% of respondents obtained dung from outside the farm and still responded that the gas output was "only sometime sufficient" or "insufficient". The survey draws a conclusion from this, that the biogas production and obtaining dung from outside the farm are correlated. 52% of respondents agreed that they have reduced the use of chemical fertilizer after application of bio-slurry, while 6% stopped using chemical fertilizer altogether. However, 31% did not decrease their chemical fertilizer use, and 9% even increased it. This implies that the application of bio-slurry does not replace the use of chemical fertilizer, but instead it replaces dung as soil enhancer. (NBP Cambodia, 2008)

Building a biogas digester can save around $12 per month per household, $8 from buying fuel wood and $4 from buying kerosene or charging a battery. Not included is savings from buying a chemical fertilizer, which might cost $60 per year. When asked about the money saved after investing on the biodigester, respondent's expenditure on cooking energy was reduced by 90% and money on lightning by 30% by using biogas. Before owning a biodigester households were using firewood (98% of respondents), charcoal (22%), bottled gas (12%) and batteries (8%). 47% of respondents though that energy costs were a major household expenditure. After their plant was constructed, 90% of the respondents used gas for lightning, and while gas became most important cooking energy resource, more than half of the household still used firewood and/or charcoal for cooking. According to NBP employee, the savings from buying the fuel wood is the main motivation of the farmers to invest in biogas digester plant. The programme in Cambodia is implemented in areas, where the deforestation is a major problem, and thus the fuel wood is expensive, especially in Takeo and Svay Rieng provinces. (NBP Cambodia, 2008; Kaisti, Käkönen, 2010 c)

4 Discussion: differences between national programmes and their national contexts

In this chapter I present my own impressions how the national biogas digester programmes and their socio-economic-cultural contexts differ from each other. Note that these findings are my own, and do not represent the views of SNV or FFRC.

In Cambodia the domestic energy resources are scarce and the overall electrification rate in the country is only 27%. Also, the forest loss is alarming in most parts of the country. In long-term, the country has to resolve its increasing energy demand by fossil fuel imports, or invest on the potential for renewable electricity production; micro- to large scale hydroelectricity, solar, wood- and biomass gasification, biogas and energy crops all can be a part of the electrification in Cambodia. Biogas program has had some success so far and the knowledge of such programme is increasing, thus likely bringing even wider demand in coming years. It seems that using humanure for cooking energy and crop production is not a major issue in Khmer culture. The fuel wood situation is dire, and the demand for fertilizer is increasing in Cambodia's large agricultural sector. All these socio-economic aspects are likely to bring more popularity to biogas digester technology in the future. NBP Cambodia has made baseline assessment and is prepared to implement funding mechanism to receive funds from Clean Development Mechanism, which possibly brings more economic resources to the programme in near future.

In Lao PDR the electrification potential is large, and already well in use; electrification rate is 60%. However, not all parts of the country are likely to have grid connection in near future. The Government of Lao PDR together with World Bank support micro-hydro and solar as electricity resources in those areas where grid connection is not realistic in near future. The forest loss is less serious issue, as many parts of the mountainous country are unreachable by road. But even electricity is relatively cheap in Lao PDR, SNV biogas program is still beneficial to rural people in areas with no grid connection, for the cooking and lightning energy it provides, and also for some rural folk in areas with grid connection, for the bio-fertilizer it provides. Fertilizers are commonly used in Laos, and it is usual that a farmer has to pay 25% of his profit to cover the costs from chemical fertilizer. Those Laotians can benefit from having a biogas digester. However, it

should be noted, that terrain in Laos brings difficulties the construction in many off-grid areas, as those areas also usually tend to be without proper roads.

Similar socio-economic issues create interest to biogas in Ethiopia. Rural areas are electrified only along the main roads, and majority of population is not connected to the grid. The forest loss has been a major problem for decades, and almost all people in the country rely on fuel wood for cooking energy. What should be noted is that not all cooking needs are possible to be met with biogas; Injera, the local pancake served with every meal is only possible to be cooked with wood stove. In using human waste in cooking energy has received mixed reactions in Ethiopia; in Amhara region this was not an issue, but in SNNP region only one household was willing to connect toilet latrine to their digester. The demand for fertilizer is another pressing issue in Ethiopia, as many areas suffer from severe land degradation, while the country should feed its 90 million people population. The demand for biodigester technology is likely to increase in Ethiopia for these reasons.

5 Conclusion

In long term, the goal should be that all rural villages get affordable electrification by grid connection or from small scale renewable source. Lightning by electrification improves leisure time household activities, study activities and security. Rural people's communications to outside world improve if they invest on a radio or a TV. Grid availability creates potential for local manufacturing industry and services.

This long term goal is indeed important for all above reasons, but one must be realistic about the phase of rural electrification in the developing countries. In some areas, of all case study countries, the energy and transportation infrastructures are limited, and it is unrealistic to expect to bring grid quality electricity to all rural villages and households in next 10-20 years. Meanwhile, the forest resources for cooking energy are low in many areas and only renewable energy resource available in abundance is often animal dung. The practice of using feces as cooking energy resource tend to disgust the users at first, as might the smell, but after users start to use the digester and experience benefits of it, they are happy with their investment. If user applied a micro-loan to invest a digester, the payback

time is usually 1-2 years. Even though majority of farmers are not yet able to afford the investment, there is always a proportion of rural population who do, and implementation of micro-credit system makes the technology available for larger amount of people.

5.1 Findings to the research questions

In following chapter I introduce my own views to the research questions. Note that these conclusions are my own, and do not represent the views of SNV or FFRC.

How the SNV operates, and how is the SNV biodigester programme funded?

SNV biogas digester programme can be considered successful as a development programme in all countries it is implemented. The implementation model is similar in all case study countries. In demonstration phase the regional network is created: SNV personnel start training the masons, promoting the programme and making contracts for materials and appliances. At this phase before this the appliances are mainly imported. One of the findings of my study was, that already in demonstration phase some problems were encountered in Ethiopia; in SNNP, NBP uses black market to acquire rubber hose, and SNV specialists in SNNP and Amhara regions pointed out their worry of rapidly increasing material costs, especially concrete. After demonstration phase, the programme is expanded; plants are made available for more people and local companies are involved in production of appliances and banks are involved in providing credit for the programme.

The final cost of digester plant is funded by user (about 60%, depending plant model and the region), and subsidy of about 40% comes from external sources. SNV biogas digester is funded by development budget of the Dutch government. Some funding is also received from German government to the African Biodigester programme. This foreign donor contribution attributes 90% of programme's external funding. National governments contribute 10% of external funding.

Biogas technology in socio-cultural context: which different benefits people in different countries want? Which kind of socio-cultural limitations have the programme encountered in case study countries?

Biogas creates cooking and lightning energy, and fertile bio-slurry as a side product. Cooking energy was beneficial for users in all countries. If electricity grid connection is available, it is preferred as primary source of lightning. The biodigester reduces the money used on energy (see table 4, pg. 43). The bio-slurry was commonly used as fertilizer. However, survey conducted in Laos suggests that bio-slurry replaces dung, not chemical fertilizer as soil enhancer. Users are interested in all digester's benefits. If electricity is available, electricity remain main source of lightning.

In initial phase SNV does not offer latrine connection to digester plant. The reason for this is that use of human waste as a resource might be considered a taboo, especially in cooking and food growing. The survey conducted in Laos suggests that there is some reservation against using dung in these activities, but majority (67%) of respondents were interested of using human waste for additional input to digester plant. Similar hesitation in using human waste was discovered in SNNP region of Ethiopia.

Who are potential customers for biogas technology?

People who own at least 4 cattle heads can have sufficient input for the biogas digester. Usually in rural areas, this means better-off people of the communities. These people are able to decrease their use and cost of other energy sources and improve their farm yields, further improving their economical position. Micro-credit system is in place in Cambodia, and at Oromia region of Ethiopia. If loan was taken for investment, the payback time was usually 1-2 years. The survey in Cambodia found out that 75% the people who made investment fully with loan were making regular payments. This suggests major savings from the plant.

While only better-off people are able to invest on digester plant, the rest of the community might have lowered cost and effort to acquire fuels, due decreased

fuel demand of the users of the digester plant, and benefit from digester plan in this, indirect way.

How biogas compares as an energy source to other energy sources and how it serves the needs of rural people in on- and off-grid areas compared to fuel wood and grid electricity?

Biogas is remarkably different from electricity and traditional fuels. Biogas cannot be stored outside the process tank, and gas production is not constant. Irregular gas output would force people to use other means for cooking. In most cases this would mean return to wood products for cooking energy. The users might not be able to replace all their need for traditional means of cooking. Survey in Cambodia found out that only 63% of the users think that gas output is sufficient at all times. Ethiopian food injera, which is served with every meal, can only be cooked with wood stove.

According to NBP Cambodia, collection of manure and human waste into digester plant could improve the health conditions in community. Diseases originating from fecal matter are major problem in developing countries; four to six million people die of diarrhea per year. This issue is improved while making energy from the plant.

In combustion process methane gas turns into carbon dioxide, water and energy. No particulate matter is emitted into indoor air. This reduces deaths and respiratory diseases of household members, especially women who most often are responsible for cooking activities. The carbon impact to atmosphere is negative, as more harmful CH_4 is converted into CO_2.

The digester plant also produces organic slurry as a by-product.

How have the users received the biogas technology?

Users have received digester technology very positively. Users have managed to decrease amount of money used on other fuels. Some users have managed to reduce their chemical fertilizer use. Crops have increased in some cases since application of bio-slurry. The short payback time (1-2 years) indicates major savings when using biogas. People tend to be doubtful of the technology before installing, but when digester operation starts, the advantages become obvious that people become very happy of their plant.

In early phases of the programme, SNV does not offer toilet connection to the digester tank, to minimize the chances for negative reception for the technology. Reasoning for this is that use of human waste in cooking and crop production is considered a taboo in some cultures. This was studied in survey done by BPP (Laos), in which 27% of respondents reported that they have some reservations against using human waste as input. Such reservations was also mentioned by Ethiopian SNV expert; in SNNP region the toilet connection was offered, but only one user wanted toilet connection.

All case study governments were observed to be supportive and dedicated towards programme.

5.2 Recommendations to SNV

Here I shortly present my own proposals how biogas programme could be improved in the future. These ideas might be already considered by SNV, but I mention these proposals, because I see the following issues key areas for future success and possible future improvement.

Promotion

Lack of knowledge of biodigester technology seems to be major obstacle in future expansion of the programme. If people don't know about options, they cannot substitute their fuel wood use. Promotion with newspapers, radio, television, and word of mouth marketing are possible ways to promote the technology.

Toilet input

SNV does not offer toilet connection to the digester plant in initial phases of the programme. The rationale behind this is that use of human feces is a taboo in many cultures, and programme should establish some customers first, before offering toilet connections to new and existing plants.

The technology is based on use of feces, and some people might be reserved towards this practice. However, after the reactor has started gas production, no foul smell or other nuisances remain, and the advantages become obvious. After this, users see that benefits are greater than any shortcomings.

In this study, I discovered some such reservations, in Laos and SNNP, Ethiopia. However, in some other areas no such reservations seemed to be present. My recommendation is to make inquiries about this practice when conducting initial baseline study for the programme (before demonstration phase); if such reservations are recorded, current SNV policy is recommendable, if not, toilet input could be offered to users from the very beginning.

Preparation for funding from Clean Development Mechanism

At the time when the interviews for this study were made, NBP Cambodia was preparing a baseline study for CDM funding. CDM funding can become a substantial source of funding in the future, and thus, my recommendation is to prepare for CDM funding in all countries where SNV biogas programme operates. However, such baseline study for CDM is bureaucratic and challenging. First priority should still be that the programme functions without this external funding source.

Consultation to other biogas projects

During my practical training in Bahir Dar, Ethiopia, one of my tasks was to consult SNV expert for some assistance to Tampere University of Applied Sciences' SAWE 2 –project.

The SNV personnel were very helpful to me, especially by providing plans for Sinidu-biodigester plant model. As SNV is such large biogas actor, and it has long experience around the world, it could provide assistance to other biogas projects in similar fashion. During my stay in Ethiopia, I became aware that there are dozens of biogas projects in Addis Abeba (capital of Ethiopia) alone, conducted by independent development organizations. As SNV is major biogas actor in many developing countries, it could provide assistance the other organizations might need.

Local appliance production and use of local materials

SNV supports regional companies or workshops to produce biogas appliances locally. The biogas stove and pipes are usually produced locally, but biogas lamps and rubber hoses are commonly imported. To provide maximum employment for local actors all appliances should be made locally, if possible.

The cost of concrete is increasing rapidly in many developing countries. This affects the price of biogas plant, as the dome is made from concrete. If possible, users should be supported to use as much local materials (e.g. stones) as possible.

Involvement of local credit organizations

Micro-credit system makes digester plants available to much larger audience. Micro-credit system is in place in Cambodia and at the Oromia region of Ethiopia (latter from late 2010). Survey conducted in Cambodia resulted that of people who took loan for investment, 75% were making regular payments and 17% had late payments. This suggests low, but present, financial risk to credit organizations. The payback period was commonly 1-2 years. My recommendation is to expand the micro-credit system to all areas where biodigester programme is implemented, if interested financial institution can be found.

Programme expansion to other countries

The programme seems successful in all case study countries. The programme could have success in any area where traditional fuels are used for cooking energy. Large scale forest loss, traditional use of dung as fuel, high cost of traditional fuels and high cost of chemical fertilizer create potential for successful introduction of the technology. Countries that suffer from these issues are many in Africa, Asia and Latin America. If the political atmosphere is safe enough, possibilities of SNV to expand to new countries is recommended. In all developing countries there are better-off class of rural people who can afford and benefit from biogas technology.

However, such technology is not necessary in all countries: if electricity is used for cooking energy and sanitation is adequate level, biogas technology is unlikely to meet large scale success.

5.3 Recommendations to Finnish development organizations and policy makers

Some of Finland's goals in developing aid include promotion of health, improving rural development, mitigating climate change, water quality issues, and promoting sustainable environmental policies. Biogas digester technology support these goals in several ways: prevention of water-borne diseases is improved due improved handling of fecal matter. Energy use and sustainable use of forest resources are promoted due substituting wood with dung. Climate change is mitigated due methane gas (CH_4) is turned into more climate-friendly carbon dioxide (CO_2). Indoor air quality is improved due no soot is emitted in the process. Farmers have their soil quality improved due organic fertilizer. All these effects support the goals of development policy of Finland.

Our University's SAWE 2 –project included installing several dry toilets into the city of Bahir Dar (3 of them with biogas digesters). Also other Finnish dry toilet actors might be interested, and able, of promotion of biogas digester technology into their development projects. However, such projects could prove challenging to start. Biogas technology is relatively unknown, while it requires right appliances and skilled mason.

Should any such project occur by a Finnish development organization, I recommend cooperation with SNV in acquiring such resources. Discussion with SNV official confirmed SAWE 2 –project with right mason and SNV official provided me blueprints of Sinidu-model biodigester plant, for our project to use.

My opinion is that Finnish dry toilet actors should look into possibilities of construction of biogas digester plants in their dry toilet construction projects. The technology seems supportive of Finnish development goals in all its aspects.

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