CHALMERS

Etablering av småskaliga biogasanläggningar i utvecklingsländer

- kriterier för framgång

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Förord

Denna kandidatuppsats om småskaliga biogasanläggningar i utvecklingsländer är skriven under vårterminen 2014 för intuitionen för Energi och miljö på Chalmers Tekniska Högskola.

Uppsatsen innehåller en litteraturstudie som kompletterats med två fältstudier: Kambodja och Kenya. Studien syftar till att identifiera, sammanställa och analysera framgångsfaktorer för etablering av biogasanläggningar i utvecklingsländer.

Vi vill rikta ett stort tack till vår handledare Professor Erik Ahlgren för hjälp och stöttning under projektet samt möjligheten att genomföra fältstudierna. För hjälp under fältstudierna vill vi tacka Cambodia National Biodigester Programme, Kenya National Domestic Biogas Programme samt Takamoto Biogas.

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Sammanfattning

Ren och billig energi för matlagning är en bristvara i många utvecklingsländer och människor är beroende av bränslen som skapar allvarliga miljö-, sociala- och folkhälsoproblem. Biogas är ett alternativ till traditionella energikällor och i flera utvecklingsländer ses idag en ökad satsning på småskalig biogasproduktion. Fördelarna med biogas i utvecklingsländer har lett till att flera projekt har startats upp för att introducera tekniken. Etablering av biogasanläggningar har skett med olika resultat, i en del länder har det fungerat bra och i andra sämre.

Studien är en litteraturstudie som kompletterats med två fältstudier. Utifrån ett tekniskt, ekonomiskt och socialt perspektiv har faktorer identifierats, sammanställts och analyserats, samt kopplingen mellan dessa, som är centrala för framgångsrik etablering av småskalig biogasproduktion i utvecklingsländer.

Under studiens gång har faktorer som är viktiga för etablering och drift av biogasanläggningar i utvecklingsländer tagits fram. Anpassad anläggning som konstrueras efter de resurser och förutsättningar som finns lokalt är en avgörande faktorer för framgång. Kunskap om anläggningen och konstruktion av denna är viktig för att öka biogasproduktionen och för att undvika tekniska problem. För att nå en större målgrupp skall investeringskostnaden inte vara för hög samt minimeras med hjälp av subventioner. För att ytterligare bredda målgruppen har lån en viktig påverkan. Andra centrala faktorer som studien visar är en god relation mellan organisation, murare och hushåll. Det är även avgörande att organisationerna har en tydlig marknadsföring där drivkrafter är identifierade.

Abstract

A clean and affordable energy source for cooking is deficient in developing countries. People rely on fuels that contribute to environmental, social and health problems. Biogas is an alternative energy source and an increased investment in small-scale biogas production can in several developing countries be found. Several projects have started to use the technology in developing countries because of the benefits with biogas. Some cases in the establishment of biogas plants have succeeded and some have not.

The study is a literature review supplemented by two field studies. Factors have been identified, collected and analyzed from three different perspectives; technical, economic and social. These factors are central for the success of the establishment of small-scale biogas production in developing countries.

Factors that are important for the establishment and operation of biogas plants in developing countries have been compiled. A biogas plant should be constructed with the local resources and its condition in mind. Knowledge regarding the biogas plant and its construction is important to avoid technical problems. To be able to reach a large group of households, the investment cost should not be too high and subsidies should be used to minimize the cost. With the availability of loans more households have the opportunity to invest in a biogas plant. The study presents two more factors that are significant for the establishment of biogas plants. The first one is the relationship between the organization, masons and households and the second one is the way the marketing is performed.

Ordlista

Slurry	Ordet används som benämning på det organiska materialet då det är utspätt med vatten.
Substrat	Det material som används som råvara i rötningsprocessen.
Restprodukt	Det material som återstår efter rötningsprocessen och leds ut från rötningskammaren genom ett utlopp.
TS	Torrsubstanshalt (TS-halt) anger andelen återstående föreningar i ett material då vatteninnehållet indunstats vid 105 °C (Biogasportalen, 2014).
Glödförlust	Glödförlust beskriver hur stor del av materialets innehåll som är förbrännbart vid 550 °C. Parametern ger en uppskattning av substratets organiska innehåll och är således ett mått gasutbyte vid förbränning (Biogasportalen, 2014).
Murare	En person som bygger och installerar biogasanläggningar.
Kontraktare	En kontraktare kan ha en eller flera murare som arbetar åt honom, vilket kan liknas vid ett biogasföretag.

Innehållsförteckning

1 Inledning

Dagens samhälle står inför flera miljöproblem där klimatförändringar och utarmning av jordens resurser är centrala (Gröndahl and Svanström, 2010). Klimatförändringarna beror bland annat på koldioxidutsläpp vid förbränning av fossila bränslen som olja, kol och naturgas. Även skogsskövling bidrar till ökad koldioxidhalt då kol som lagrats släpps ut på nytt (WWF, 2013). Förhöjda halter av växthusgaser i atmosfären bidrar till den globala uppvärmning som påverkar både miljö och människor (Gröndahl and Svanström, 2010).

Utöver nämnda effekter bidrar skövling av skog till jorderodering vilket i sin tur leder till ökenutbredning och att odlingsmark förstörs (Gröndahl and Svanström, 2010). I många utvecklingsländer används ved som energikälla vid matlagning vilket på flera håll leder till avskogning. Avskogning är ett stort problem i dessa länder och alternativa energikällor är ett måste för ett hållbart levnadssätt (Nes, 2012).

Ren och billig energi för matlagning en bristvara för 2,7 miljarder människor och i utvecklingsländer är många beroende av bränslen som ved, träkol och gasol (Nes, 2012). Förbränning av dessa bränslen skapar allvarliga miljö-, sociala- och folkhälsoproblem (Surendra et al., 2013). Biogas är en alternativ energikälla som småskaligt kan produceras lokalt och användas för matlagning. Att ersätta tidigare nämnda energikällor med biogas bidrar till förbättrad folkhälsa, minskade energikostnader samt en restprodukt vilken kan användas som gödsel (Nes, 2012). Då biogas är en förnybar energikälla bidrar den inte heller till något nettoutsläpp av koldioxid (Biogasportalen, 2014).

Småskaliga biogasanläggningar drivs av organiskt material som djurdynga, hushållsavfall och skörderester (Surendra et al., 2013). Eftersom biogasanläggningar kan förses med både biologiskt avfall och fekalier reduceras mängden avfall från hushållen (SNV, 2014). Genom reducerad mängd avfall kan anläggningarna även lösa problem kopplade till sanitet, som höga halter av smittämnen eller gifter i dricksvatten (Blume, 2010).

Fördelarna med biogas i utvecklingsländer har lett till att flera projekt har startats upp för att introducera tekniken. Etableringen av biogasanläggningar har skett med olika resultat, i en del länder har etableringen fungerat bra och i andra sämre. Det finns flera olika faktorer som påverkar etableringen, som tekniska, ekonomiska och sociala (Arthur et al., 2011) (Blume, 2010). Studien syftar till att identifiera, sammanställa och analysera faktorer, samt kopplingen mellan dessa, som är centrala för framgångsrik etablering av småskalig biogasproduktion i utvecklingsländer.

1.1 Avgränsningar

Småskaliga anläggningar definieras som anläggningar på hushållsnivå och inte på industriell nivå. Etablering av småskaliga biogasanläggningar i utvecklingsländer inkluderas i projektet. Utvecklingsländer definieras som länder med BNP (PPP) per capita under det världsgenomsnittliga 10,700 USD (IMF, 2012). Tekniska detaljer som maskindelar och utveckling av dessa kommer inte att studeras utan anläggningar studeras som helhet. Samtliga valutor anges i USD utan att hänsyn tas till valutans värde i Kambodja och Kenya.

2 Metod, litteraturstudie

Studien är en beskrivande och integrerad litteraturstudie där publicerad forskning inom det valda området har sammanställts och analyserats. Litteraturstudien har kompletterats med två fältstudier som sedan jämförts i en gemensam analys och slutsatser har sedan dragits utifrån analysen.

Litteraturstudien har utförts i tre steg: identifiering, sammanställning och analysering. Identifieringen består av en litteraturgenomgång som därefter sammanställs och analyseras tillsammans med fältstudierna. För att effektivt samla in material till litteraturgenomgången skapades ett tillvägagångssätt för insamling och bearbetning av litteratur.
Tillvägagångssättet har bestått i att specificera sökord samt kombinationer av dessa, utifrån syftet och problemformuleringen. Sökord som har använts är: *biogas, domestic biogas, household digester, developing countries.* Sökningen har genomförts på ett antal relevanta databaser, exempelvis Scopus.

Tillvägagångssätt för vald litteratur:

i. Litteratur med relevant rubrik
ii. Relevant sammanfattning eller *abstract*
iii. Relevant innehåll

Litteratur som uppfyller ovanstående tre punkter har granskats källkritiskt och sedan inkluderats i urvalet. Urvalet har presenterats, strukturerats och motiverats utifrån kriterierna: publicerad vetenskaplig artikel, rapport från organisation samt engelska eller svenska.

Ingen gräns har satts för när den valda litteraturen skall vara publicerad. Fokus har dock legat på att använda aktuell litteratur och äldre litteratur har endast använts som komplement.

Litteraturen i urvalet har analyserats utifrån studiens syfte och problemformulering. Resultatet från litteraturstudien ligger till grund för vad som har undersökts under fältstudierna. Parametrar som ansetts var relevanta från litteratur- samt fältstudier har sedan analyserats i tre steg. Först har de sammanställts i en tabell, för att därefter betygsättas och slutligen har de jämförts samt diskuterats.

3 Teoretisk bakgrund

Biogas produceras både små- och storskaligt. Småskalig produktion är väl etablerad i utvecklingsländer där produktion sker i mindre byar, gårdar eller enskilda hushåll. Biogasen används främst i gasspisar till matlagning men även till belysning (SNV, 2014).

3.1 Framställning av biogas

Biogas består främst av metan och koldioxid. Gasen bildas då organiskt material bryts ner under anaeroba förhållanden (syrefri miljö), så kallad rötning. Under rötningsprocessen bildar mikroorganismer, med tillgång av kväve och fosfor, enzym som bryter ner det organiska materialet (Biogasportalen, 2014). Processen kan beskrivas i fyra olika steg (Karthik Rajendran, 2013):

i. Hydrolys
ii. Acidogenesis
iii. Acetogenesis
iv. Metanisering

I hydrolysen bryter enzymer ner det organiska materialet till olika monomerer som exempelvis aminosyror och glukos (Biogasportalen, 2014), (Blume, 2010). Under processteget acidogenesis omvandlas monomerna till flyktiga fettsyror och alkoholer som i sin tur omvandlas till ättiksyra, väte och koldioxid i acetogenesissteget (Biogasportalen, 2014). Etanol tillsammans med koldioxid kan exempelvis omvandlas till ättiksyra och metan under acetogenesissteget vilket ses i reaktion (1).

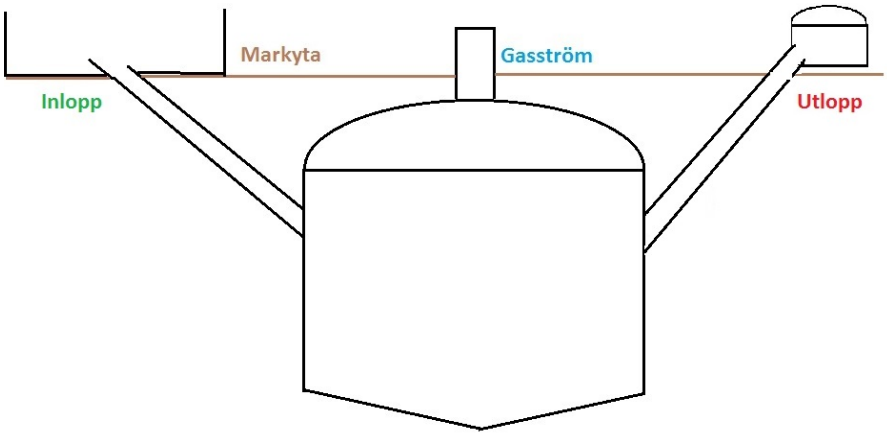
$$2CH_3CH_2OH + CO_2 \rightarrow CH_4 + 2CH_3COOH \qquad (1)$$

Under metaniseringen omvandlas ättiksyra, väte och koldioxid till metan och koldioxid enligt reaktion (2) och (3) (Blume, 2010):

$$CH_3COOH \rightarrow CH_4 + CO_2 \qquad (2)$$
$$CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O \qquad (3)$$

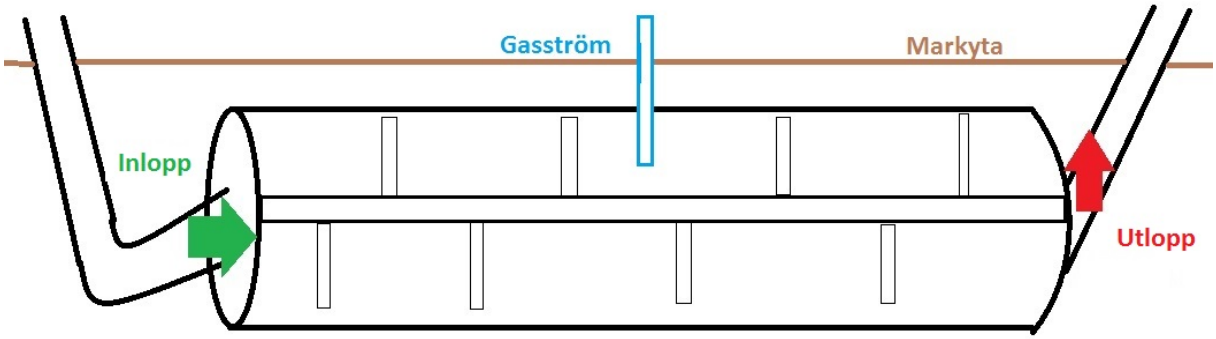
3.2 Biogasanläggning

Vid produktion av biogas på småskalig nivå består anläggningen av en mindre reaktor, vilken i fortsättningen kommer att benämnas rötningskammare, med ledningar för in- och utlopp samt ett rör för att avlägsna gasen. Det nedbrytbara organiska materialet benämns substrat och blandas med vatten i förhållandet 1:1 innan det förs genom inloppet (Surendra et al., 2013). Mixen av substrat och vatten kallas slurry. Innehållet i utloppet benämns restprodukt vilket kan används som gödningsmedel. Kammaren är tillverkad av stål, betong eller tegel beroende på vilket material som finns tillgängligt i området där kammaren installeras (Blume, 2010).



Figur 1. Skiss över en biogasanläggning med tankformad rötningskammare.

Produktion av biogas kan ske satsvis eller kontinuerligt i en tub- eller tankrötningskammare. Figur 1 ovan visar en skiss av en tankrötningskammare. Om rötningskammaren är tank- eller tubformad har betydelse för processen (Blume, 2010). Vid användning av en tank erhålls konstant koncentration av nedbrytbart material i hela tanken och i en tub varierar koncentrationen beroende på var i tuben det uppehåller sig (Blume, 2010). Konsekvensen blir att restprodukten från tanken innehåller större andel icke nedbrutet material jämfört med tuben. Att materialet befinner sig i olika faser längs med tuben gör att det bryts i större utsträckning ner än för fallet med tankformad rötningskammare (Blume, 2010). I figur 2 nedan visas en förenklad konstruktion av en tubformad rötningskammare.



Figur 2. Skiss över en biogasanläggning med tubformad rötningskammare.

4 Litteraturstudie

Utvecklingen av alternativa energikällor som biogas sker i ett komplext sammanhang där en kombination av faktorer som teknik, politiskt stöd, ekonomi och personlig drivkraft är essentiella för möjligheterna att lyckas (Akinbami et al., 2001).

4.1 Tekniska faktorer

Vid småskalig produktion av biogas i utvecklingsländer används olika typer av rötningskammare där de tre vanligaste typerna undersöks närmare i studien. Produktion av biogas optimeras utifrån flera drift- och processparametrar där de viktigaste tas upp och beskrivs mer detaljerat. Vidare ges en redogörelse av vilka typer av substrat som kan användas och hur samrötning av dessa kan resultera i en effektivare process.

4.1.1 Rötningskammare

De tre mest förekommande rötningskamrarna är *Chines fixed dome (CFD), Indian floating drum digester (IFD)* och *Polyethylene tubular digester (PTD)*.

CFD har en enkel design utan några rörliga delar och byggs antingen i tegel eller sten. Slurry tillförs genom inloppet till kammaren som består av ett eller flera fack. Gasen som bildas samlas i toppen av kammaren och skapar ett tryck som medför att slurryn pressas mot utloppet. När biogasen avlägsnas minskar trycket i kammaren och bidrar till en automatisk omrörning genom att slurryn förs från utloppet tillbaka in i kammaren (Surendra et al., 2013). CFD är den vanligaste kammaren i utvecklingsländer men är mer etablerad i Asien jämfört med Afrika. Den tidiga introduktionen samt materialkostnaden, vilken är billigare i Asien, har bidragit till den ökade etableringen (Ocwieja, 2010). Kammaren placeras vanligtvis under jord för att skyddas mot skador samt för att spara plats då den har en volym på mellan 4 och 20 m^3 (Surendra et al., 2013). Rötningskammaren har en livslängd på upp till 20 år (Rakotojaona, 2013).

IFD har en mer komplicerad konstruktion än CFD på grund av sin rörliga del men har fortfarande en relativ enkel konstruktion. IFD kan beskrivas som en stående cylinder bestående av en grundkonstruktion samt en flytande dom (Ocwieja, 2010). Grundkonstruktionen består ofta av betong eller tegel och den flytande domen är tillverkad i stål eller järn (Surendra et al., 2013). Slurrynivån hålls konstant då restprodukt tappas av motsvarande den volym som tillförs (Blume, 2010). Den bildade biogasen samlas i toppen och trycket hålls konstant genom den flytande domen som rör sig vertikalt. Det är möjligt att reglera trycket med hjälp av tyngder som placeras på domen (Blume, 2010), (Surendra et al., 2013). Biogasen förs ut genom ett rör i toppen av systemet. IFD har en volym på cirka 1,2 m^3 och en livslängd på mellan 5 och 15 år (Surendra et al., 2013).

Vanligtvis saknas omrörare i CFD och IFD men båda kan modifieras med en mekanisk omrörare, IFD kan även modifieras med en manuell omrörare (Surendra et al., 2013), (Blume, 2010). Genom att modifiera kamrarna förbättras förhållandet inuti kammaren då ackumulationen av skum på slurryytan minskar och samlingar av tyngre material på botten undviks (Surendra et al., 2013). När omrörare finns kan olika typer av substrat användas.

För att växtbaserat material skall kunna användas som substrat, krävs det att omrörare finns eftersom materialet annars samlas på botten av kammaren (Blume, 2010).

PTD har en tubformad design med ett 5:1 förhållande mellan längd och bredd (Surendra et al., 2013). Systemet består av en lång tub vanligtvis av polyeten (Ocwieja, 2010) och rörledningar för in- och utlopp som är tillverkade i PVC (Martí-Herrero, 2011). Biogasen samlas i det övre skiktet av tuben och förs ut genom ett anslutande rör (Surendra et al., 2013). Tuben är vanligtvis placerad i ett dike eller i en damm då det skapar bättre förutsättningar för strukturell stabilitet (Blume, 2010). Den genomsnittliga volymen på modellen ligger på mellan 2,4 och 7,5 m^3 (Surendra et al., 2013) och har en beräknad livslängd på tre år (Ocwieja, 2010).

Rötningskamrar kan kopplas samman med latriner för att kunna använda mänskliga fekalier som substrat. Användningen förbättrar de sanitära förhållandena då mänskliga fekalier innehåller smittförande mikroorganismer, patogener, vilka kan orsaka sjukdomar (Hällqvist, 2010). I nuläget finns det enligt Josefsson (2009) inga specifika riktlinjer om vilken utrustning och design som bör användas vid byggande och sammankoppling av latriner. Konstruktionen bör anpassas efter de lokala förutsättningarna som exempelvis tillgång på konstruktionsmaterial och användarnas ekonomiska förhållanden (Josefsson, 2009).

4.1.1.1 För- och nackdelar med olika rötningskammare

Rötningskamrarna som tidigare nämnts skiljer sig åt med avseende på design, material och konstruktion. Det går att peka på både för- och nackdelar med olika konstruktioner vilka bör tas i beaktning vid val av rötningskammare.

En fördel med CFD är att den inte har någon rörlig del, flytande dom, vilket minskar materialkostnaden då kostnaden för trumman är hög (Ocwieja, 2010). Den är även byggd under mark vilket skyddar systemet mot gasreducering vilket kan förekomma vid ackumulation av skum på slurryytan (Surendra et al., 2013). Faktorer som påverkar produktionen av biogas är att trycket inte är konstant i rötningskammaren vilket kan leda till gasläckage vilket är komplicerat att laga (Ocwieja, 2010). Främsta nackdelen med CFD är att endast djurdynga kan användas som substrat då omrörare saknas (Blume, 2010).

IFD har rörliga delar och en mer komplicerad konstruktion vilket bidrar till en högre kostnad. Driften av detta system är lättare än CFD och mindre kunskap krävs för att driva anläggningen då den är mer självgående (Ocwieja, 2010). Ytterligare en fördel med IFD är att trycket hålls konstant och risken för gasläckage är liten (Ocwieja, 2010). En nackdel är att den flytande domen är konstruerad i järn eller stål, vilket korroderar med tiden. Rost leder till ökade materialkostnader samt kräver underhåll (Ocwieja, 2010), (Surendra et al., 2013). Om kammaren modifieras med omrörare kan växtbaserat material användas vilket är en fördel för IFD som då kan använda fler sorters substrat (Blume, 2010).

PTD är en enkel konstruktion där trycket kan regleras genom att addera extra vikt (Ocwieja, 2010). Enligt Ocwieja (2010) är konstruktionen också billig och användaren kan själv se in i anläggningen vilket bidrar till en ökad förståelse för systemet (Ocwieja, 2010). Den enkla konstruktionen underlättar vid reparationer men nackdelen är att den är konstruerad i plast, vilket är mer ömtåligt än ovanstående biogassystem som är konstruerade i sten, betong eller

tegel, och har en kortare livslängd (Ocwieja, 2010). En annan nackdel med PTD är att den saknar omrörare och då inte kan använda sig av växtbaserat material som substrat (Blume, 2010).

4.1.2 Faktorer som påverkar processen

För att optimera processen vid småskalig produktion av biogas finns det olika typer av drift- och processparametrar att ta hänsyn till. De mest centrala parametrarna är torrsubstanshalt (TS-halt), glödförlust, temperatur, pH-värde, syretillgång, näringssammansättning och C/N-förhållande (Surendra et al., 2013), (Blume, 2010). Då biogasproduktion är en bakteriell process bör de fysiska förhållandena inuti rötningskammaren hållas konstanta för att skapa en optimal levnadsmiljö för de aktiva bakterierna (Blume, 2010).

Valet av substrat har stor betydelse för gasutbytet vid rötningsprocessen (Blume, 2010). Vid utvärdering av substratet används bland annat parametrarna TS och glödförlust. TS-halten anger andelen återstående föreningar i materialet då vatteninnehållet indunstats vid 105°C (Biogasportalen, 2014). Vilken TS-halt som lämpar sig bäst för processen varierar men generellt späds material med hög TS-halt, högre än 15 %, för att underlätta hanteringen (Carlsson and Uldal, 2009). Med hantering menas att materialet skall kunna transporteras genom kammaren i pumpar och ledningar samt att det skall fungera väl med omrörare. För att sänka TS-halten kan enligt Carlsson and Uldal (2009) en blandning av material med låg TS-halt, mindre än 10 %, användas som metod. Glödförlust används för att beskriva hur stor del av ett materials innehåll som är förbrännbart vid 550 °C (Biogasportalen, 2014). En hög glödförlust anger en hög andel organiskt material av den totala mängden TS. Som tidigare beskrivits bildas biogas vid nedbrytning av organiskt material och en hög glödförlust resulterar därmed i ett högt gasutbyte (Biogasportalen, 2014). Färskt substrat kan producera upp till 11 % mer biogas än torkat substrat. När substrat torkar försvinner 11 % av det organiska materialet vilket leder till minskad biogasproduktion (Day et al., 1990).

Vilken temperatur som råder i rötningskammaren är av betydelse då det har direkt inverkan på bakteriell aktivitet samt uppehållstid (Surendra et al., 2013). Generellt betyder högre temperatur kortare uppehållstid (Rakotojaona, 2013). Små, eller inga, temperaturvariationer är önskvärt då det skapar en trivsam levnadsmiljö för bakterier som då inte behöver använda sin energi till att anpassa sig till förändrade förhållanden (Blume, 2010). Temperaturen i rötningskammaren bör därför maximalt variera med 1 °C för att uppnå hög verkningsgrad (Surendra et al., 2013), (Blume, 2010). Vilket temperaturintervall som är mest optimalt för biogasproduktion råder det delade meningar om. Blume (2010) hävdar att en temperatur mellan 35 och 40° C är att föredra medan Rakotojaona (2013) rekommenderar en temperatur mellan 15 och 30° C.

Olika bakterier trivs bäst i olika pH-värden och värdet kommer därför att variera beroende på var i nedbrytningsprocessen slurryn befinner sig. Kammare som är konstruerade för att pH-värdet kan variera i olika delar av tanken är därför positivt (Blume, 2010). Det är dock svårt att kontrollera pH-värdet i rötningskammaren men oftast utgör detta inte ett problem (Rakotojaona, 2013). För att erhålla en hög verkningsgrad skall pH-värdet på det tillsatta substratet ligga mellan 6 och 7,8 (Surendra et al., 2013), (Blume, 2010), (Rakotojaona, 2013).

Eftersom rötning är en anaerob process är det viktigt att rötningskammaren hålls syrefri (Blume, 2010). Om syre läcker in kommer det att hämma de bakterier som är känsliga för syre vilket resulterar i en ineffektiv rötningsprocess. För att undvika detta problem är det viktigt att vid konstruktionen se till att kammaren är helt lufttät (Blume, 2010).

Vid rötning konsumerar bakterierna energi i form av olika näringsämnen. Dessa näringsämnen är bland annat kol, kväve, fosfor, mikronäringsämnen, vitaminer och spårämnen (Carlsson and Uldal, 2009). Carlsson menar också att det är viktigt att slurryn innehåller tillräckligt av dessa ämnen för att tillgodose bakteriernas energibehov. Restprodukten vid biogasproduktion används ofta som gödningsmedel och det är då en fördel om substratet innehåller höga halter näringsämnen (Carlsson and Uldal, 2009).

En annan viktig faktor för en effektiv biogasproduktion är förhållandet mellan kol, C, och kväve, N. C/N-förhållandet är optimalt mellan 20 och 30 då nedbrytning av substratet är effektivast (Blume, 2010). Vid lågt kväveinnehåll konsumerar bakterierna kvävet för att fylla sitt eget proteinbehov, och kolet passerar rötningskammaren utan att ha brutits ner vilket leder till att ingen biogas produceras (Blume, 2010). Vid högt kväveinnehåll bildar det överblivna kvävet ammoniak som bidrar till ett ökat pH-värde vilket hämmar produktionen. Det går dock att kompensera kvävehalten genom att tillsätta sågspån vid högt kväveinnehåll och mänskliga fekalier vid lågt kväveinnehåll (Blume, 2010). I tabell 1 nedan återfinns olika typer av råmaterial med motsvarande C/N-förhållande.

Tabell 1. Substrat med motsvarande C/N-förhållande (molärt eller viktmässigt) (Blume, 2010).

Råmaterial	**C/N-kvot**
Ankdynga	8
Mänsklig avföring	~ 8 (beroende på kost)
Hönsdynga	10
Getdynga	12
Grisdynga	18
Fårdynga	19
Dynga från ko eller buffel	24
Vattenhyacint	25
Elefantdynga	43
Halm från majs	60
Halm från ris	70
Halm från vete	90
Sågspån	över 200

4.1.3 Substrat

Varje år produceras cirka 38 miljarder ton organiskt avfall över hela världen (Suthar, 2010). Organiskt avfall från människor, djur och grödor kan användas som substrat till rötningskammaren och omvandlas till biogas. På så sätt minskas avfallshanteringen samtidigt som avfallet bidrar till biogasproduktion. Användning av organiskt avfall bidrar

till ett högt näringsinnehåll i restprodukten vilken kan användas som ett miljövänligt och effektivt gödningsmedel (Suthar, 2010). Hushåll som idag köper kemiskt konstgödsel kan spara pengar och bidra till ett miljövänligare jordbruk om restprodukten används som gödsel (Blume, 2010).

Vanligt i utvecklingsländer är att använda det substrat som finns lokalt tillgängligt vilket exempelvis är djurdynga, matavfall, restprodukter från jordbruk eller mänskliga fekalier (Surendra et al., 2013). Djurdynga lämpar sig bra för rötning då det har en hög fukthalt, 75 till 92 %, och hög glödförlust på mellan 72 och 93 % av TS-halten (Surendra et al., 2013). Värdena varierar dock beroende på djurets art och geografiska ort. Enligt Blume (2010) är det bästa substratet kodynga men tillgången kan vara begränsad, vilket resulterar i att andra substrat måste används som inte ger önskad biogasproduktion eller att produktionen helt uteblir (Blume, 2010). Även matavfall har en hög fukthalt, högre än 80 %, och en hög glödförlust på 95 % av TS-halten. I utvecklingsländer är dock tillgången på matavfall mycket begränsad vilket gör att det inte hör till ett av de mest använda substraten (Surendra et al., 2013).

Skörderester från jordbruk är ett substrat som produceras kontinuerligt och finns tillgängligt för biogasproduktion. Det är dock vanligt att använda resterna som föda till boskap, vilket gör tillgången begränsad (Surendra et al., 2013). Sammansättningen av skörderesterna varierar men har generellt låg fukthalt och hög glödförlust (Surendra et al., 2013). Beroende på mognadsgrad kräver skörderester längre uppehållstid i rötningskammaren för fullständig nedbrytning av det organiska materialet (Surendra et al., 2013), (Blume, 2010).

Mänskliga fekalier kan som nämnts tidigare användas som substrat för att producera biogas. För att erhålla en effektiv rötningsprocess krävs det att en latrin är sammankopplad med rötningskammaren (Surendra et al., 2013). Mänskliga fekalier har något lägre C/N-förhållande än optimalt men kan ändå användas för produktion av biogas (Josefsson, 2009). Mänskliga fekalier innehåller höga halter av näringsämnen jämfört med andra typer av substrat. Detta är effektivt för rötningsprocessen men resulterar även i en näringsrik restprodukt som med fördel kan användas som gödselmedel (Josefsson, 2009).

Det är möjligt att blanda olika typer av substrat för att erhålla ett optimalt förhållande mellan kol och kväve. Exempelvis har kodynga ett högre C/N-förhållande än optimalt men genom att blanda detta med mänskliga fekalier som har ett lägre C/N-förhållande, fås en blandning som vid rötning kan producera en större mängd biogas än om substraten hade genomgått processen var för sig (Josefsson, 2009).

När småskaliga biogasanläggningar introducerades lades enligt Rahman (2008) stor vikt vid att förenkla användningen av biogasen vid matlagning och för belysning. Hänsyn togs inte till att förenkla användandet av restprodukten vilket gör att den ibland läggs på deponi. Under de senaste åren har det genomsnittliga organiska materialet i jorden minskat och mer kemiskt konstgödsel används (Rahman, 2008), (Suthar, 2010). En ökad användning av restprodukten från biogasanläggningar som gödsel skulle bidra till mindre användning av kemiskt konstgödsel och öka jordens bördighet (Rahman, 2008).

4.2 Ekonomiska faktorer

De ekonomiska förutsättningarna för att kunna etablera och driva biogasanläggningar i utvecklingsländer ser olika ut i olika länder och varierar även mellan olika jordbruk (Gwavuya et al., 2012). Gemensamt är att många nyetableringar grundar sig på biståndsfinansiering, antingen genom organisationer eller genom statliga projekt (Buysman and Mol, 2013). Ofta ges bistånd till organisationer som driver ett biogasprogram vilket informerar om, bygger och utvecklar anläggningarna (Buysman and Mol, 2013). Biståndet bekostar programmet och en eventuell subvention till användarna. Finansiering av enskilda anläggningar sker sedan genom mikrolån eller privata finansieringar.

4.2.1 Ekonomiska förutsättningar

Den initiala investeringen är den största utgiften vid etablering av en biogasanläggning (Surendra et al., 2014). Utgiften för utrustning, där rötningskammaren är den enskilt största posten, är den största finansiella barriären för biogasprojekt (Bond and Templeton, 2011). Även efter den initiala investeringen finns det ekonomiska barriärer eftersom kostnader för underhåll och reparationer är svåra för ägaren att finansiera (Surendra et al., 2014).

Utöver kapital till den initiala investeringen, driftkostnader, reparationer och underhåll krävs det vissa materiella förutsättningar för att kunna driva en biogasanläggning som på sikt skall bli lönsam (Gwavuya et al., 2012), (Amjid et al., 2011). Den viktigaste aspekten är tillgången till substrat, där erfordrad mängd varierar med anläggningens storlek. En minimumnivå enligt Amjid et al. (2011) är att jordbruket skall bestå av minst två nötkreatur med en stabil tillgång på föda. Gwavuya et al. (2012) menar att det krävs minst fyra nötkreatur för att driva en biogasanläggning som är 4 m^3 stor och på motsvarande sätt sex nötkreatur för en anläggning på 6 m^3.

Förutsättningarna både ekonomiskt och materiellt påverkar intresset och möjligheterna att investera i en biogasanläggning (Gwavuya et al., 2012). För att övervinna den finansiella barriären rekommenderar Arthur et al. (2011) att ekonomiska incitament som mikrolån eller subventioner skall införas i ett inledande skede. Regeringen kan även ge stöd till lokala energiföretag eller organisationer som i sin tur regelbundet kan ge ekonomiskt och tekniskt stöd till inhemska ägare av biogasanläggningar. Det är ett tillvägagångssätt som varit framgångsrikt i Indien och Nepal, där tillväxten av biogasanläggningar har ökat när staten gått in och finansierat etableringen av nya anläggningar samt gett tekniskt stöd till dessa (Surendra et al., 2014).

4.2.2 Anläggningskostnader

Den totala utgiften för att etablera en anläggning varierar mycket mellan olika storlekar och olika typer av anläggningar. Rötningskammaren CFD är en relativt billig anläggning där utgiften varierar mellan 600 USD och 3 000 USD beroende på storlek. För andra typer, exempelvis IFD och PTD, kan priset variera mellan 3 000 och 4 500 USD för anläggningar med storleken 10 m^3 (Arthur et al., 2011), (Amjid et al., 2011), (Gwavuya et al., 2012).

Även om utgiften för att etablera en biogasanläggning kan variera mycket mellan olika länder har de gemensamt att den oftast är relativt hög i förhållande till ägarnas inkomst (Bond and Templeton, 2011). Den höga investeringskostnaden är en barriär då få hushåll har

ekonomiska förutsättningar (Arthur et al., 2011). Många hushåll på landsbygden är beroende av jordbruket för sin försörjning och har inte tillräckligt ekonomiskt kapital för att finansiera den initiala investeringskostnaden (Akinbami et al., 2001). I många biogasprogram uppgår investeringskostnaden för det enskilda hushållet till 500 till 550 USD och den årliga kostnaden beräknas till 70 USD. Dock är detta en liten del av den totala kostnaden då biståndsorganisationer står för den större delen (Akinbami et al., 2001) (Gwavuya et al., 2012).

Möjliga besparingar varierar beroende av typ av anläggning och storlek. Ju större hushåll desto mer fördelaktigt är det med biogas då kostnaden för alternativa energikällor är högre (Gwavuya et al., 2012). Enligt Akinbami et al. (2001) beräknas investeringen ge en årlig besparing på ungefär 160 USD medan Amjid et al. (2011) menar att den årliga besparingen är 640 USD. Den ekonomiska analysen motiverar den höga initiala kostnaden men bidrar ändå till att göra investeringen oåtkomlig för många avsedda användare (Akinbami et al., 2001). En annan skillnad mellan olika typer av anläggningar, kopplad till design och investeringskostnad, är livslängden. I många projekt har den valda modellen av rötningskammare haft en kortare livslängd än beräknat (Surendra et al., 2014). Den korta livslängden innebär att många anläggningar redan efter ett år är i behov av reparationer, vilket inte är ekonomiskt hållbart. Reparations- och underhållskostnaderna leder till att många anläggningar tas ur bruk eftersom ägaren inte har råd att byta ut de delar som gått sönder och får inte heller ekonomiskt stöd då staten eller organisationen endast finansierar etableringen (Surendra et al., 2014).

Anläggningarnas livslängd är en viktig ekonomisk faktor då det påverkar anläggningens möjlighet att bli lönsam. Beroende på förutsättningarna och anläggningens storlek blir investeringen lönsam efter 4 till 10 år (Gwavuya et al., 2012) vilket betyder att det krävs en beräknad livslängd som överstiger detta för att projekten skall bli lönsamma. Vissa typer av anläggningar har kortare livslängd vilket innebär sämre möjligheter att nå lönsamhet. Biswas and Lucas (1997) redogör för problem med anläggningar i Bangladesh där lönsamheten ligger efter anläggningens beräknade livslängd, vilket inte är ekonomiskt hållbart. Då möjligheten till besparingar inte finns är varken biståndsorganisationer eller hushåll villiga att investera i anläggningar. För att lyckas menar Biswas and Lucas (1997) att kostnaden för rötningskammaren behöver minska med 65 %. De skriver även att det går att vända på det så att om kammarens livslängd hade varit längre hade investeringen lönat sig.

4.2.3 Ekonomiska effekter av biogas

Ett hushålls energibehov och den nuvarande energiförsörjningen påverkar både förutsättningarna och intresset för biogas (Gwavuya et al., 2012). Gwavuya et al. (2012) menar att hushåll som idag betalar för sin energikälla har bättre förutsättningar vid omställning till biogas i jämförelse med hushåll som samlar ved eftersom de inte använder något ekonomiskt kapital till sin energiförsörjning. Samma slutsats drar även Owekisa (2008) för anläggningar finansierade genom mikrolån. Om månadskostnaden för energi för en användare blir lägre genom investering i en biogasanläggning jämfört med att köpa kol, ved eller någon annan energikälla ökar efterfrågan på biogas.

4.2.4 Bistånd och subventioner

Med tanke på de långsiktiga fördelarna med biogasteknik ekonomiskt, miljömässigt och tidsbesparande, är det bra att överbrygga de höga investerings- och underhållskostnader som finns vid införandet av biogasteknik (Akinbami et al., 2001).

Ett flertal småskaliga biogasprogram i utvecklingsländer är biståndsfinansierade och bygger på antagandet att de finansiellt skall tas över av lokalbefolkningen eller staten när projektet visar sig vara lönsamt (Buysman and Mol, 2013). Buysman and Mol (2013) menar att lönsamheten är tänkt att skapa motivation för invånarna där projektet etablerats och att få dessa att fortsätta investera i projektet. I praktiken finns dock många fall där projekten övergetts då donationerna upphört.

4.2.5 Lån

Utgiften för en biogasanläggning kan i vissa utvecklingsländer finansieras genom att hushållen tar ett mikrolån (AMDI, 2012). Banker, institutioner, organisationer och privata investerare kan alla fungera som långivare i olika utsträckning. För att främja utvecklingen på energimarknaden, särskilt på landsbygden, kan det vara nödvändigt att införa ekonomiska incitament (Akinbami et al., 2001). Sådana incitament inkluderar mikrolån och subventioner på tekniken, både direkt och indirekt.

För att underlätta för banker och hushåll är standardiserade lån en möjlig väg då de är enklare att förstå och administrera enligt Owekisa (2008). För att skapa goda förutsättningar för lån är det viktigt att bankerna använder sig av marknadsundersökningar och support utifrån, med kunskap om biogasanläggningar och hushållens situation. Speciellt då förståelsen för biogas och konsumentens speciella behov är liten. Vidare menar Owekisa (2008) att för att lyckas med investeringen genom mikrolån är det av stort intresse att utbilda användarna i hur banker och låntagande fungerar. Det är även viktigt att tydligt visa skillnaden mellan lån och subventioner för att minska missförstånd och öka möjligheter för banken att få tillbaka sina pengar.

Nepal är ett av många länder där möjligheten att finansiera en biogasanläggning via mikrolån finns (Surendra et al., 2014). Där har över 260 mikrolånsinstitutioner hjälpt lokalbefolkningen med den finansiella delen av etableringen vilket har lett till att Nepal idag är det land i världen som har högst antal småskaliga anläggningar per capita. Exempel på sådana institutioner är utvecklingsbanker, mikrofinansierade banker och kooperativ. Enligt Surendra et al. (2014) har det fungerat väl i Nepal då dessa institutioner har haft en nära relation till låntagarna vilket har lett till att tiden som spenderas på vägledning och utbildning kring dels lånen men även anläggningarna har kunnat reduceras. För den fattigare delen av befolkningen i Nepal har det varit bekvämare och säkrare att ha kontakt med mindre enheter som kooperativ än exempelvis en bank då det varit lättare för de att få hjälp samt att få kontakt med rätt personer när de behövt (Surendra et al., 2014).

4.3 Sociala faktorer

Sociala faktorer innebär drivkrafter för investering i biogas, vikten av utbildning, marknadsföring, acceptans av ny teknik samt genusperspektiv.

4.3.1 Sociala drivkrafter

Biogasteknik ses som en drivkraft för utveckling och förbättring av situationen i utvecklingsländer. Enligt Surendra et al. (2013) har biogasanläggningar både hälsomässiga och sociala fördelar som reducerad arbetsbörda för kvinnor och flickor, besparing av tid samt minskad förekomst av rök i hemmet, vilket leder till färre hälsoproblem. Studier från olika länder visar att sociala fördelar påverkar hushållens beslut om etablering av biogas som energikälla. Både en undersökning av Prokaushali Sangsad (2010) från Bangladesh och av AMDI (2012) från Vietnam visar att de främsta anledningarna för etablering av biogasanläggningar är gas för matlagning, minskade energikostnader, förbättrad inomhusmiljö samt egenproduktion av gödsel. Vidare menar AMDI (2012) att de främsta faktorerna för att biogas inte etableras är brist på kapital, för lite boskap eller för att kunskap om fördelarna med biogastekniken saknas. Studien från Vietnamn visar även att biogasen främst används till matlagning medan belysning är ett mindre användningsområde.

Biogas har haft en gynnsam inverkan på hushåll utifrån flera olika aspekter. Enligt studien av Prokaushali Sangsad (2010) ansåg 76 % av de tillfrågade hushållen i Bangladesh att inomhusmiljön har förbättrats och 80 % av hushållen hade fått en ökad produktion av grödor genom att använda restprodukten som gödningsmedel. Även studien från Vietnamn gjord av AMDI (2012) visar på sociala förbättringar för hushållen efter etablering av biogasanläggningar. Samma studie visar även att 80 % av hushållen har fått renare inomhusmiljö samt förbättrad luftkvalité genom mindre damm, sot och rök i hemmet. Dessutom har 88 % av hushållen minskat sin anvädning av andra energikällor.

4.3.2 Marknadsföring

För att hushållen skall få kunskap om biogas och om fördelarna med etablering av anläggningar krävs spridning av information. Enligt Kahubire et al. (2010) fick 78 % av hushållen i Uganda information om energibesparande tekniker. Av de har 59,1 % fått informationen via organisationen NGO, 14,3 % via radio eller tv och 9,5 % fick informationen via lokala samlingar. Studien av AMDI (2012) visar att majoriteten i Vietnamn fick information om biogas via släktingar, vänner eller lokala myndigheter och anställda inom biogasorganisationer. Mindre än 1 % av de tillfrågade hushållen i Vietnamn har fått information via massmedia. En studie från Pakistan gjord av Amjid et al. (2011) visar att projekt som har marknadsförts genom olika kanaler har lyckats bättre än projekt som inte har gjort det. Ytterligare visar studien att om samarbete mellan intressenter saknas och det inte finns en tydlig informationssamordning försvårar det etablering av biogas. Amjid et al. (2011) skriver även att en nationell policy är nödvändig för att öka framgången av etablering av biogasanläggningar. Detta stöds av undersökningen från Nigeria gjord av Akinbami et al. (2001) som menar att ett välorganiserat statligt ramverk och intensiva utbildningar och kampanjer är viktigt för biogasprojekt i landet.

4.3.3 Statligt stöd

Ett statligt stöd är en viktig aspekt för att långsiktigt kunna driva biogasanläggningar (Buysman and Mol, 2013). Buysman and Mol (2013) menar att om organisationer etablerar anläggningar krävs det ett statligt program för att fastställa och upprätthålla kvalitetsnormer för rötningskammare, stödtjänster och spridning av information om biogasteknik. Ett statligt

ägande och övertagande av biogasprogrammen är enligt Buysman and Mol (2013) en viktig aspekt för att säkerställa att projekten består långsiktigt då biståndsorganisationer förr eller senare kommer att lämna landet eller skifta fokus.

Flera studier visar att biogasprojekt ofta misslyckas om det inte finns ett statligt stöd, både politiskt och under en längre tid även ekonomiskt (Amjid et al., 2011). I Afrika har många biogasprojekt misslyckats på grund av att staten varken har stöttat tekniken genom sin energipolitik eller haft en tydlig policy för förnybara energikällor. Program har misslyckats på grund av minskat statligt bidrag och höga materialkostnader (Amjid et al., 2011) (Arthur et al., 2011). Även utvärderingar av ett projekt från Pakistan visar hur viktig statens inverkan är (Bond and Templeton, 2011). Under projektet installerades och drevs över 4 000 anläggningar genom att staten finansierade projektet under den tid då det pågick. Efter något år slutade staten bidra med finansiellt stöd och projektet misslyckades, bland annat på grund av brist på teknisk kunskap, höga kostnader och bristande samarbete.

Nepal är ett av de länder där staten hjälpt till både finansiellt och tekniskt samt fortsatt med det. Det har lett till att Nepal idag är ett av de utvecklingsländer som producerar mest biogas per capita och där intäkterna från projektet har gått till att genomföra ytterligare spridning av biogasteknik i landet (Surendra et al., 2014).

För att lyckas med en hållbar biogassektor krävs det att den förr eller senare blir självförsörjande. Många biogasprogram är idag beroende av extern finansiering genom bistånd eller statligt stöd för att kunna drivas då investeringen och de årliga driftskostnaderna blir för höga för hushållen (Akinbami et al., 2001).

4.3.4 Acceptans

En barriär för etablering av biogasanläggningar i utvecklingsländer är enligt flera studier acceptans för biogas framställd från mänskliga fekalier. Resultatet från en undersökning av Prokaushali Sangsad (2010), visar att acceptansen för att koppla en latrin till en biogasanläggning var låg i Bangladesh. 93 % av de tillfrågade hushållen föredrog att inte koppla latrinen till anläggningen eftersom de ansåg att det är ohygieniskt eller för att de hade tillräckligt med kogödsel för att täcka hushållets behov av biogas. Även i Ghana är acceptansen låg för att använda mänskliga fekalier som substrat enligt Arthur et al. (2011). I Uganda menar dock Kahubire et al. (2010) att acceptansen varierar mellan olika geografiska områden. I områden utan tillräckligt med betesmarker är acceptansen högre.

En annan barriär i Nigeria är enligt Akinbami et al. (2001) motstånd mot förändring och införande av ny teknologi. Studien visar också att möjliga orsaker till detta var oviljan att byta välkänd teknik mot okänd samt tveksamhet på grund av eventuella faror som gas kan innebära.

4.3.5 Utbildning

Utbildningsnivån hos hushållen påverkar enligt Akinbami (2001) etableringen av biogasanläggningar i Nigeria. Författarna visar att den låga andelen läskunniga i byarna hindrar etableringen eftersom spridningen av information begränsas. AMDI (2012) menar att utbildningsnivån för hushåll i Vietnam som äger en biogasanläggning är relativt hög vilket även en studie från Uganda visar (Kahubire et al. (2010)). Både rapporten från

Vietnamn och från Uganda visar att majoriteten av ägarna har högstadieutbildning. Enligt AMDI (2012) hade 50 % av de manliga och 57 % av de kvinnliga beslutstagarna högstadieutbildning. Studien visar även att endast 3,5 % av ägare var analfabeter. Den låga andelen analfabeter som innehar en biogasanläggning stöds även av Kahubire et al. (2010) där endast 8,4 % av de tillfrågade hushållen med biogasanläggning i Uganda var analfabeter, jämfört med Ugandas genomsnittliga andel analfabeter som är 32 %.

Kunskap om anläggningen är viktigt för framgångsrik etablering. Enligt AMDI (2012) hade hälften av de tillfrågade hushållen i Vietnamn inte fått någon utbildning gällande drift och underhåll av anläggningen. Yttligare hävdar en undersökning av Dohoo et al. (2012) genom ett projekt i Indien att deltagarna var mer måna om att sköta underhållet av anläggningen om de praktiskt fick vara med och se fördelarna med biogas. Studien visar även att det är viktigt att demonstrera anläggningen på plats för att övertyga befolkningen om att använda den nya tekniken. Andra anledningar till att program har misslyckats är för att ansvariga har otillräcklig praktisk och teoretisk utbildning samt låg motivation (Amjid et al., 2011). Arthur et al. (2011) menar att vissa program misslyckas eftersom underhåll och hantering av anläggningarna är bristfällig.

4.3.6 Genusperspektiv

Flera studier konstaterar att biogas har en positiv inverkan på kvinnors situation. Enligt AMDI (2012) sparar hushållen tid genom att använda biogas eftersom kvinnorna inte behöver samla ved, matlagningen går snabbare och mindre städning krävs genom att inomhusmiljön förbättrades. Tiden som sparas kan användas för att öka levnadsstandarden och undersökningen visade att 70 % av de tillfrågade använde tiden till att ta hand om barnen och 30 % använde tiden till inkomstgenererande sysslor. En undersökning från Etiopien visar att hushållen i genomsnitt lägger ner tolv timmar per vecka för insamling av material för energiframställning och vid användning av biogas kan tiden halveras (Gwavuya et al., 2012).

Flera undersökningar visar att mannen oftast är beslutstagaren vid införskaffandet av en biogasanläggning (Prokaushali Sangsad, 2010), (AMDI, 2012), (Kahubire et al., 2010). Trots det anser majoriteten av hushållen att både mannen och kvinnan hade ansvar för drift och underhåll enligt Prokaushali Sangsad (2010). Kahubire et al. (2010) menar dock att männen i Uganda är ensamt ansvariga för drift och underhåll. Vidare menar Kahubire att kvinnorna ändå gör hälften av det arbete som krävs för drift och underhåll men att deras arbete försvåras när männen inte är hemma eftersom de inte har den kunskap som krävs.

5 Metod, fältstudier

Syftet med fältstudierna är att komplettera litteraturstudien genom att i praktiken studera specifika biogasprojekt. I litteraturstudien framkom tydliga skillnader vid etablering av biogasanläggningar i Afrika och Asien, med avseende på geografi, kultur samt drivkrafter bakom projekten. Därför har ett flertal organisationer och företag från båda världsdelarna kontaktats. Att Kambodja och Kenya valdes berodde på stabil kontakt samt möjlighet till hjälp under fältstudierna.

Fältstudier har genomförts under tre veckor i Kambodja och i Kenya, med två gruppmedlemmar i varje land. I Kambodja har studien utförts genom den nationella biogasorganisationen NBP och i Kenya genom biogasprogrammet KENDBIP samt företaget Takamoto Biogas.

Fältstudierna bygger på intervjuer med hushåll som använder sig av småskaliga biogasanläggningar samt ansvariga på företag och organisationer i respektive land. För att identifiera brister och täcka in olika typer av kompetenser har olika delar inom varje företag respektive organisation intervjuats. Intervjuerna har transkriberats för att minska risken att viktig information bortfaller. Transkriberingar av samtliga intervjuer finns bifogade i bilaga 2 och 3.

5.1 Intervjuer

Fältstudierna har utförts i två länder med olika organisationer, vilket har påverkat vilket material och vilken information som samlats in. För att erhålla liknande förutsättningar för samtliga intervjuer och minska risken för skillnader mellan de två fältstudierna har intervjuerna baserats på förbestämda frågor, se bilaga 1. Frågorna är baserade på litteraturstudien för att kunna göra en jämförelse mellan litteraturstudien och fältstudierna. Frågor som under fältstudierna visat sig vara relevanta har lagts till efter hand. Intervjufrågorna är strukturerade enligt följande övergripande kategorier:

- Tekniska faktorer
    - Drift
    - Underhåll
    - Tekniska problem
    - Konstruktion av en biogasanläggning
    - Rötningskammare
    - Substrat
    - Faktorer som kan påverka processen
- Ekonomiska faktorer
    - Ekonomiska förutsättningar
    - Kostnader för anläggningen
    - Lönsamhet av biogas
    - Finansiering
    - Statligt stöd
- Sociala faktorer
    - Drivkraft för att investera i en biogasanläggning
    - Användningsområden

- Utbildning
- Marknadsföring
- Acceptans
- Genusperspektiv

Intervjufrågorna har skrivits för att vara relevanta utan att vara missvisande eller ledande. Frågorna har i under studiens gång reviderats för att anpassas till förutsättningarna i respektive land. Följdfrågor och frågornas ordningsföljd kan skilja sig åt mellan intervjuerna beroende på vilken information som kommit fram under samtalet. I samband med att ett hushåll intervjuas har även dess biogasanläggning observerats. Intervjuerna har genomförts på engelska, spelats in och därefter transkriberats. Teori och upplägg för kvalitativ intervjumetodik var för omfattande för att kunna inkluderas i projektet och kom därför inte att granskas.

5.1.1 Kambodja

I Kambodja har en programkoordinator från NBP och en huvudkoordinator på provinsnivå samt hushåll med och utan installerad biogasanläggning intervjuats. Intervjuerna i Kambodja har utförts tillsammans med en doktorand från Sheffield University, England, och en representant från NBP som hjälpte till med översättning. Totalt har 20 hushåll intervjuats, 13 med en biogasanläggning och sju utan. Lämpliga hushåll för intervju bestämdes inte i förväg utan bestämdes av NBP efter tillgänglighet. Alla hushåll tillhör samma program och därför finns många likheter varför frågor angående finansiering, typ av anläggning samt livslängd inte var relevanta. Fältstudien har genomförts i provinsen Kampong Speu, i de två kommunerna Kaheng och Tang Kroch.

5.1.2 Kenya

I Kenya har personer inom tre olika områden intervjuats: representanter från företaget och organisationen, murare samt hushåll med biogasanläggning. Företag och organisationer som har intervjuats i studien är KENDBIP och Takamoto Biogas. Representanter från dessa har närvarat vid samtliga intervjuer med hushåll och murare. Totalt har 14 hushåll och sex murare intervjuats. Fältstudien har genomförts i Nairobi, Kiambu och Nakuru.

5.2 Tolkning av resultat

Resultatet från fältstudierna baseras på transkriberade intervjuer från respektive land. Transkriberingarna från intervjuerna i Kambodja är inte ordagrant återgivna eftersom engelskan inte var flytande. Det medför en risk för feltolkningar som är större än för studien från Kenya, vilket har tagits i beaktning vid tolkning av resultatet. I valet av hushåll har organisationerna i båda länderna bestämt vilka som är lämpliga för intervju, vilket gör det möjligt för dem att välja hushåll som är fördelaktiga att visa upp. Representanter från företag eller organisationer har varit närvarande under intervjuerna vilket kan påverka den intervjuades svar. Vilka som närvarat under respektive intervju framgår i transkriberingarna i bilaga 2 och 3. Antalet intervjuade hushåll i studien är begränsat vilket påverkar underlaget för resultatet.

6 Fältstudie, Kambodja

Cambodia National Biodigester Programme (NBP) är ett nationellt biogasprogram som startades som en gemensam satsning av Ministry of Agriculture, Forestry and Fisheries (MAFF) och Netherlands Development Organization (SNV). NBP är även en del av Asia Biogas Programme (ABP) vars mål var att mellan 2005 och 2012 förse 1,3 miljoner människor i Asien med biogas. NBPO, huvudkontoret hos NBP, ansvarar för att påbörja, samordna och kontrollera arbetsuppgifter för programmet inom marknadsföring, utbildning, forskning samt utveckling. I varje provins finns regionala kontor, PBPO, som ansvarar för samordning på regionalnivå (NBP, 2011).

År 2004 beslutade SNV att etablera ett nationellt biogasprogram i Kambodja. Bakgrunden till beslutet var att konsumtionen av ved som bränsle inte ansågs hållbar för landets skogar. Majoriteten av hushållen i Kambodja har två eller fler boskap vilket gör det möjligt att driva en anläggning, samtidigt som boskapen innebär en finansiell säkerhet. En tredje faktor för beslutet var att öka levnadsstandarden i hushållen, framförallt för kvinnor, genom förbättrad inomhusmiljö och minskad arbetsbörda. Biogasanläggningar har etablerats i Kambodja sedan 2006 och fram till och med november 2013 har totalt 20 198 biogasanläggningar etablerats (NBP, 2011).

6.1 Tekniska faktorer, Kambodja

År 2005 valde NBP att anlita konsultfirman ILI Consulting Engineers Mekong Ltd för att undersöka vilken modell av biogasanläggning som var bäst lämpad att använda. Kambodja Fixed dome var den modell som rekommenderades eftersom den ansågs vara mest passande för det rådande klimatet. Idag använder NBP modellen *Farmers Friend Biogasdigester Model of Cambodia* (FFB), se figur 3 nedan. FFB är en modifierad modell av Fixed dome som är anpassad för att fungera optimalt i Kambodja. De största modifikationerna som gjorts är en ökning av kapaciteten för gaslagring, för att tillgodose det dagliga behovet av gas, samt ändring av den genomsnittliga uppehållstiden för att anpassas till klimatet. Kostnaderna för biogasanläggningen har även optimerats genom att ändra storleken på inloppsrören till anläggningen samt tjockleken på plasten (NBP, 2011).

Figur 3. Biogasanläggning under konstruktion, Kampong Speu, Kambodja.

Storleken på FFB varierar mellan 4 och 15 m^3 och konstruktionen består av två inloppsrör, ett för djurdynga och ett inloppsrör som ger hushållen möjligheten att koppla anläggningen till en latrin. Koppling mellan anläggning och latrin rekommenderas av NBP eftersom det förbättrar saniteten runt hushållet, ökar mängden gas som kan produceras, dödar patogener i kammaren (NBP, 2011).

Enligt Sophan[1], huvudkoordinator på PBPO i provinsen Kampong Speu, används samma typ av anläggning till alla hushåll i Kampong Speu eftersom det är en populär modell, den är enkel att använda och modellen är prisvärd för hushållen. Utöver FFB används enligt Sophan även modellen *Plastic bag* i begränsad omfattning. Sophan menar att Plastic bag inte är användbar för hushållen i Kambodja eftersom livslängden endast är ett år, den luktar och gasen går inte att använda till biogaslampor. Anledningen till att Plastic bag luktar är eftersom allt substrat inte omvandlas till metan vilket sker i FFB. Det beror på att bottnen i Plastic bag är platt vilket skapar sämre flöde än i FFB som är rundad. Samtliga biogasanläggningar som installeras i Kambodja idag byggs under markytan och täcks med jord, enligt Sophan för att anläggningen då skyddas bättre från solljus och mindre konstruktionsmaterial behövs.

6.1.1 Substrat

Ett gynnsamt C/N-förhållande för produktion av biogas är 20 till 30. Kodynga eller grisdynga är de mest lämpade substraten då tillgången är hög i landet och de har ett bra C/N-förhållande. Substrat som tillsätts skall vara neutralt eftersom bakterierna inte överlever annars. Material som har sura eller basiska pH-värden som tvål och andra kemikalier skall undvikas (NBP, 2011).

Då FFB är färdigställd skall den förses med 1,5 ton djurdynga[1]. Därefter dröjer det tio dagar innan hushållen kan börja använda gasen som produceras[1]. För att driva anläggningen skall den förses med 20 till 30 kg djurdynga dagligen[1]. Det är även viktigt att trycket i kammaren aldrig understiger 2 kPa. Djurdynga eller mänskliga fekalier får endast användas som substrat i anläggningen, vilket beror på att hushållsavfall kan leda till att anläggningen går sönder (NBP, 2011).

För att bakterier skall kunna omvandla organiskt material till biogas krävs det att vatten tillsätt i förhållande 1:1, till 20 kg djurdynga måste 20 kg vatten tillsättas (NBP, 2011). Sophan[1] menar att inget hushåll i provinsen Kampong Speu har problem med att förse anläggningen med vatten. Samtliga hushåll i studien får vatten via brunnar, dammar eller vattendrag och inget av de tillfrågade hushållen svarade att tillgång till vatten är ett problem. Innan hushållen hade biogasanläggning användes djurdyngan som gödsel för risodling[1]. Restprodukten från anläggningen är enligt Sophan ett bättre gödningsmedel då den innehåller mer näringsämnen vilket skapar en högre kvalité än djurdynga och plantan har lättare att absorbera restprodukten än vid gödsling med ren djurdynga.

Samtliga intervjuade hushåll har en biogasanläggning som är 4 eller 6 m^3 och majoriteten av hushållen äger fem eller sex kor. Två av hushållen äger tre kor och två av de tillfrågande

[1] Khy Sophan, (Head of Coordinator, PBPO) intervjuad av författaren 25 mars 2014

hushållen äger även grisar. Resultatet från intervjuerna visar att majoriteten av hushållen har tillräckligt med biogas för att täcka det dagliga behovet och hushållen anser att storleken på anläggningen är lämplig. De två hushåll som enligt intervjuerna inte har tillräckligt med biogas beror i det ena fallet på att antal djur inte var tillräckligt, hushållet äger endast tre kor. I det andra hushållet var anledningen att de är många i familjen, tio medlemmar, vilket gör att biogasen inte alltid räcker till. I tabell 2 nedan följer en sammanställning av anläggningen i Kambodja.

Tabell 2. Sammanställning av anläggning i Kambodja (NBP, 2011).

Användare	Tillhörande organisation	Design	Modell	Storlek [m^3]	Mängd substrat [kg/dag]	Framställd gas [liter/kg kodynga]
Hushåll	NBP	Fixed dome	FFB	4	20-40	40
Hushåll	NBP	Fixed dome	FFB	6	40-60	40

6.1.2 Underhåll

Livslängden för FFB är 20 till 25 år och enligt Sophan[1] är problem med biogasanläggningarna mycket ovanligt. Sophan förklarar även att det är ungefär 10 av 2 000 anläggningar som går sönder, oftast på grund av för mycket gas inuti kammaren vilket leder till läckage. För att underhålla anläggningen har hushållen ansvar för att dagligen förse den med substrat, se till att den är täckt med jord, speciellt under regnperioden, samt rengöra utlopp[1].

Tio av hushållen har inte haft problem med anläggningen. Två av hushållen angav att de har haft problem med kammaren men att de har reparerat anläggningen på egen hand. Ett annat hushåll använde inte anläggningen under ett år eftersom de inte hade några kor under den perioden. Samma hushåll berättade även att anläggningen sedan var tvungen att repareras för uppstart vilket utfördes på egen hand. En undersökning gjord av NBP visar ett endast sex av 150 hushåll som tillfrågades har haft problem med anläggningen (Mansvelt et al., 2012).

6.2 Ekonomiska faktorer, Kambodja

Kostnaden vid etablering av en biogasanläggning innefattar för hushållen byggnadsmaterial och arbetskraft (NBP, 2011). En 4 m^3 anläggning kostar utan subvention 550 USD att bygga och en 6 m^3 uppgår till 620 USD. I priset ingår en biogasspis samt en biogaslampa. Av den totala kostnaden uppgår priset för arbetskraft till mellan 80 och 90 USD per anläggning (NBP, 2014). Den exakta kostnaden beror på det lokala marknadspriset eftersom byggnadsmaterialet inhandlas lokalt. Enligt Soeleng[2] har marknadspriserna för material ökat under de senaste åren och kommer fortsätta att öka.

Drift och underhållskostnader för en anläggning består av löner och materialkostnader, insamling och transport av substrat, vattentillförsel, tillförsel av substrat till anläggningen

[2] Lam Soeleng, (Programme Coordinator, NBP) intervjuad av författaren 28 mars 2014

samt underhåll och reparation vid problem. Driftkostnaderna är försumbara så länge substrat inte behöver köpas in (NBP, 2011).

Enligt en rapport från NBP har antalet hushåll med biogasanläggning som använder sig av en annan energikälla utöver biogas för matlagning sjunkit från 51 % till 18 % (NBP, 2011). Hushåll som tidigare använde ved sparar idag i genomsnitt 11,49 USD per månad. Totalt kan biogasanvändare spara 14,55 USD på bränsle och kemiska gödningsmedel. Fortfarande är det dock 86 % som använder andra energikällor än biogas för belysning (Mansvelt et al., 2012).

6.2.1 Finansiering av anläggning

För att finansiera en biogasanläggning erbjuder NBP, genom olika finansinstitutioner, mikrolån till hushållen. Enligt Sophan[1] finansieras idag hälften av anläggningarna kontant och hälften via lån. Genom samarbete med två mikrofinansinstitutioner kan hushållen ta lån för investering av en biogasanläggning med ränta på 1.2 % (NBP, 2011).

En del hushåll har enligt Soeleng[2] problem med att få lån eftersom det krävs en säkerhet av hushållen för att finansinstitutionerna skall bevilja lån. Hushållens säkerhet är ett ägandebevis på att de äger sin mark. Många hushåll har inte de ägandebevis som krävs och det kostar pengar att få dem utfärdade. Ett annat problem för hushållen är att deras ägandebevis inte kan delas mellan olika företag vilket gör det svårt för dem att få lån om de redan är belånade. Soeleng menar dock att det här är ett problem som på sikt skall lösas genom bättre administration mellan olika finansinstitutioner och banker.

Ett annat problem är att alla hushåll inte förstår förutsättningarna i kontrakt och fakturering (Mansvelt et al., 2012). 23 % av de tillfrågade hushållen hade inte förstått innebörden och 9 % var förvånade över kostnader och avgifter kopplade till lånet.

6.2.2 Subvention

För varje anläggning som byggs subventionerar NBP med 150 USD. När anläggningen är färdigställd visar hushållen upp ett intyg på att de har en biogasanläggning och får då tillbaka 150 USD, vilket gör att hushållen i slutänden betalar 400 USD för en 4 m^3 anläggning istället för 550 USD (NBP, 2011). Subventionen används främst för att kvalitetssäkra produkten, minska hushållens utgift samt som marknadsföring för att locka nya hushåll att investera i en biogasanläggning (NBP, 2011). Enligt Soeleng[2] har NBP de senaste åren fått mindre bistånd från SNV på grund av den ekonomiska krisen 2008 och även på grund av minskade utsläppsrätter. Soeleng menar att NBP därför kommer vara tvungna att sänka subventionerna till 100 USD.

6.2.3 Garanti

NBP ger hushållen en garantitid på ett år för tillbehör och två år för grundkonstruktionen. Under garantitiden står NBP för alla kostnader vid eventuella problem. Efter att garantitiden gått ut får hushållen själva betala för kostnaderna (NBP, 2011). En medelkostnad för reparation är enligt Sophan[1] 13 till 15 USD.

6.3 Sociala faktorer i Kambodja

Sociala faktorer fungerar som drivkrafter för etablering av biogasanläggningar. Nedan följer en sammanställning över sociala faktorer som energisituation, användningsområden, utbildning och marknadsföring i Kambodja.

6.3.1 Energikällor

Kambodja har få exploaterbara energikällor i landet förutom biomassa. Skog står för 80 % av landets totala energianvändning. Fossila bränslen som olja och diesel importeras för att användas för transporter och elproduktion och exploatering av naturgas ute till havs förväntas inte påbörjas inom de fem närmaste åren (NBP, 2011). Hushållen i Kambodja står för 84,4 % av användningen av biomassa, främst för matlagning. Ved och kol står idag för 96,3 % av energikällorna som används vid matlagning, främsta anledningen är det låga priset (NBP, 2011). Den stora användningen av kol och ved har gjort att skogarna i Kambodja minskar kraftigt. Förutom skogsskövling är de främsta konsekvenserna av vedeldning, obalans i ekosystemet, ökade kostnader för energikällor, ökad arbetsbörda för insamling av ved samt hälsoproblem på grund av dålig luftkvalité (NBP, 2011). I figur 4 nedan visas en bild över ett kök med vedeldning.

Figur 4. Kök för matlagning i hushåll utan biogasanläggning, Kampong Speu, Kambodja.

Etableringen av biogasanläggningar för hushåll i Kambodja bidrar på en global nivå till minskad påverkan på klimatet och den globala uppvärmningen. På nationell nivå resulterar etablering av biogasanläggningar till minskning av skogsskövling, jordbruksproduktionen ökar, nya arbetstillfällen skapas och importen av fossila bränslen och gödningsmedel kan minskas. För hushållen i Kambodja innebär installation av biogas minskad arbetsbelastning,

en restprodukt som kan användas som gödsel och en ökad produktion av grödor (NBP, 2011).

Kambodja har god potential för etablering av biogasanläggningar eftersom landet har varmt klimat, god tillgång till konstruktionsmaterial och hög tillgång till substrat från djurdynga hos hushållen. Teknisk kunskap finns och tillgången på vatten finns via brunnar eller lokala dammar (NBP, 2011).

6.3.2 Användningsområden för biogas

I Kambodja används biogasen främst för matlagning men i viss mån även för belysning med biogaslampor. För tillagning av mat under en timme med en biogasspis krävs 350 till 400 liter biogas vilket kräver ungefär 10 kg kodynga (NBP, 2011). Restprodukten från biogasanläggningen fungerar bra som gödsel och har många fördelar för jordbruket. Restprodukten är luktfri och drar inte till sig insekter eller termiter och den minskar tillväxten av ogräs. Den har även bättre effekt som gödningsmedel vid jämförelse med djurdynga eller kemiska gödningsmedel. Andra fördelar med restprodukten är att den ökar näringsämnena i jorden och den är fri från patogener. Användning av restprodukten från biogasanläggningar leder till ökad produktion av grödor (NBP, 2011).

Figur 5. Installerad biogasspis, Kampoung Speu, Kambodja.

Samtliga av de tillfrågade hushållen i studien använder biogasen för matlagning, se figur 5 för bild av biogasspis. Innan hushållen ägde en anläggning användes istället ved. Fyra av hushållen med biogasanläggning använder även biogas för belysning med biogaslampor och resterande hushåll använder elektricitet eller batteri för belysning. Ett av hushållen angav att de haft problem med lampan som är ömtålig och lätt går sönder. Två hushåll svarade att de tidigare använt biogaslampa men lampan hade gått sönder. Undersökning gjord av NBP visar att det största klagomålet från hushållen var att biogaslampor inte fungerade och att underhåll av lampan anses vara krångligt (Mansvelt et al., 2012).

Resultatet visar att tre av sex tillfrågade hushåll anser att elektricitet är mer betydelsefullt än biogas eftersom den är mer användbar. Två hushåll anser att elektricitet och biogas är lika viktigt och ett av hushållen anser att biogas var viktigare då biogas inte ger någon kostnad varje månad jämfört med elektricitet. Studien visar även att de finns ett stort intresse för att få tillgång till elektricitet eftersom det ökar hushållens levnadsstandard.

Studien visar att samtliga hushåll använder restprodukten som gödningsmedel. Innan hushållen hade tillgång till restprodukten användes kodynga som gödsel på åkrarna. Ett av de tillfrågande hushållen svarade att restprodukten har dubblerat hushållets produktion av grödor och ett annat hushåll anser att kvalitén är betydligt högre på restprodukten än ren kodynga som de tidigare använt.

6.3.3 Marknadsföring

NBP arbetar i tolv provinser i Kambodja med etablering av biogasanläggningar där målgruppen är hushåll med en daglig tillgång av 20 kg djurdynga, vilket kräver minst två kor eller fyra grisar. PBPO arbetar med att finna nya potentiella biogasanvändare i provinserna. PBPO söker byar med minst tio hushåll som har potential för att driva en anläggning och där det finns entusiasm för biogastekniken (NBP, 2011).

Enligt Sophan[1] arbetar PBPO bara med hushåll som har minst tre kor. Vidare förklarar han att NBP anordnar mindre möten för ledare i byarna för att marknadsföra programmet. En studie gjord av NBP visar att hälften av hushåll i undersökningen hade fått information om biogasanläggningar via PBPO (Mansvelt et al., 2012).

Enligt NBP marknadsförs programmet genom att upplysa hushåll om fördelarna med tekniken och öka intresset för biogas genom demonstrationer av anläggningar, spridning av information via posters, broschyrer samt via media som TV och radio. De anordnar även workshops i byarna. NBP arbetar utifrån flera sätt att öka motivationen speciellt i områden i Kambodja där kommunikationsmöjligheter inte är lika utvecklade. För att öka intresset används demonstrationer samt samarbete med ledare och olika grupper i byarna. För att sprida tekniken samarbetar PBPO även med myndigheterna inom olika områden som jordbruk, hälsa och utbildning (NBP, 2011).

6.3.4 Utbildning

NBP arbetar med teknisk utbildning och utveckling. NBP förser murare och PBPO med teknisk utbildning och workshops ordnas på både nationell- och provinsnivå (NBP, 2011). Efter installation av biogasanläggning får hushållen utbildning av PBPO i hur anläggningen skall underhållas samt hur man använder biogaslampa och biogasspis[1]. Hushållen bekräftar att de fått tillräcklig utbildning via NBP i skötsel och underhåll av anläggningen för att effektivt och enkelt kunna driva anläggningen. Enligt studien av NBP hade 70 % av de tillfrågade fått en utbildning i underhåll och 61 % hade fått utbildning i användningen av restprodukt som gödningsmedel (Mansvelt et al., 2012).

6.3.5 Sociala drivkrafter

Vem som är ansvarig för beslutet att installera en anläggning varierar mellan hushållen. Oftast är det ett gemensamt beslut men ibland står mannen eller kvinnan som ensam

beslutstagare. Hushållen svarade i studien att fördelarna med en biogasanläggning är hög kvalité på restprodukten, besparing av tid samt renare och snabbare matlagning. Dessa faktorer är även viktiga för beslutet att installera en anläggning. Vedinsamlingen anses som ett problem då det tar lång tid samtidigt som skogsområdena minskar och det var en viktig faktor för beslutet att investera i biogas. Majoriteten av hushållen anser att användning av biogas leder till tidsbesparing men restprodukten anses efter installation som den främsta fördelen. Information om biogastekniken och fördelarna har hushållen fått via andra hushåll eller PBPO genom exempelvis träningskurser eller marknadsförare i byarna.

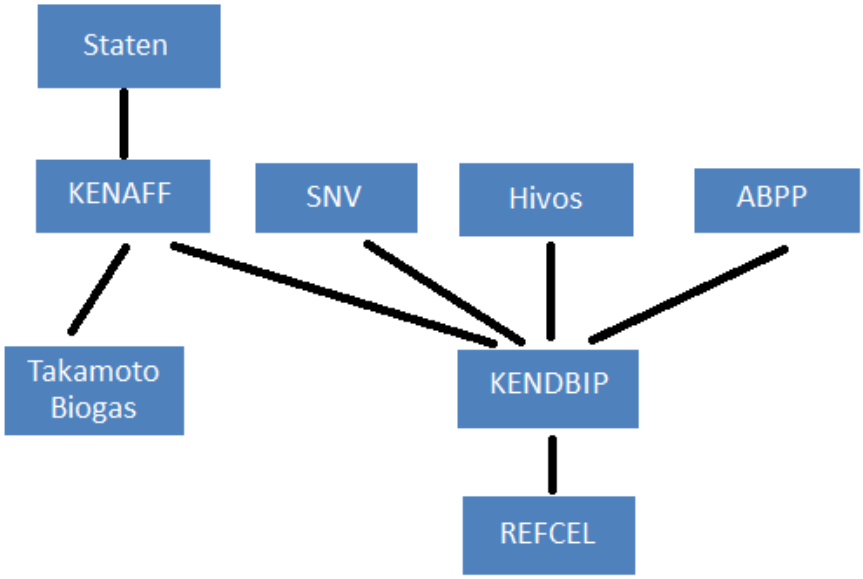
Resultatet från intervjuerna med hushåll som inte har biogasanläggning visar att av de fyra hushåll som är intresserade är investeringskostnaden den faktor som har gjort att de inte har någon möjlighet till investering. Av de hushåll som inte var intresserade av biogasanläggning saknas kunskap om fördelarna eller så är de kritiska mot att byta energikälla från något man är van vid. Majoriteten av de tillfrågade hushållen utan anläggning har kännedom om problemet med minskade skogsområden i Kambodja och några anser att de i framtiden kommer att bli tvungna att byta energikälla.

7 Fältstudie, Kenya

I Kenya har intervjuer med representanter från KENDBIP, REFCEL och Takamoto Biogas genomförts för att hitta faktorer som bidrar till framgång för etablering av biogasanläggningar i landet.

KENDBIP

Kenya National Domestic Biogas Programme (KENDBIP) startades av den Holländska staten i september 2009 och är en del av Kenya National Farmers Federation (KENAFF), se figur 6 nedan. Genom samarbete med African Biogas Partnership Programme (ABPP) och ekonomiskt stöd från SNV och HIVOS etablerar KENDBIP småskalig biogas i Kenya.



Figur 6. Organisationsstruktur för KENDBIP.

KENDBIP:s syfte är att utveckla en biogassektor i Kenya. Mellan september 2009 och december 2013 har närmare 11 600 småskaliga biogasanläggningar installerats i Kenya genom KENDBIP. Programmet har under den perioden endast marknadsfört en biogasanläggningsmodell men sedan början av 2014 väljer hushållen själva vilken typ av anläggning de vill investera i. De som konstruerar anläggningar åt KENDBIP:s hushåll kallas för murare. En murare som driver ett företag, där andra murare konstruerar anläggningar, kallas för kontraktare.

REFCEL

Renewable Energy for Forest Conservation and Enhanced Livelihoods (REFCEL) är ett projekt inom KENDBIP för att bevara skogarna genom att installera biogasanläggningar där hushåll skövlar skog för att kunna laga mat och värma upp huset. Speciellt för detta projekt är att hushållen blir subventionerade av KENDBIP med 85 % vid investering i en biogasanläggning.

Takamoto Biogas

Takamoto Biogas grundades 2011 av amerikanen Kyle Schutter. Företagets affärsidé är att köpa in biogasanläggningar och installera dessa hos hushållen som sedan får köpa gasen som rötningskamrarna producerar. Utöver att betala för gasen står hushållen även för 10 % av installationskostnaden. Företagets vision är att installera biogasanläggningar till hushåll med sämre ekonomiska förutsättningar för att göra biogas tillgängligt för alla. Fram tills idag har företaget installerat 107 biogasanläggningar, främst i Kiambu, ett område nordöst om Nairobi.

7.1 Tekniska faktorer, Kenya

Enligt KENDBIP (2014) är en viktig framgångsfaktor vilken standard rötningskammaren har. Enligt rapporten uppstår problem vid avsaknad av kvalitetskontroller, vid bristande kvalité på de ingående delarna i anläggningarna eller vid underskott av lämpliga byggnadsmaterial. Enligt Nyamu[3] har det varit viktigt för KENDBIP att fokusera på kvalitén eftersom informationen om biogasanläggningar främst sprids mellan hushållen och det är då viktigt att dessa är nöjda med sin investering. I tabell 3 nedan presenteras de intervjuade hushållen och vilken biogasanläggning de använder.

Tabell 3. Data för intervjuade hushåll i Kenya.

Användare:	Tillhörande organisation eller företag:	Design:	Modell:	Storlek [m³]:	Användings-period:	Antal kor [st]:	Mängd substrat:	Framställd gas [h/dag]:
Charles K. Ngémo	KENDBIP	Fixed dome	Kenbim	12	1 år	8	3 hinkar dynga var 3:e dag	8 till 12
Peter Wangendo	KENDBIP	Fixed dome	Kenbim	12	2 år	2	6 hinkar dynga varannan dag	8 till 12
David Wawsrú Kahenya	KENDBIP	Fixed dome	Kenbim	10	1 år	2	6 hinkar dynga/dag	1
Brenda Nabtutu Wekesa	KENDBIP	Fixed dome	Kenbim	8	4 månader	2	4 hinkar dynga/dag	9
Felister Mumbi Kimunja	KENDBIP	Fixed dome	Kenbim	8	4 till 5 år	5	3 hinkar dynga/dag	9
David Too	KENDBIP	Fixed dome	Kenbim	12	1 år	8	3 hinkar dynga/2 ggr i veckan	10
Mary Wanja	KENDBIP	SimGas	GesiShamba	6	2 år	5	2 hinkar dynga/dag	6
Grace Gathungu	KENDBIP	SimGas	GesiShamba	8	1 år	8	4 hinkar dynga/dag	0,5
Peter Githuka	REFCEL	Fixed dome	Kenbim	8	2 år	6	3 hinkar dynga var 3:e dag	5 till 6
Moses Ngugi Gichuhi	REFCEL	Fixed dome	Kenbim	8	2 månader	2	1 hink dynga varannan dag	5 till 7
Simon Gitura Mwangi	REFCEL	Fixed dome	Kenbim	8	1,5 år	2	2 hinkar dynga/dag	6
Francis Mburu Kamitha	Takamoto Biogas	SimGas	Floating Drum	3,5	7 månader	15	1 hink dynga/dag	0,33
José Kamitha	Takamoto Biogas	SimGas	Floating Drum	3,5	7 månader	15	1 hink dynga/dag	0,33
Jane Nungari Ngonga	Takamoto Biogas	SimGas	Floating Drum	3,5	15 månader	2	2 hinkar dynga/dag	4

1 hink = 20 liter

[3] George Nyamu (Programme Coordinator, KENAFF) intervjuad av författaren den 27 mars 2014.

KENDBIP har en egen modell av rötningskammaren Fixed dome som kallas *Kenbim*, se figur 7 nedan. Det finns två varianter av denna modell: en som är murad i sten och tegel samt en annan som är tillverkad i plast[4]. Den murade rötningskammaren konstrueras på plats medan den i plast tillverkas industriellt. Rötningskammaren tillverkad i plast placeras ovanför markytan medan den som är tillverkad i sten kan placeras antingen ovan eller under marknivå, men vanligast är under marknivån. En fördel med den murade designen är att den byggs med material som finns tillgängligt lokalt [5]. Livslängden för Kembim tillverkad i plast är 20 år enligt Mindri[4] och för den murade designen är livslängden mellan 20 och 30 år enligt Gichuhi[6]. Då ingen anläggning funnits i programmet i mer än fem år har livslängderna inte fastställts.

Figur 7. Installerad Kenbimanläggning, Nairobi, Kenya.

Företaget Takamoto Biogas har främst installerat biogasanläggningar av modellen *Floating drum*. Benton[7] förklarar att modellen är enkel och tålig eftersom den består av få delar. Floating drum uppges ha en livstid mellan 10 och 20 år men Benton berättar att ungefär 50 % av denna rötningskammarmodell har gått sönder inom sex månader efter installation.

En annan modell som hushållen kan välja är en cylindrisk rötningskammare, *GesiShamba,* som är tillverkad i plast[8]. Modellen finns i olika storlekar mellan 3 till 14 m³, installationen tar 14 dagar och anläggningen konstrueras under marknivå. Gekara[8] förklarar att GesiShamba är fördelaktig då den är prefabricerad, består av återvunnen plast, har en låg

[4] Philip Minrdi (Biogas Engineer, KENDBIP) intervjuad av författaren den 26 mars 2014.
[5] Duncan Muchiri (Mason, contractor, Biogas Contractor) intervjuad av författaren den 4 april 2014.
[6] Daniel Gichuhi (Administration Coordinator, REFCEL) intervjuad av författaren den 4 april 2014.
[7] Graham Benton (Director of Market Development, Takamoto Biogas) intervjuad av författaren den 1 april 2014.
[8] Moses Ogeto Gekara (General Manager, SimGas) intervjuad av författaren den 7 april 2014.

investeringskostnad samt att den är flyttbar. Rötningskammaren är även anpassad för solljus och växtsubstrat.

7.1.1 Identifierade problem med anläggningar

Hälften av de tillfrågade hushållen har inte upplevt några problem med sina anläggningar. En tredjedel uppgav att de har eller har haft problem med mängden substrat de skall förse rötningskammaren med vilket har lett till att de inte har fått förväntad mängd gas. Enligt hushållen beror detta på att anläggningen förses för ofta, med för mycket substrat eller att substratet blandats med för mycket eller för lite vatten.

Rördragningen är enligt KENDBIP det vanligaste tekniska problemet med den murade designen Fixed dome (KENDBIP, 2014). Om rördragningen brister mellan anläggningen och hushållet uppstår läckage och hushållet får mindre eller ingen gas alls[2]. Ytterligare problem som har identifierats är att rören blockeras eller brister, att rördragningen är felkonstruerad eller att ingen regnbalk installerats[4]. Benton[7] påstår att spisarna ofta går sönder eftersom användarna inte är tillräckligt varsamma och ungefär 20 % av deras användare har upplevt detta problem. Benton[7] förklarar även att gasen kan bli fuktig i rören, vilket gör att kondens bildas och gasen kommer att pulsera fram i omgångar för att tillslut inte komma fram alls. En av Takamoto Biogas hushåll informerar om att mätaren som mäter gasen inte fungerar ordentligt utan ofta stängs av automatiskt vilket leder till att räkningen för gasen inte är korrekt.

Ett problem som uppstod med en modell som tidigare användes var enligt Gekara[8] att plasten sprack när denna utsattes för solljus, och i en annan modell blandades plasten med stål vilket ledde till hög sprödhet. Rötningskammare med ingående metalldelar kan börja rosta vilket kräver underhåll som är arbetskrävande och kostsamt[9].

Det finns tre viktiga faktorer att ha i åtanke då en biogasanläggning konstrueras enligt Muchiri[5]. Den första är vilket substrat som skall användas i anläggningen och hur många djur hushållet äger. Den andra faktorn är vilka material som används för att bygga biogasanläggningen och den tredje faktorn är yrkesskickligheten och rådgivningen från den tekniskt kunniga personalen.

Innan en biogasanläggning installeras är det viktigt att utvärdera marken genom att jordarten identifieras, grundvattennivån samt platsens höjd över havet fastställs[5]. Det är besvärligt att konstruera biogasanläggningar i områden med jordarten *Black Cotton* som expanderar när det regnar och krymper när det är torrt[5].

7.1.2 Substrat

För att få investera i en biogasanläggning via KENDBIP eller Takamoto Biogas krävs minst två nötkreatur[4,7]. Samtliga hushåll som intervjuats använder kodynga som substrat till biogasanläggningen. Dock har det visat sig att gris- och kycklingdynga är ett bättre substrat än kodynga eftersom dessa producerar mer gas per kilogram substrat[7,10]. Dessa substrat är dock inte lika förekommande som kodynga eftersom det inte finns lika många hushåll med

[9] John Thuku Macharia (Mason and contractor, Jotmac Contractors) intervjuad av författaren den 7 april 2014.
[10] Roda Kilonzi (Promotion and Training, KENDBIP) intervjuad av författaren den 26 mars 2014.

gris- eller kycklingproduktion jämfört med antal användare som har kor. I Kenya finns det även en stor tillgång på fårdynga, den är dock inte lämplig att använda so substrat vid biogasframställning då den kräver en lång och arbetsam behandlingsprocess innan den kan användas i rötningskammaren[10]. Även växter kräver en komplicerad behandling för att kunna användas som substrat enligt Mindri[4]. Dessutom är inloppsröret till Kenbim för smalt för att växtdelar skall kunna glida ned i röret och används därför inte som substrat för denna modell[4].

7.1.3 Drift

Innan substratet hamnar i rötningskammaren hälls kodyngan i en behållare där den blandas med vatten i förhållande 1:1[4]. Förhållandet är en riktlinje för att konsistensen på substratet varierar och det viktigaste är att konsistensen på slurryn är korrekt[6], se figur 8 nedan. Om detta görs felaktigt kan problem uppstå med att anläggningen producerar mindre eller ingen gas alls. Om substratet inte fylls på medan det är färskt hinner det torka och den gas som då produceras är otillräcklig för hushållet[7]. Enligt både KENDBIP och Takamoto Biogas är den viktigaste delen av driften att kontinuerligt fylla på anläggningen med substrat, samt att det görs i rätt mängd[7,11.] Exempelvis kan användaren fylla på anläggningen varje dag med 40 kg dynga, varannan dag med 80 kg dynga eller var tredje dag med 120 kg dynga[7]. Ingen av de intervjuade användarna upplevde att tillgången på vatten var för låg för att kunna försörja rötningskammaren.

Figur 8. Slurry i inloppet till en biogasanläggning. Nairobi, Kenya.

[11] George Wakesho (Monitor and Evaluation Manager, KENDBIP) intervjuad av författaren den 26 mars 2014.

7.1.4 Underhåll

Det är viktigt att kontinuerligt rengöra inloppet på Fixed dome för att hindra att rester av slurry torkar och bildar klumpar[4]. Om torkat substrat kommer in i kammaren bildas mindre gas och på sikt måste rötningskammaren tömmas och rengöras, vilket är en omfattande process. Inloppet skall rengöras dagligen efter påfyllning för att underlätta det totala arbetet med anläggningen[12]. Det är även viktigt att ta bort restprodukten då denna annars orsakar blockering vilket stoppar flödet i anläggningen[4].

Inom KENDBIP skall ett hushåll som får problem med sin anläggning kontakta muraren som installerat anläggningen[11]. När muraren Kimenyi[13], som installerar anläggningar åt KENDBIP, blir återkallad till en anläggning inspekterar han först hur anläggningen förses med substrat, ifall hushållet har försett denna med för mycket eller för lite slurry, samt hur konsistensen av slurryn ser ut. Därefter kontrollerar han om några kemikalier, vilka påverkar bakterierna i kammaren, används eller om det läckage finns. Upptäcks inget fel töms rötningskammaren för att kunna undersökas ordentligt efter läckage eller dålig ytbehandling.

Takamoto Biogas reparationer innefattar främst tekniken för att mäta gasförbrukningen då den är ny och outvecklad[7]. Företaget har regelbundna kontroller av sina anläggningar för att upptäcka problem med exempelvis läckage, proppar i rören, fel på spisen eller lågan samt gasmätaren[7].

7.1.5 Geografiska förutsättningar

Benton[7] förklarar att Takamoto Biogas valde Kenya eftersom landet har bättre infrastruktur och elektriska nät jämfört med andra länder i Afrika. Han berättar även att området Kiambu valdes med anledning av den stora mängden hushåll med kor, men även för att majoriteten av hushållen i detta område inte har råd att investera i en biogasanläggning själva och därför passar Takamotos Biogas affärsidé att sälja gasen.

Det är viktigt att temperaturen inuti rötningskammaren är konstant[4]. Regnperioden påverkar de biogasanläggningar vars rötningskammare är placerade över marken då regnet som kyler ner påverkar temperaturen inuti kammaren. Processen för gasbildning går då långsammare[14]. Den variant av Fixed dome som är placerad under marknivå påverkas inte av regnperioden men kan påverkas om utomhustemperaturen sjunker[4]. På samma sätt påverkas Floating drum av regnperioderna när utomhustemperaturen sjunker, vilket leder till att verkningsgraden minskar[11]. Samtliga av de tillfrågade användarna förklarade att regnperioden inte påverkade rötningskammarna eller framställningen av biogas. I området Kiambu investerar dock hushållen inte i de mindre anläggningarna då de på grund av det svala klimatet skulle producera för lite gas[6].

[12] Robert Kiamu (Public Relations, KENAFF) deltog i en intervju av författaren den 28 mars 2014.

[13] Stephen Macharia Kimenyi (Mason and contractor, Makimenyi Green Energy) intervjuad av författaren den 7 april 2014.

[14] Charles K. Ngéno (Mason and contractor, Ngeno Biotec co.) intervjuad av författaren den 8 april 2014.

7.2 Ekonomiska faktorer, Kenya

Den totala utgiften för en biogasanläggning av modellen Kenbim är 1 100 USD[4]. Modellen GesiShamba med storleken 6 m³ kostar 875 USD[8]. I denna kostnad är dock inte arbetskostnaden för utgrävande inkluderad. I Takamoto Biogas kontrakt framgår det att hushållen skall betala 10 % av den totala kostnaden för anläggningen, vilket ungefär uppgår till 125 USD samt 0,69 USD per m³ gas som används[7]. Där 1 m³ gas beräknas räcka i ungefär två timmar.

Enligt KENDBIP (2014) är den höga installationskostnaden en barriär för etablering av biogasanläggningar i Kenya. Den höga installationskostnaden beror på hög material- och arbetskostnad samt spridda bosättningar (KENDBIP, 2014). Produktionen av komponenter till anläggningarna görs i Asien och därför är materialkostnaderna högre i Kenya då dels importskatt tillkommer[4,7]. Enligt Benton[7] är arbetskraften dessutom dyrare i Afrika jämfört med i Asien vilket bidrar till att den totala kostnaden av en biogasanläggning är högre.

Av installationskostnaden för Kenbim går 330 USD till murarens lön och resterande 770 USD till material[15]. Lönen för en murare är uppdelad och muraren erhåller 50 % då arbetet startar, 30 % när arbetet är klart och resterande 20 % när anläggningen fungerar som den skall och hushållet får sin gas[15]. Denna uppdelade betalning underlättar även för hushållen att investera i en biogasanläggning då investeringskostnaderna delas upp[15].

7.2.1 Underhållskostnad

Enligt kontraktaren Gikuhi[15], som installerar biogasanläggningar inom KENDBIP, får ett hushåll betala 62,5 USD om en murare skall komma och felsöka anläggningen. Kostnaden inkluderar endast identifiering av felet och inga reparationskostnader. Takamoto Biogas underhållskostnad per anläggning ligger år 2014 runt 12,5 USD per månad vilket för företagets samtliga anläggningar blir 1 250 USD[7]. Denna kostnad beror främst på underhåll av de underutvecklade mätarna som används för att mäta gasförbrukningen.

7.2.2 Finansiering av anläggning

I Kenya har många banker och mikroinstitutioner insett att den växande biogassektorn är en möjlighet för att expandera deras kundbas (KENDBIP, 2014). KENDBIP har därför flera samarbeten vilket underlättar för hushåll som vill ta lån och även för biogasentreprenörer som kräver ett arbetskapital för att kunna tillfredsställa efterfrågan. KENDBIP samarbetar med olika kreditinstitut för att ta fram lån anpassade för hushåll som vill investera i biogasanläggningar. Återbetalningstiden för användarna ligger mellan ett och tre år[16]. Avsaknad av eller begränsad tillgång till lämpliga biogaslån, gällande både kontraktare och hushåll, hindrar etableringen av småskaliga biogasanläggningar i Kenya (KENDBIP, 2014). Lokala försäljare av biogasanläggningar i Kenya har låg ekonomisk kapacitet för finansiering av marknadsföring och utbyggnad av sin verksamhet.

För att sektorn skall fortsätta expandera är det viktigt att möjligheten att ta lån fortsätter att utvecklas (KENDBIP, 2014). I rapporten från KENDBIP (2014) framgår det att

[15] Andreki Wambuga Gikuhi (contractor and mason) intervjuad av författaren den 4 april 2014.
[16] Bernad Mulandi (Finance and Administration Officer, KENDBIP) intervjuad av författaren den 26 mars 2014.

majoriteten, 68 %, av användarna finansierade anläggningen genom egna besparingar, 18 % tog lån och 11 % kombinerade besparingar med lån. Det framgår även att av låntagarna lånade 34 % av en bank, 33 % av Savings and Credit Cooperative Society, SACCO, 23 % av familjemedlemmar och resterande 14 % från en social grupp.

Två av tolv hushåll tillhörande KENDBIP tog lån för att kunna komplettera betalningen, resterande sju nyttjade sina besparingar. Två av hushållen har sin anläggning på avbetalning, vilket är ytterligare ett sätt att finansiera investeringen. Ett av hushållen berättar att de betalar tillbaka 62,5 USD på lånet när de har möjlighet, att de haft rötningskammaren i två år och att de fortfarande betalar av på den.

7.2.3 Subvention

För att stimulera biogasmarknaden i Kenya och för att introducera den nya tekniken subventionerades varje hushåll med 25 % av installationskostnaderna fram tills 2014. En förutsättning för subventionen var att hushållet var medlemmar i KENAFF och installerade modellen Kenbim (KENDBIP, 2014). Ett hushåll betade då motsvarande 787,5 USD.

Under de fem första åren subventionerades 11 600 hushåll och dessa finansierades främst av Humanist Institute for Cooperations with Developing Countries, Hivos, och Netherlands Development Organization, SNV (KENDBIP, 2014). Fördelen med subventionerna var det ökade intresset och den förhöjda trovärdigheten för biogas[3]. När anläggningarna subventionerades hade KENDBIP en närmare relation till både murare och användare. KENDBIP betalade ut subventionen då användaren besökte kontoret och bekräftade att anläggningen fungerade. För att KENDBIP idag skall få den information de behöver om murare och det arbete som utförts fylls ett formulär i av både murare och hushållen. När formuläret lämnas in till KENDBIP får muraren en liten summa pengar, 12,5 USD. Av de tolv tillfrågade hushållen från KENDBIP fick nio sina anläggningar subventionerade.

Sedan KENDBIP slutade med subventioner har efterfrågan på biogasanläggningar minskat[9]. Enligt Kilonzi[10] är de som investerar i biogasanläggningar i Kenya idag hushåll med goda ekonomiska förutsättningar. Takamoto Biogas når däremot ut till både hushåll med en låg inkomst, runt 18,75USD per månad, och till de som har råd att investera i en egen anläggning[7].

Området för projektet REFCEL valdes för att bevara skogarna som huggs ned av människor som använder veden som energikälla för matlagning[6]. REFCEL subventionerar både material- och arbetskostnad för installation av en biogasanläggning till hushållen vilken motsvarar 85 %[6]. Hushållen får stå för material som exempelvis rör och förstärkningsstänger och införskaffar detta när de har dem tillgångar som krävs. Denna kostnad motsvarar 15 % av den totala investeringskostnaden och uppgår till 165 USD[6]. För majoriteten av hushållen i Kiambu är investering av en biogasanläggning för dyr vilket leder till att få hushåll har möjlighet att investera i en anläggning utan att bli subventionerad med den större summan pengar[6].

7.2.4 Garanti

KENDBIP har en garantitid på ett år vilket innebär att om något går sönder måste muraren reparera problemet, förutsatt att användaren själv inte orsakat skadan[3]. För att programmet

skulle kunna finansiera problem som uppstått med anläggningarna inom garantitiden behöll KENDBIP 10 % av subventionen som en säkerhet[16]. Vissa modeller har en två års garanti[8].

Det är endast fyra av de åtta tillfrågade användarna, tillhörande KENDBIP, som är medvetna om att det är de själva som få bekosta reparationerna om garantitiden har gått ut och en reparation är nödvändigt. Två av de tre användarna som är delaktiga i projektet REFCEL var medvetna om att KENDBIP kommer att stå för samma kostnad. De övriga fem vet inte vem som får betala för reparationskostnaderna.

7.2.5 Effekter av biogas

I Kenya har 87,6% av hushållen sparat pengar genom att byta ut gasol, elektricitet, träkol, ved och fotogen mot biogas (KENDBIP, 2014). En av användarna berättar att han sedan investeringen av biogas minskat sina utgifter för energi med 50 % per månad. En annan hade tidigare en kostnad för träkol runt 25 USD per månad och denna utgift är idag försumbar. 13 av de tillfrågade hushållen säger att de sparar pengar och tid genom att använda biogas framför andra energikällor då biogas är en mer effektiv källa än exempelvis ved, träkol, gasol, fotogen och elektricitet. Biogas är renare, lättare och mer effektivt att använda jämfört med träkol och ved[7]. Den är dock är mindre effektiv än gasol men mycket billigare och fotogen är dyrare än gasol[7].

7.3 Sociala faktorer, Kenya

Samtliga tillfrågade använder biogasen för matlagning och för att värma vatten. Av dessa ansåg fyra att biogasen inte är tillräcklig medan resterande tio är mer än nöjda med den mängd biogas som framställdes. Tidigare använde samtliga tillfrågade sig av energikällor som ved, träkol, gasol, elektricitet och fotogen. Dock är det enbart fem som endast använder biogas som energikälla för matlagning. Sex av hushållen kompletterar biogasen med någon annan energikälla för att vissa måltider traditionellt skall tillagas på ett sätt eller när de skall laga mat åt ett större sällskap då biogasspisen är för liten. Tre hushåll använder sig av samma energikällor som innan installationen eftersom de inte får ut den mängd gas som önskas och kompletterar då gasen med dessa.

7.3.1 Marknadsföring

En barriär av etablering för biogasanläggningar i Kenya är avsaknad av, eller otillräcklig teknisk medvetenhet då många potentiella hushåll inte är medvetna om att teknologin existerar (KENDBIP, 2014). KENDBIP har delat upp sin marknadsföring i två delar, en övre och en undre[10]. Den övre delen sköter de som är ansvariga i programmet och sker genom lokala radiostationer, marknader och samarbeten med andra organisationer. KENDBIP marknadsför sig främst genom de fördelar som finns med biogas. När KENDBIP var nystartat satsades mycket pengar på marknadsföringen av att sprida informationen om biogas och syftet var inte kvalité utan endast att sprida ordet om biogas och dess positiva effekter[11]. Idag marknadsför sig programmet främst genom att erbjuda olika modeller och varianter på biogasanläggningar[3]. Den undre delen av marknadsföringen lämnas till murarna, där de får ta ansvar för att sprida information om biogas vilket leder till fler jobb[10].

Kontraktarna marknadsför sig genom nuvarande hushåll som berättar om sin biogasanläggning till vänner och refererar till kontraktaren vilket leder till att en viktig del är relationen till hushållen[5]. Även att använda en biogasanläggning som demonstrationsanläggning dit nya potentiella användare kan komma för att för se hur biogas fungerar samt hur restprodukten bäst används utnyttjas av kontraktarna för att marknadsföra sig[9]. Takamoto Biogas marknadsför sig för tillfället enbart genom att sprida budskapet från mun till mun[7].

7.3.2 Utbildning

Utbildning är en viktig del av etableringen av biogasanläggningar i Kenya. Vilken utbildning hushållen får, av vem och hur de erhåller kunskapen om anläggningen skiljer sig åt. Även vilken utbildning den som konstruerar biogasanläggningen har, är av betydelse för framgångsrik etablering.

7.3.2.1 Utbildning för användare

Av de 14 användare som intervjuats har endast ett hushåll utbildning på universitetsnivå. Två av de tillfrågade har ingen utbildning alls. En av de tillfrågade hade hoppat av skolan efter ”Standard Eight”, vilket motsvarar årskurs åtta i Sverige, och de resterande tio har en examen från ”Form Four”, vilket motsvarar en avslutad en svensk gymnasieutbildning.

Enligt KENDBIP (2014) är avsaknad av eller otillräckligt stöd efter installation en faktor som förhindrar etablering av biogas i Kenya. För att uppnå en hög varaktighet måste användarna utbildas gällande biogasanläggningen[6]. Enligt de ansvariga inom KENDBIP skall alla hushåll erhålla affischer och manualer vid installation av en biogasanläggning[10]. I dessa finns information om hur anläggningen skall skötas samt hur restprodukten kan användas på ett förmånligt sätt. Under intervjuerna med hushållen framkom det dock att endast två hushåll har erhållit detta material. Samtliga hushåll inom KENDBIP fick dock någon form av utbildning av den ansvariga muraren om hur substrat skall blandas samt hur de skall rengöra och driva anläggningen. Hushåll som investerat i vissa modeller som exempelvis GesiShamba utbildas av en representant från Nederländerna[8]. När företaget Takamoto Biogas är färdiga med installationen av en biogasanläggning spenderar en tekniker en timme med användarna för att svara på frågor samt gå igenom systemet från början till slut[7].

7.3.2.2 Utbildning för murare

Murare, inom KENDBIP, som är ansvariga under installering av biogasanläggningar skall genomföra en utbildning som programmet erbjuder där de lär sig hur konstruktion av en rötningskammare går till[16]. Enligt Wakesho[11] erhåller muraren ett certifikat efter godkänd utbildning som visar att muraren är kvalificerad att utföra installationer av biogasanläggningar för KENDBIP. Utbildningarna är intensivutbildningar som pågår mellan två till tre veckor och består av både teoretisk och praktisk undervisning samt avslutas med ett prov[15]. Alla intervjuade kontraktare utbildar sina murare på egen hand då deras murare inte har genomgått programmets utbildning. Det är dock alltid kontraktaren som är ansvarig för att installationen sker korrekt och han kommer tillbaka ett flertal gånger under konstruktionen för att undersöka att allting är som det skall vara[13].

Låg utbildningsnivå bland murarna försvårar intensivutbildningen inom KENDBIP och avhopp bland murare är ett problem KENDBIP (2014). För att undvika att murare hoppar av programmet samordnas möten under implementeringsperioden där erfarenheter utbytes och problem tas upp. De främsta murarna blir uppmuntrade att bli kontraktare och att inspektera anläggningar för att minska upprepningsjobb samt för att undvika den medföljande kostnad som muraren själv får stå för. Avsaknaden av ett nationellt utbildningsprogram för murare försvårar etableringen av biogas i Kenya.

I Takamoto Biogas genomgår alla anställda en provanställning de tre första månaderna där de får en inblick i företaget, lär sig hur det fungerar samt får en internutbildning om hur en biogasanläggning byggs[7].

7.3.3 Acceptans för mänskliga fekalier som substrat

Att ansluta en latrin till anläggningen har inte fått genomslag i Kenya eftersom det kulturellt inte är accepterat (KENDBIP, 2014). Hushållen är medvetna om att gasen går att använda men anser att det är orent att använda den för matlagning om den framställs från mänskliga fekalier[11]. I Kenya har 0,045 % av anläggningarna installerats med en anslutning till en latrin och bedrivs därför dels på mänskliga fekalier (KENDBIP, 2014). Dock har majoriteten av anläggningar i Kenya installerats med ett anslutningsrör som innebär att anläggningen i framtiden kan använda mänskliga fekalier som substrat om intresse finns[11]. En del skolor har biogasanläggningar med mänskliga fekalier som substrat gör att barnen vänjer sig vid processen[11].

7.3.4 Sociala drivkrafter

Majoriteten av användarna har valt att investera i biogas då de ansåg att andra energikällor är för dyra. Men även för att dessa är svåra att få tag på och att tillgången är osäker. Förutom de ekonomiska fördelarna investerade de i en biogasanläggning för att förbättra hälsan, spara tid samt värna om miljön.

Fem av hushållen har upplevt en förbättring av hälsan i form av minskad hosta eller rinnande ögon samt mindre värk i kroppen efter att bärande av ved minskat, medan sju inte har märkt någon skillnad. I Kenya spenderar 97,8 % av de med biogas mindre än en timme per dag på hushållenergi jämfört med 39,2 % för de utan biogas. Detta resulterar i att kvinnor och barn har mer tid för studier och andra sysslor när biogas används (KENDBIP, 2014).

7.3.4.1 Samarbeten

Statlig finansiering av KENDBIP förekommer inte men staten och KENDBIP har ett partnerskap[16]. Till exempel styrde statliga departement grundandet av reglerna för hur biogassektorn skall fungera. Programmet har 160 partnerskap med olika institutioner och organisationer både från den privata samt den statliga sektorn[3]. Syftet med partnerskapen är att de skall underlätta finansieringen och bidra med kunskap inom marknadsföring, kvalitetskontroll av biogasanläggningar, utbildning av användare och identifiering av utvecklingspotentialen i biogassektorn[3]. Exempel på partners till KENDBIP är Non Government Organisations, finansinstitutioner, banker och mikroinstitutioner, kommersiella biogasföretag, leverantörer av delar, serviceföretag för biogasdelar och murare. Enligt

Nyamu[3] har samarbetena mellan länder genom ABPP till stor del bidragit till KENDBIP:s framgång eftersom de lär och hjälper varandra med allt från problemlösning till att ta fram nya modeller. Enligt Benton[7] har Takamoto Biogas flera statliga samarbeten, bland annat med KENAFF men även med Kenya Byro of Standards som har makten att göra rötningskammarna skattefria.

7.3.4.2 Relationer mellan ansvariga, murare och användare

När ett hushåll vill installera en biogasanläggning tar de kontakt med en murare[16]. Muraren kontrollerar om hushållet har tillräcklig kapacitet för att installera en biogasanläggning. Muraren installerar anläggningen och ger instruktioner om hur den fungerar och skall skötas. Enligt Wakesho[11] får hushållen kontaktuppgifter till KENDBIP att använda om det skulle uppstå ett problem med anläggningen och om det inte får kontakt med muraren. Wakesho förklara att KENDBIP har en databas med kontaktuppgifter till alla användare och respektive murare. Om en murare inte sköter sitt arbete eller konstruerar en anläggning som visar sig vara felaktig kan KENDBIP svartlista muraren från framtida arbeten inom programmet[11].

8 Analys

För att ta fram de viktigaste faktorerna för framgång sammanställs parametrar som påverkar etablering och drift av småskaliga biogasanläggningar i utvecklingsländer. Tekniska, ekonomiska och sociala faktorer har identifierats utifrån litteratur- och fältstudier samt sammanställts i enskilda tabeller för att få en tydlig överblick av resultatet.

I varje tabell viktas parametrarna för att fastställa faktorernas betydelse för framgång, gällande etablering av småskaliga biogasanläggningar, utifrån skalan: 0, +, ++.

0 Ingen påverkan
\+ Påverkan
++ Avgörande påverkan
i.s. Information saknas

8.1 Analys, tekniska faktorer

Tekniska parametrar som påverkar etablering och drift av småskaliga biogasanläggningar har sammanställts och viktas i tabell 4 nedan.

Tabell 4. Sammanställning av tekniska parametrar och dess betydelse för framgång.

Parameter	Litteratur-genomgång	Fältstudie Kambodja	Fältstudie Kenya
Anläggning:			
- Val av rötningskammare	++	++	+
- Konstruktionsmaterial	+	+	++
Substrat:			
- Färskt/torkat substrat	+	+	+
- Typ av substrat	+	++	++
- Vattentillgång	++	++	++
- Stabil tillgång av substrat	++	++	++
- Glödförlust	+	i.s.	i.s.
Faktorer som påverkar processen:			
- Stabilt temperaturintervall	++	i.s.	i.s.
- pH-värde	++	i.s.	i.s.
- Syretillgång	++	i.s.	i.s.
- C/N-förhållande	+	+	i.s.
Underhåll	i.s.	+	++
Geografiska förutsättningar:			
- Klimat	i.s.	+	+
- Regnperiod	i.s.	0	+

8.1.1 Anläggning

Vid etablering av biogasanläggningar måste klimat, tillgängliga konstruktionsmaterial, typ och mängd av tillgängligt substrat samt hushållets gasbehov utvärderas då det spelar stor roll för val av anläggning. Att anpassa rötningskammaren efter lokala förutsättningar är avgörande då många tekniska problem undviks. De geografiska förutsättningarna skiljer sig åt i Kenya vilket är en anledning till att olika modeller används och detta leder till risken att en anläggning som inte är anpassad efter hushållets behov installeras. En orsak till att etableringen fungerar bra i Kambodja är att det finns en anpassad modell och att val av anläggning därför inte är ett problem.

För att konstruera en rötningskammare med lång livslängd är konstruktionsmaterialet en av de viktigaste aspekterna, enligt litteraturstudien. När val av material görs måste olika faktorer tas i beaktan, hållbarhet och tillgänglighet. Fältstudierna visar även att det är viktigt att välja material som tål de rådande klimatförhållandena som solljus. Det är viktigt att välja material som finns lokalt tillgängligt om eventuella reparationer skulle behövas. Då tillgängligheten på material är sämre i Kenya är det där avgörande att använda lokalt tillgängligt material för att undvika driftstopp vid reparation.

8.1.2 Substrat

Stabil tillgång på substrat är en avgörande faktor för att erhålla en stabil tillgång på gas och för att de flesta anläggningar är konstruerade för kontinuerlig tillförsel. Samtliga studier visar att substratets färskhet påverkar gasutbytet. Det är dock inte en avgörande faktor eftersom torrt substrat fortfarande producerar biogas, men inte i samma mängd. Anläggningarna i Kambodja och Kenya har anpassats efter specifika substrat, som lokalt finns tillgängligt, vilket gör användandet av rätt substrat avgörande för att anläggningen skall fungera väl. Litteraturstudien visar även att olika substrat blandas, för att erhålla en hög glödförlust och optimera produktionen av biogas. Att blanda olika substrat kräver ökad kunskap hos användaren men skulle kunna bidra till en ökad produktion av biogas och göra det möjligt för fler hushåll att framställa biogas. I Kenya är ett vanligt förekommande problem för användarna att få rätt förhållande mellan vatten och substrat då vattenhalten i substratet varierar. Det visar på att ytterligare typer av substrat skulle öka svårigheten att få rätt förhållande.

För att olika typer av substrat skall kunna användas krävs manuell eller en mekanisk omrörning i anläggningen visar litteraturstudien. Dock är den mekaniska omröraren att föredra då risken för gasläckage minskar. Det beror på att den är placerad inuti kammaren och mer kontrollerad än den manuella. Fältstudierna visar däremot att en automatisk omrörning räcker.

8.1.3 Processen

De aktiva bakterierna i processen kräver konstanta förhållanden för att effektivt bryta ner det organiska materialet. Det är därför avgörande med en stabil temperatur, stabilt pH-värde samt en syrefri kammare. För att uppnå det mest gynnsamma C/N-förhållandet skall olika substrat enligt litteraturstudien blandas. I praktiken är dessa värden svåra att påverka eftersom teknisk kunskap krävs och användarna är hänvisade till de lokala förutsättningarna.

8.1.4 Underhåll av anläggning

Fältstudierna skiljer sig åt angående underhåll av anläggningen. I Kambodja fungerar anläggningarna väl och deras konstruktion kräver minimalt med underhåll. I Kenya däremot är behovet av underhåll större och driften påverkas negativt om inget underhåll utförs. Sköts inte rengöringen av inloppet måste rötningskammaren till slut tömmas för att torkad slurry skall kunna avlägsnas. Finns inte den kunskap som krävs för att underhålla anläggningen kan anläggningarna på sikt vara tvungna att tas ur drift.

8.1.5 Geografiska förutsättningar

Fältstudierna visar att de geografiska och lokala förutsättningarna måste tas i beaktning när en anläggning skall konstrueras och installeras. Om detta inte görs kan det påverka anläggningens framtida reparationer men framförallt dess livslängd. Resultatet från Kenya visar att jordtypen är av betydelse då vissa jordarter inte är lämpliga att konstruera biogasanläggningar i. Väderförhållanden är viktiga att ta hänsyn till då starkt solljus kan påverka en anläggnings livslängd. Även temperaturväxlingar påverkar anläggningar över marknivå i större utsträckning än under vilket påverkar gasproduktionen då den minskar när kammaren kyls.

8.2 Analys, ekonomiska faktorer

I tabell 5 nedan har ekonomiska parametrar som har betydelse för etablering och drift sammanställts och bedömts.

Tabell 5. Sammanställning av ekonomiska parametrar och dess betydelse för framgång.

Parameter	Litteraturgenomgång	Fältstudie Kambodja	Fältstudie Kenya
Finansiering av projekt, bistånd	++	++	i.s.
Finansiering av anläggning: - Investeringskostnad för anläggning - Kostnader som uppstår vid drift och underhåll - Anläggningens livslängd	 ++ + +	 ++ + +	 ++ + ++
Subventioner till användare	+	+	+
Möjlighet till lån för användare	+	++	+
Möjlig besparing	+	0	++
Politiska styrmedel	i.s.	+	+
Garantitid	i.s.	0	+

8.2.1 Finansiering av projekt

För att långsiktigt kunna driva ett biogasprogram framgångsrikt måste, enligt litteraturstudien, biogasprogrammet bli självförsörjande. Det är i dagsläget inte möjligt och fältstudierna visar att biogasprogrammen är beroende av bistånd. För att organisationerna skall kunna bli självförsörjande krävs det att kostnader för marknadsföring, forskning och utveckling täcks av hushållen istället för från bistånd. Det skulle i dagsläget innebära en avsevärt högre investeringskostnad, vilket påverkar möjligheten att investera i tekniken.

För att garantera ett långsiktigt arbete är det viktigare att anläggningarna, snarare än programmen, blir självförsörjande. Genom att anläggningarna blir självförsörjande, både ekonomiskt och kunskapsmässigt, kommer produktionen av biogas kunna fortsätta även om programmen avvecklas.

8.2.2 Finansiering av anläggning

Studierna visar att vid etablering av en biogasanläggning är investeringskostnaden en avgörande faktor då en för hög kostnad resulterar i utebliven investering. Även kostnader som uppstår vid drift och underhåll har betydelse då reparationer kan vara nödvändiga för

fortsatt produktion. Kostnaden för en anläggning påverkar hur många hushåll som har möjlighet att investera i en biogasanläggning och därmed programmens möjligheter till fortsatt etablering. Kostnaden för att etablera en anläggning i Kenya är högre än i Kambodja, även litteraturstudien pekar på biogasanläggningar är dyrare i Afrika än i Asien. Det går dock inte att avgöra om detta har påverkat Kenyas framgång. Ett alternativ i Kenya är att betala 10 % av kostnaden för anläggningen samt en kostnad för mängden biogas som används istället för att stå för hela investeringskostnaden. På så sätt får även hushåll utan tillräckliga ekonomiska förutsättningar möjlighet att använda biogas.

En faktor som påverkar den ekonomiska lönsamheten är anläggningens livslängd vilken också påverkar hushållens beslut om investering. Fältstudierna visar att livslängden är en viktig faktor vid etablering då hushållen är intresserade av att investera långsiktigt utan stora reparations- och underhållskostnader. I Kenya är den största drivkraften den möjliga ekonomiska vinningen, vilket gör livslängden till en avgörande faktor.

I fältstudien från Kambodja är reparations- och underhållskostnaderna obefintliga. Möjligheten till långsiktig drift påverkas då en anläggning av ekonomiska skäl kan tvingas tas ur drift om reparationskostnaden är för stor, vilket bekräftas av litteraturstudien och fältstudien från Kenya.

8.2.2.1 Subvention

Genom att minska den initiala kostnaden för en anläggning går det att nå fler hushåll då investeringskostnaden är avgörande för hushållens möjlighet att investera i tekniken. Subventioner genom biståndsprogram spelar en viktig ekonomisk roll vid etablering av biogasanläggningar men påverkar även intresset och trovärdigheten för biogas, vilket visas i samtliga tre studier. Ett minskat intresse och en smalare målgrupp för biogasteknik noteras i Kenya sedan subventionen tagits bort.

8.2.2.2 Lån

Möjligheten att investera i en biogasanläggning ökar då hushållen kan ta mikrolån och dessa har därför positiv påverkan för ökad etablering, enligt litteraturstudien. Resultatet från fältstudierna visar att 30 till 50 % av hushållen finansierade sin anläggning med hjälp av lån och därför är detta en avgörande faktor för etablering. Genom mikrolån är det även möjligt för programmen att nå hushåll med sämre ekonomi. En del hushåll hindras dock av de administrativa problemen kring mikrolån i Kambodja. I Kenya är avsaknad av eller begränsad tillgång till lämpliga biogaslån ett hinder för etableringen av småskaliga biogasanläggningar.

8.2.2.3 Möjlig besparing

Ekonomisk besparing är en drivkraft för investering och hushåll som betalar för sin energikälla har i detta avseende större intresse av biogas jämfört med hushåll som samlar ved. I allmänhet har större hushåll mer att vinna på att investera i biogas då mer kapital läggs på energiförsörjning, jämfört med mindre hushåll, visar litteraturstudien. Den möjliga besparingen som drivkraft skiljer sig åt mellan fältstudierna och är avgörande för hushåll i Kenya men har ingen påverkan i Kambodja. En orsak kan vara att få hushåll i Kambodja

betalar för sin tidigare energikälla. Även litteraturstudien bekräftar att hushåll som betalar för sin energi är mer benägna att välja biogas då det påverkar deras ekonomi positivt.

8.2.3 Politiska styrmedel

Politiska styrmedel kan användas för att påverka etableringen av biogas. Genom att minska tillgången på ved och därmed kräva att hushållen betalar för sin energikälla kommer det på sikt vara ekonomiskt fördelaktigt att investera i biogas. Energipolitiken i Kambodja har påverkat etableringen då förbud mot skövling av skog har införts i vissa områden. Detta påverkar hushållens energisituation och styr mot användandet av andra energikällor som biogas. Även i Kenya påverkar staten etableringen av biogasanläggningar genom att ekonomiskt stödja biogasprojekt för att hindra avskogningen.

8.2.4 Garanti

Ur marknadsföringssyfte används garantitiden för att öka hushållens tillit till tekniken. I Kambodja har inte garantitiden påverkat hushållens inställning till investering. Det kan bero på att få hushåll har haft problem med sin anläggning och då inte har behövt använda sig av garantin. I Kenya har flera hushåll haft tekniska problem vilket har påverkat vikten av garantitid. Garantitiden är ett sätt att höja förtroendet för biogasanläggningar eftersom kvalitén varierar.

8.3 Analys, sociala faktorer

I tabell 6, som ses nedan, har sociala parametrar listats och värderats vilka är av betydelse för etablering och drift.

Tabell 6. Sammanställning av sociala parametrar och dess betydelse för framgång.

Parameter	**Litteraturgenomgång**	**Fältstudie Kambodja**	**Fältstudie Kenya**
Marknadsföring	++	++	++
Acceptans:			
- Införande av ny teknologi	+	+	+
- Att använda mänskliga fekalier som substrat	+	0	0
Sociala drivkrafter:			
- Tidsbesparing	+	+	+
- Förbättrad inomhusmiljö	+	0	+
- Egenproduktion av gödningsmedel	+	++	+
Utbildning:			
- Läskunnighet	+	0	0
- Drift och underhåll av anläggningen	++	+	++
- Konstruktion	i.s.	i.s.	++
Relation mellan organisationer, murare och hushåll	i.s.	++	++
Statligt stöd	++	i.s.	+

8.3.1 Marknadsföring

Spridning av information till hushåll är avgörande för etablering då detta skapar intresse för investering. Marknadsföring för projekten i Kambodja och Kenya är centralt för etablering eftersom kunskap om fördelarna med biogas ökar motivationen för installation av en anläggning. I Kambodja är PBPO:s marknadsföringsarbete helt avgörande för att nå ut till hushåll och det finns en tydlig målgrupp vilken innefattar hushåll som har förutsättning för att driva en anläggning. I Kenya har demonstrationer av anläggningar i drift visat sig vara ett framgångsrikt koncept för att marknadsföra biogasprojekt. Fältstudierna visar att den främsta marknadsföringen är muntlig informationsspridning, vilket stöds av litteraturstudien.

8.3.2 Acceptans

Samtliga tre studier visar att acceptans för ny teknik påverkar etablering. Hushåll som motsätter sig den nya tekniken resulterar i färre etableringar. Fältstudierna visar att det inte finns något större motstånd mot att använda biogas som energikälla. I Kambodja är det ett fåtal hushåll som inte har en biogasanläggning och som inte vill byta. Dessa hushåll är väldigt få och acceptans mot biogastekniken är därför ingen barriär för framgångsrik etablering.

Användning av mänskliga fekalier har en positiv påverkan för produktion av biogas då det används som komplement till annat substrat samtidigt som det minskar hälsorisker. I Kenya och Kambodja vet hushållen att biogas från mänskliga fekalier går att använda men i Kenya är det till skillnad från Kambodja inte kulturellt accepterat. Anläggningar i båda länderna installeras med ett anslutningsrör som gör att hushållen i framtiden kan koppla latrinen med anläggningen.

8.3.3 Sociala drivkrafter

Vetskap om fördelarna med biogas fungerar som en drivkraft och påverkar etableringen. I Kambodja är restprodukten avgörande för att hushåll skall etablera en anläggning då det anses som den viktigaste fördelen och används därför i marknadsföringssyfte. Även i Kenya har restprodukten en positiv inverkan för etablering men är inte huvudorsaken till investering. Samtliga studier visar att andra fördelar med biogas som tidsbesparing, förbättrad hälsa och det faktum att andra energikällor är dyra samt svåråtkomliga, har en positiv påverkan för etablering.

8.3.4 Utbildning

Litteraturstudien visar att det är en fördel om användaren är läskunnig vilket inte stöds av fältstudierna. Enligt fältstudierna har läskunnighet hos hushållen inte någon betydelse då de får muntliga instruktioner och praktisk utbildning. Murarnas utbildning i Kenya försvåras av låg utbildningsnivå bland de blivande murarna och därför bör utbildningen anpassas efter deras tidigare kunskaper.

Kunskap om drift och underhåll är, enligt litteraturstudien och fältstudien från Kenya, en avgörande faktor då denna kompetens är viktig för att undvika att problem uppstår. Litteraturstudien visar att det är ett problem att hushåll inte får den utbildning som krävs. Denna observation har inte gjorts i Kambodja då de flesta har fått den utbildning som

anläggningen kräver vilket inte är fallet för Kenya. I Kenya skall hushållen förses med affischer och manualer men alla tar inte till sig kunskapen, vilket skapar problem.

Litteraturstudien tar upp problemet med att det är männen som blir utbildade men att det är kvinnorna som sköter driften av anläggningarna. Fältstudierna visar däremot att personen som sköter anläggningen får utbildning, oavsett kön.

Fältstudien i Kenya visar att teoretisk och praktisk utbildning om konstruktion av biogasanläggningar är en avgörande faktor. Ett av de mest förkommande problemen i Kenya, för användare som äger sin anläggning, innefattar att rören mellan anläggning och hus går sönder. Detta problem beror på brist i rördragningen men är även ett resultat av okunskap om vart rören är dragna. Då många av de problem som har uppstått beror på dålig konstruktion, visar detta hur viktigt det är med utbildning för murare så att anläggningen konstrueras på rätt sätt. Utbildningen för murarna, i Kenya, har visat sig variera och detta har påverkat etableringen.

Sammanfattningsvis är kunskap om konstruktion, drift och underhåll en avgörande faktor för etablering av biogasanläggningar, där utbildning rörande dessa områden är en förutsättning.

8.3.5 Relation mellan organisationer, murare och hushåll

I Kambodja är relationen mellan organisation, murare och hushåll avgörande. Informationsflödet mellan organisation och hushåll fungerar bra vilket tyder på en god relation. Fältstudien i Kenya visar på otillräcklig internkommunikation. Information från KENDBIP till murarna är bristfällig vilket leder till att hushållen i sin tur inte nås och programmet inte fungerar som det är tänkt. Detta leder till att det blir svårt att genomföra förändringar i programmet och att saker tar längre tid. Till skillnad från den interna kommunikationen fungerar samarbetet mellan olika organisationer bra, till exempel mellan KENDBIP och ABPP, som till en stor del har bidragit till programmets framgång. Skillnaden mellan länderna indikerar att en bra relation mellan organisation, murare och hushåll har stor betydelse för framgång.

8.3.6 Statligt stöd

Litteraturstudien visar att statligt stöd är nödvändigt för att långsiktigt kunna driva biogasprogram, då flera projekt misslyckats när detta har saknats. Fältstudien i Kenya visar att KENDBIP har haft nytta av statligt stöd.

9 Slutsatser

Studien har identifierat faktorer för framgångsrik etablering av småskalig biogasproduktion samt kopplingen mellan dessa. Förutom faktorer vilka är en förutsättning för att framställa biogas, som tillgång till vatten och substrat, har följande urskilts som centrala.

Vid val av anläggning skall hänsyn tas till lokala resurser och förutsättningar, men samtidigt vara anpassningsbar till flera platser. Substrat som det finns en kontinuerlig tillgång till och som anläggningen är anpassad för skall användas för att anläggningen skall fungera.

En förutsättning för biogasprojekt är att de finansieras med bistånd och att anläggningarna, snarare än programmen, blir självständiga både kunskapsmässigt och ekonomiskt.

Investeringskostnaden för en biogasanläggning får inte vara för hög då målgruppen minskar med ökad kostnad. Subventioner är en viktig faktor för att minska investeringskostnaden och lån ger fler möjlighet till investering. För att en hög investeringskostnad skall vara motiverbar krävs en lång livslängd.

Det är avgörande med marknadsföring där drivkrafter tydligt är identifierade, exempelvis restprodukten i Kambodja, den ekonomiska besparingen och garantitiden i Kenya. Om drivkrafterna är kända kan politiska styrmedel användas för att påverka etableringen. Den mest framgångsrika marknadsföringen är muntlig informationsspridning, då det leder till ökad trovärdighet och acceptans.

Kunskap om konstruktion, drift och underhåll är avgörande för etablering av biogasanläggningar, där utbildning rörande dessa områden är en förutsättning. Utbildningen skall vara både praktisk och teoretisk samt anpassad efter målgruppens förkunskaper. Viktigt i utbildningen för användare är till exempel beredning av slurry och för murare om hur konstruktion av en anläggning går till.

Internkommunikation inom organisationer samt en god relation mellan organisationer, murare och hushåll är avgörande för framgångsrik etablering av biogasanläggningar i utvecklingsländer.

10 Referenser

AKINBAMI, J. F. K., ILORI, M. O., OYEBISI, T. O., AKINWUMI, I. O. & ADEOTI, O. 2001. Biogas energy use in Nigeria: current status, future prospects and policy implications. *Renewable & sustainable energy reviews,* 5**,** 97-112.

AMDI 2012. Biogas user survey 2012. Hanoi: Consultant team of Asian Management and Development Institute.

AMJID, S. S., BILAL, M. Q., NAZIR, M. S. & HUSSAIN, A. 2011. Biogas, renewable energy resource for Pakistan. *Renewable and Sustainable Energy Reviews,* 15**,** 2833-2837.

ARTHUR, R., BAIDOO, M. F. & ANTWI, E. 2011. Biogas as a potential renewable energy source: A Ghanaian case study. *Renewable Energy,* 36**,** 1510-1516.

BIOGASPORTALEN. 2014. *Biogasportalen-Vad är biogas* [Online]. http://www.biogasportalen.se/FranRavaraTillAnvandning/VadArBiogas: Energigas Sverige. [Accessed 2014-02-18.

BISWAS, W. K. & LUCAS, N. J. D. 1997. Economic viability of biogas technology in a Bangladesh village. *Energy,* 22**,** 763-770.

BLUME, E. 2010. Biogas för den afrikanska landsbygden. University of Gothenburg: Department of Plant and Environmental Sciences.

BOND, T. & TEMPLETON, M. R. 2011. History and future of domestic biogas plants in the developing world. *Energy for Sustainable Development,* 15**,** 347-354.

BUYSMAN, E. & MOL, A. P. J. 2013. Market-based biogas sector development in least developed countries -The case of Cambodia. *Energy Policy,* 63**,** 44-51.

CARLSSON, M. & ULDAL, M. 2009. Substrathandbok för biogasproduktion. http://www.biogasnordic.se/dokument/SGC200.pdf: Svenskt Gastekniskt Center.

DAY, D. L., CHEN, T. H., ANDERSSON, J. C. & STEINBERG, M. P. 1990. Biogas Plants for Small Farms in Kenya. England: Elsevier Science Publishers

DOHOO, C., GUERNSEY, J. R., CRITCHLEY, K. & VANLEEUWEN, J. 2012. Pilot study on the impact of biogas as a fuel source on respiratory health of women on rural Kenyan smallholder dairy farms. *Journal of Environmental and Public Health,* 2012.

GRÖNDAHL, F. & SVANSTRÖM, M. 2010. *Hållbar utveckling - en introduktion för ingenjörer och andra problemlösare,* Stockholm, Liber AB.

GWAVUYA, S. G., ABELE, S., BARFUSS, I., ZELLER, M. & MÜLLER, J. 2012. Household energy economics in rural Ethiopia: A cost-benefit analysis of biogas energy. *Renewable Energy,* 48**,** 202-209.

HÄLLQVIST, E. 2010. Patogener i svenskt dricksvatten. Uppsala universitet: Institutionen för biologisk grundutbildning.

IMF. 2012. *World economic outlook database* [Online]. http://www.imf.org/external/pubs/ft/weo/2012/01/weodata/index.aspx IMF. [Accessed 18 februari 2014.

JOSEFSSON, O. 2009. Getting Attached, A study on domestic biogas and the integration of sanitation in Ethiopia. University of Gothenburg: Department of Plant and Environmental Science.

KAHUBIRE, E. B., BYARUHANGA, A. B. & MOHAMMED, S. 2010. A Socio-economic and gender baseline survey for the Uganda domestic biogas project.

KARTHIK RAJENDRAN, S. A., FREDRIK JOHANSSON, MOHAMMAD J. TAHERZADEH 2013. Experimental and economical evaluation of a novel biogas digester. *Energy Conversion and Management,* 74**,** 183–191.

KENDBIP 2014. Kenya National Domestic Biogas Programme.

MANSVELT, R. V., SRAS, P. & PINO, M. 2012. Biodigester User Survey

MARTÍ-HERRERO, J. 2011. Reduced hydraulic retention times in low-cost tubular digesters: Two issues. *Biomass and Bioenergy,* 35**,** 4481–4484.

NBP 2011. National Biodigester Programme Cambodia. *In:* HEALTH, D. O. A. P. A. (ed.).

NBP. 2014. http://www.nbp.org.kh/index.php National Biodigester Programme. [Accessed 2014-05-06 2014].

NES, W. V. 2012. *Potential of domestic biogas* [Online]. http://www.snvworld.org: SNV Netherlands Development Organisation.

OCWIEJA, S. M. 2010. Life cycle thinking assessment applied to three biogas projects in central Uganda. Michigan Technological University Master of Science Environmental Engineering.

OWEKISA, D. 2008. Case 1: Microfinance and Environment: Financing clean Energy in Rwanda A case of developing a Biogas loan product for small farmer. .

PROKAUSHALI SANGSAD, L. 2010. Study on effect of biogas in the biogas villages households with focus on gender issues. National Domestic Biogas and Manure Programme.

RAHMAN, D. M. A. 2008. Bio-Slurry management and it´s effect on soil fertility and crop production Bangladesh: Bangladesh agricultural research institute soil science division & on-farm research division Gazipur 1701.

RAKOTOJAONA, L. 2013. Open ideas - DOMESTIC BIOGAS DEVELOPMENT IN DEVELOPING COUNTRIES http://www.enea-consulting.com/: ENEA Consulting.

SNV. 2014. *Biogas* [Online]. http://www.snvworld.org/en/node/1489/. 2014].

SURENDRA, K. C., TAKARA, D., HASHIMOTO, A. G. & KHANAL, S. K. 2014. Biogas as a sustainable energy source for developing countries: Opportunities and challenges. *Renewable and Sustainable Energy Reviews,* 31**,** 846-859.

SURENDRA, K. C., TAKARA, D., JASINSKI, J. & KUMAR KHANAL, S. 2013. Household anaerobic digester for bioenergy production in developing countries: Opportunities and challenges. *Environmental Technology (United Kingdom),* 34**,** 1671-1689.

SUTHAR, S. 2010. Potential of domestic biogas digester slurry in vermitechnology *Bioresource Technology* 101**,** 5419–5425.

WWF, V. 2013. *Klimat* [Online]. http://www.wwf.se/vrt-arbete/klimat/mnsklig-pverkan/1124268-mnsklig-pverkan-klimat. [Accessed 2014-05-14.

Bilaga 1. Frågeunderlag fältstudier

Questions to people responsible at the programmes

Technical Factors

1. Is there a certain reason for choosing these areas to establish the biogas plants?
2. What kind of digesters do you use at your facilities?
    a. How large are they?
3. How many biogas plants do you have?
    a. What is the distribution of the digesters in your biogas plants?
    b. Are there a certain reasons for that distribution?
    c. When you decided what kind of digesters you were going to use in your biogas plants, which factors were important?
4. Regarding the different kinds of digesters in the plants, what life span do they have?
    a. Is there a certain part that usually breaks first?
5. How long does the part of the process for digestion take?
6. What is the efficiency of the different kinds of digesters? (feedstock/biogas)
7. What are the most common feedstock?
    a. What is the availability of this feedstock?
    b. Is the demand of feedstock larger than the supply?
    c. Is the feedstock an environmental issue?
8. What is done to the feedstock to gain the best biogas? (C/N ratio, moisture, temperature, pH, mixture of different feedstock)
9. What is most important to have in mind when you're constructing a biogas plant?
10. What kind of maintenance is important to make sure that the biogas plant works properly?
    a. How many hours a week does these tasks take?
11. Which technical problems are common regarding the plants?
    a. How do you solve them?
    b. Do you solve all of them?
12. Do the rain seasons effect the plants?
    a. If so, how?

Economic factors

1. How are the biogas plants financed?
    a. Do they all get subsidy?
2. Does it cost anything to maintain the plants?
3. Is the idea for the biogas plant to eventually become self-sufficient?
    a. If so, what is the time limit for this?
4. Are government agencies involved in any way, are there political interest in the establishment and operation of the biogas plants?
5. Are any non-profit organisations involved?

Social factors

1. Who was responsible for the establishment?
    a. Who has the current responsibility?
2. Can you tell us about the journey from the point where a farmer is interested to where the biogas is installed and active?

Questions to masons or people with technical knowledge

Technical Factors

1. Regarding the different kind of digesters in the plants, what lifespan do they have?
    a. Is it usually a part that breaks first?
2. How long does the part of the process for digestion take?
3. What main materials are the digester made of?
4. What's most important to have in mind when you're constructing a biogas plant?
5. What kind of maintenance is important to make sure that the biogas plant works properly?
6. Which technical problems are common regarding the plant?
    a. How did you solve them?
    b. Did you solve all of them?
7. Do the rain seasons effect the plant?
    a. If so, how?

Economic factors

8. Does it cost anything to maintain the biogas plant?
9. How does your payment look like?

Social factors

10. Who is responsible for the establishment of a biogas plant?

Questions to households with a biogas plant

Technical Factors

1. What kind of digester is used in the plant?
    a. How big is it?
2. For how long has the biogas plant been used?
3. Have you experienced any technical problems with the plant?
    a. How did you solve them, independently or with help from someone else?
4. What type of feedstock do you use?
5. Before you installed the biogas plant, did you use the feedstock for anything?
    a. If so, for what?
6. Do you use the slurry which is left?
    a. If so, for what?
    b. If not, what do you do with it?
7. Before the biogas, what energy source did you use?

    a. Does the biogas plant require more or less maintenance compared to your former energy source?
8. Through the year, do you have enough water to supply the biogas plant?

Economic factors

1. What is the household's main source of income?
2. How was the biogas plant financed?
    a. How long is the payback time?
3. If something breaks, who pays for that?
4. Are you able to sell the biogas to neighbours?

Social factors

1. Which were the main reasons for investing in a biogas plant?
2. What is the biogas used for?
3. How has the biogas plant effected your daily life?
4. Since installing the biogas plant, have you noticed any difference in your health?
    a. If so, what?
5. What level of education do the people in this household have?
6. Is the produced biogas enough for your household?
7. Do you still use other energy sources?
    a. If so, which ones?
    b. For what?

Questions to households without a biogas plant

Technical Factors

1. Which energy sources do you use?
    a. If wood, how much labour does that require?
2. What kind of maintenance do these energy sources require?
3. Do you get enough energy from the source you use today?
4. If you had a biogas digester, what kind of substrate would be available?

Economic factors

5. What is the household's main source of income?

Social factors

6. Have you had an opportunity to participate in the biogas digester project?
7. Do you want to change your energy source to biogas?
    a. Why/why not?
8. What level of education do the responsible people in the household have?

Bilaga 2. Transkriberade intervjuer, Kambodja

PBPO

Intervju 1: Khy Sophan, Head of Coordinator of PBPO

Hushåll

Intervju 2: Hushåll utan biogasanläggning
Intervju 3: Jin Poli, med biogasanläggning
Intervju 4: Chai Lon, med biogasanläggning
Intervju 5: Sapt Suhn, med biogasanläggning
Intervju 6: Chem Li, med biogasanläggning
Intervju 7: Ri Supche, utan biogasanläggning
Intervju 8: Hushåll med biogasanläggning
Intervju 9: Sman Khon, med biogasanläggning
Intervju 10: Man Kim, med biogasanläggning
Intervju 11: Hem Sol, utan biogasanläggning
Intervju 12: Bun Han, med biogasanläggning
Intervju 13: Tun Veng, utan biogasanläggning
Intervju 14: Shun Siamli, utan biogasanläggning
Intervju 15: Pong Pen, med biogasanläggning
Intervju 16: Mang Sokom, med biogasanläggning
Intervju 17: Jah Sam, med biogasanläggning
Intervju 18: Kap Kimn, med biogasanläggning
Intervju 19: Wong Sokher, med biogasanläggning
Intervju 20: Heng Komsoa, med biogasanläggning
Intervju 21: Hol Seken, utan biogasanläggning

Interview 1: Khy Sophan, Head of Coordinator of PBPO

Date: March 25, 2014
Area: Kampong Speu Province, Cambodia
Organization: NBP
Household: -
Present: Nathalie Hansson – Student of Chalmers
Cecilia Johannesson – Student of Chalmers
Jacob Gower – Sheffield University, England
Bunat Pok – NBP representant
Khy Sophan - Head of Coordinator of PBPO

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- What kind of bio digester is used in this area, and how big is it?
In this province there is only one type of bio digester, we can call it the NBP bio digester. It is very popular in the province.
- How long is the lifespan of the plant?
The lifespan is about 20-25 years, and the NBP operates the program since 2006 and have never had a problem with the bio digester. Maybe only ten bio digesters of 2000 was broken because it to much gas inside, the gas leak out.
- Is it the same kind of facility in all households in the programme, and why?
It is only one kind in the province. This kind of bio digester is very popular and people enjoy to adapt the bio digester because its more affordable, the price is more cheaper and easy to use. Another kind of bio digester, a bio digester made by a plastic bag. Its not convenient by the farmer because its smell bad from the bio digester and they can not use with biogas lame slow laser, slow compressor. The quality is only one year. After one year it will break, but it cost only 100 $. Cheaper but less quality, especially the smell is very bad.
- Why are the one used in Cambodia don't smell?
Because all manure are converted to biogas and fertilizer. In the plastic bag bio digester some manure still remain, and can't convert. The NBP bio digester all of manure are converted to methane. The plastic bag bio digester can't convert to methane because of different shape of NBP bio digester. The NBP bio digester slope in the bottom and the manure can flow from the input to the outside. The plastic type bio digester is not slope, it's straight so it's very hard to flow. Sometimes they need to take out by hand.
- Is the biogas digester always built under ground?
All the NBP bio digester has to be built under the ground. But for plastic bag biogas digester sometimes problem with mouse, they make the plastic bag break and gas leak out. We have to build biogas digester under the ground because we can save material when we build under the ground. They prefer to build the biogas digester under ground because the ground can protect the bio digester body. And for the plastic bag can't tolerate the sunlight, after one year it gets… easy to break.
- How much maintenance is required for the biogas digester?
After installing the bio digester the NBP obey educated how to maintain, how to use biogas lame, and the biogas stove. The household have to take care of the biogas digester. Have to cover the soil, cover the bio digester to protect from sunlight. Another hand have to provide manure every day to the input and to take the fertilizer from the output to another place.
- How do they maintenance the facility, and who is responsible for that?
The household have to maintain the bio digester three kind; the first is to provide the bio digester the manure purely per day. The other is to protect the bio digester body, to

cover the bio digester body, to cover with soil especially during the raining season. The third is to clean the output of the bio digester. Have to collect the fertilizer from the bio digester to anther place because when there is a lot of fertilizer in the output the bio digester can't flow out. Especially if the household can't provide enough manure to the bio digester, the bio digester also provide little bit gas, it's not enough gas for the household requirement to. Unluckily it will be broken in the future because of the amount of the manure in the bio digester also increase and the biogas in the bio digester also reduce, because its not enough manure for the requirement in the bio digester.
On the other hand we use the meter, the household have to use only 2 kilo Pascal. If they use until 0 kilo Pascal it's not good. It means the biogas in the bio digester equals zero and it can be broken. If finger on 2 it have to stop. So it means that the animal manure can't flow out. Because the biogas pressure, it's pulls out the animal manure from the bio digester.
After construction you have to wait maybe ten days. The first time you have to provide 1.5-ton animal manure to the bio digester. After that you have to provide 20-30 kilo animal manure every day. Kept it in 10 day so that the bacteria in the bio digester will convert the biogas. In the first time its also oxygen in the bio digester so we can't use. After 10 day there is no oxygen in the bio digester, there is only methane in the bio digester, so we can use.
He also confirms that the first time the oxygen in the bio digester because of the water. Because the water also the oxygen in the water, the bacteria it's name protozoa it convert the bio digester to the methane and after that the bacteria was dead, it remains the bacteria body, it becomes protein. So the fertilizer from the bio digester includes a lot of protein. Because the bacteria were dead, become the protein. Some bacteria in the bio digester not need oxygen. Anaerobic. Take responsibility to convert the manure to the biogas.
- Do they only use the animal manure or do they also use leafs or household garbage in the digester?
In Cambodia according to the NBP principal they allowed the farm household only to use the manure, from the animal, animal manure or human manure. They are not allowed to use the garbage because it's very difficult. It's easy to break. It's not easy to flow out the manure from the fertilizer if you use the garbage. But in Kina they use everything. They use the animal manure, they use some plants, watergreens you can use in bio digester. But in Cambodia very difficult because different shape of bio digester. Very difficult to flow out if they use the watergreen.
- Why do they need to add water to the bio digester?
They have to use the water to make the solution with the animal manure, if they not use the water the bacteria can't convert the manure to the biogas. They have to make the solution with the water and the animal manure and swirl between the animal manure and the water. The water and the animal manure is the same amount, for example 20 kg water and 20 kg animal manure.
- Is it a problem for the household that they don't have enough water?
He say that in the whole province no household have a problem with the water. They have water enough to provide the bio digester. They can use water from the valley, or the river.
- What did they do with the manure before they had a bio digester?
Before bio digester the household they kept the animal manure for the rice cultivation. Before the farm household decide to install the bio digester they save the animal manure, maybe one ton per year. If they don't install the bio digester it's very difficult to save the animal manure, especially the chicken, they destroy and can't keep in the specific place. Very difficult to transport the animal manure to the rice field. Especially

some manure loose the quality. Some nutrients also despite out to the air.
On the other hand the bio digester can improve the quality of the fertilizer because there is a lot of … nutrient and phosphor, in the fertilizer it's a lot of…, NPK inside the fertilizer. And another thing, the plant easy to absorb the nutrition from the fertilizer rather then if they use the animal manure directly to the rice field. Because it's not easy to absorb from the animal manure. Maybe provide the fertilizer from the bio digester the plant easy to absorb the nutrient.
- Human manure, is the bio digester more hygienic for them then before?
After installing the bio digester they can connect with the toilet, so it can improve the sanitation for the household. But have to remember not use the shampoo, because the shampoo can destroy the bacteria inside the bio digester. Another thing, when they use the toilet separately from the bio digester, they have to repair, maybe ones a year they have to pump out because it's full. When using the bio digester not need to pump. Because the human manure converting to fertilizer, and no smelling.
- NBP gets money from the SNV to be able to work with the project and subsidize the households. Is the Cambodian government in any way involved in the project?
In the first time, the royal government of Cambodia had strong relationship with the NBP program, for example the biogas lamp input from Kina the price of biogas lamp around 7 $ for one. So the government also sell the biogas lamp to the farmer around 5 $. It means the government provide subsidy 2 $ for biogas lamp. But recently there's no subsidy more for the biogas lamp.
- We have also plan to change the region for material from Kina to Vietnam. The material import from Vietnam is cheaper then Kina. Recently the NBP is not only get financial support from the SNV but also get financial support from the Germany Government, GIZ.
How many of the NPB bio digesters are financed by loan and how many are paid directly?
Maybe around 50 % of the bio digester owners are set to loan for the bio digester, at least 50 %.
- For how long have they used bio digesters?
Since 2006.
- Is it possible to repair the biogas digesters that break?
The bio digesters are insured for two years after construction. During the insurance time, if the bio digester was broken the group building, the NBP, will go to repair for them without payment, free for them. If the bio digester breaks after insurance time, more than two year, they have to pay money for the group building, the NBP. If the bio digester has be broken more than two year, after insurance time, NBP groups building and the cost of repairing is according to the real condition of broken. Sometimes it's just broken a little bit. For example it's break the pipe, biogas pipe, we can repair it and they spend a little bit money to repair it again. Sometimes it broke a bit serious conditions. Maybe around 50 000-60 000 riel is the average repairing cost.
According to the NBP principal they just promote to the households that are suitable, that have manure enough. They have enough cattle to provide manure to the bio digester. Some household don't have cattle are not appropriate to build the bio digester. It means the NBP take priority only to the farmer with the cattle.
- How do they contact the farmers?
In the province it's the supervisor who take responsibility to select the priority the household that are appropriate with the bio digester. Household with cattle more than three we can regard as appropriate households.
NBP also conduct a small meeting group. The district group, to support the relationship with the head of the commune, head of village, district governor and head of commune

to hold district meeting, small meetings, to promote the NBP program to the farmer households. They also take responsible to select the suitable household for the bio digester.
They also have a promoter in the village, the number of promoters is according to the potential of the village, the number of household with cattle.
- Does every household get training in the maintaining?
The NBP also get the bio digester owner and conduct the user training after they construct the bio digester. The NBP also provide a training course how to use the bio digester, how to use the biogas lamp and how to use the stove to the new bio digester owner.

Interview 2:

Date: March 24, 2014
Area: Kampong Speu Province, Cambodia
Organization: NBP
Household: Household without biogas digester
Present: Nathalie Hansson – Student of Chalmers
Cecilia Johannesson – Student of Chalmers
Jacob Gower – Sheffield University, England
Bunat Pok – NBP representant

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- What is their main source for income?
He says he can earn a living from rice cultivation and animal husbandry.
- Who lives here?
He is head of family, only two persons in the household, he and his wife.
- How much land do they have?
He has only 30 a, in first time he had 60 but he heritage to his children.
- How many animals does he have?
He has two cattle, and several poultry.
- How often does he sell the cattle?
He just uses the cattle for rice cultivation and he can sell the cattle maybe three year, one time.
- How do they cook?
He says he doesn't have biogas or electrical cooking, he only use wood. He gets his wood from the forest. One time, one time, he gets to the forest. He uses his cattle and animal trail for transportation from the forest.
- How long time does it takes?
He has to spend one whole day for one trail. He uses the ax and machete to cut the wood from the forest to be smaller. Let it dry under the sunlight for one week and then storage under the house.
- Does he have electric lighting?
He uses only battery. He has to charge three week, one time, because use only for lighting, he doesn't have a television.
- What does he use the light for?
Maybe to have dinner during the night, and to lighting the house.
- Where does he get his water?
He use pumping machine, to pump the water from the stream near here. The pumping machine belongs to his son. He lives separately from him. He borrows the pumping machine from his son to pump the water from the stream near here.
- What does he use for wood in the raining season?
He explains that the household have to take care so much of the wood in the raining season. When they see that the sky is become black they have to collect the wood and keep it under the house.
- Have he thought about having a bio digester?
He said that he's not interesting with a bio digester. He said that he don't like to collect the animal manure to provide the bio digester. He said that now he is so old, he doesn't want to change his life, to change his lifestyle.
- For how long have them been using electricity?
He has used the battery for 20 years. He has to spend 2500 rel to recharge the battery. What would he be most interesting in using, water pipe so that he don't need to pump

water or an electrical grid?
He explains that water pipe and electricity cable he is strongly interested the same.
- The forest where he collects wood, is it getting smaller?
He explains that he think in the future the forest will be smaller and smaller. He also complain it will be difficult in future. If in the future the forest is not available for him anymore he will have to change, to buy gas from market or use electricity for cooking.
- How will that change his lifestyle?
He said that he know in the future maybe he has to change the lifestyle to adopt the new energy but recently he care about not changing anything. Everything the same as before. He also explains that NBP provide 150 financial supports to household who decide to adopt the bio digester. Maybe the 150 financial support not available in the future so if he want to install the bio digest, he should decide soon.

Interview 3: Jin Poli

Date: March 25, 2014
Area: Kampong Speu Province, Cambodia
Organization: NBP
Household: Household with biogas digester
Present: Nathalie Hansson – Student of Chalmers
Cecilia Johannesson – Student of Chalmers
Jacob Gower – Sheffield University, England
Bunat Pok – NBP representant
Jin Poli - Farmer

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- What is your name?
Jin Poli
- How does they make their livelihood?
Her family can earn their living from her husband is in the commune committee. Her daughter is working in the government factory. She also cultivated rice and animal assamentory.
- Who lives here?
She and her husband. 7 member in the household, 5 children.
- How do they cook?
Recently they used wood for cooking, because the bio digester is not completed yet.
- Where do they get the wood?
She can go near the village, sometimes she go to the mountain in the north of the village to collect wood. She is also worried because recently there was a big storm in the mountain. A lot is destroyed. But sometimes she has to buy more wood.
- How much time does she spend for collecting wood?
She has to spend a lot of time to go to the forest because it far from here. She explain that they also spend time for chopping wood.
- What does they use for lighting?
They use battery for lighting.
- How do they get their water?
Sometimes they have to buy water from the truck, and sometimes she carry by hand from the pump near here. In the dry season she has to by water every week. Need the water for cooking, drinking and for the animals. In the raining season she also buys engine to pump water for the rice field. During the raining season, some week there's no raining. So she has to use pumping engine, 10000 riel per hour. She hire from near here. She cannot save any money to buy a pumping engine because she has to support her children in school
- Who made the decision to buy the bio digester?
Her husband and her decide. Joined decision.
- What influenced that decision?
To difficult to collect wood from the forest. She decide to build a bio digester it can reduce the labour. She said if she's free she has to collect every day to save for the rainy season because in the rainy season it's very difficult to find. When she go to the mountain she has to start from 4 am and 10 or 11 am she will be back, every day.
- How did she learn about the bio digester?
She can learn how to use the bio digester from the organisation, from NBP or Sida.
- Have she received training in how to use the bio digester?
She has received training 2 or 3 times. Both her and her husband. She is strongly

confident how to use it.
- How much did it cost?
500 dollar, 150 dollar subsidized from the NBP. If there's no available subsidy she still will build the bio digester.
- Have she received training in how to use the fertilizer?
She doesn't no, she need another training in how to use the fertilizer from the bio digester.
- What else does she use electricity for?
She only use the battery electricity for only lighting, and for cell phone, for personal use.
- How many animals do they have?
5 cow, it's enough for the bio digester. Before she has a lot of cattle, but recently the household has a problem with the grass.
- Who in the household will be responsible for the bio digester?
The whole family, especially her husband and her will take responsibility for the maintaining.

Interview 4: Chai Lon

Date: March 25, 2014
Area: Kampong Speu Province, Cambodia
Organization: NBP
Household: Household with biogas digester
Present: Nathalie Hansson – Student of Chalmers
Cecilia Johannesson – Student of Chalmers
Jacob Gower – Sheffield University, England
Bunat Pok – NBP representant
Chai Lon – Farmer

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- What's her name?
Her name is Chai Lon.
- How does she make her livelihood?
She got income from rice cultivation, animal husbandry and sewing.
- Who lives her?
Her husband is head of family. Four members; her, her husband, her grand mother and her son.
- How do they cook?
She use wood and gas for cooking, She buys gas at the market. She have to buy gas tank. A tank can use for 2 or 3 months. A tank contains 12 kg. A tank cost 650 000 riel.
- How often does she use the gas and how often does she use wood?
She goes to the mountain to collect wood, and use the power tiller to transport the wood. She prefers to use gas more than wood, but just some times. If she is free, she prefers to use wood but if she's busy with the sewing she prefer to use gas.
- How does she light her home?
She uses battery, only battery. She also uses the battery for television.
- How does she get her water?
The water she buys from truck, but sometimes she has to pump with the pumping machine in the valley near her. This family only four member so they just spend a little bit with the water, so she prefer to buy water from the truck because all members are so busy. Sometimes her husband is free her husband can use pump machine. If she pumps water buy her self it's cheaper than buy water from the truck but has to spend the labour. The water quality quit different, maybe the water from the truck more quality then from the valley because the water valley is ground water the they have calcium carbonate in the ground water, it's not good for the health so she prefer to buy water from the truck. The water from the truck is transport from the canal. Sometimes they use the filter to clean the water.
- Are there any others engines they use?
Gasoline engine and a power tiller trailer. They just use the power tiller for plowing and transportation. Rice grain and wood from the mountain.
- Do they share the power tiller with the village?
She have never lend out the power tiller to another household but sometime when plow they have to rent in labour to use the power tiller because her husband is not strong enough to use the power tiller.
- How much does the power tiller cost?
3000 dollar. Two years ago. They have to sold cattle and spend money back for power tiller, to save many years. They sold two cattle to buy the power tiller and two cattle are

not enough they have to spend more money.
- How reliable is her sawing, how does it work?
The income varies from 5000 riel to 20000 riel per day. She makes everything, especially clothes. She doesn't have a contract, she sell to the villagers. For example the villager want order her to sew a shirt, she make a shirt. She buys the material from the market. She explain about the cloth, the villager go to buy from the market and bring the cloth to her and she will sew.
- Where did she learn to sew?
She said that she learn how to sew in the Khmer rough regime, because the Khmer rough regime she also worked with the sewing machine.
- Would she be interesting in using an electric sewing machine?
She is so strongly interests with the electric motor connect with the sewing machine but recently it's not available electricity cable. It's not possible to connect to the battery because it provides a lot of energy. But recently she also keep waiting for the electricity cable.
- What else would she use from the electricity cable?
If possible she will use electricity for television, DVD-player and lighting, and also connect to her sewing machine.
- How does she think that would improve her livelihood?
She explains that if electricity cable is available in this village it will improve their lifestyle; maybe she can change from the wood electricity for cooking.
- Do they have any animals?
She has three cows and two pig and several poultry.
- Has she considered having a biogas digester?
She is also interesting with the bio digester but she doesn't have enough money to build. She has to spend a lot of money at her son at the university. She has to spend for her son at the university 100 dollar per year, for fee.

Interview 5: Sapt Suhn

Date: March 26, 2014
Area: Kampong Speu Province, Cambodia
Organization: NBP
Household: Household with biogas digester
Present: Nathalie Hansson – Student of Chalmers
Cecilia Johannesson – Student of Chalmers
Jacob Gower – Sheffield University, England
Bunat Pok – NBP representant
Sapt Suhn – Farmer

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- What's his name?
Sapt Suhn
- How do they earn their living?
He can earn a living from the vegetable cultivation, animals, rice cultivation and he also works as a construction worker. His son also works in teacher at the high school. Another son also studies at the university in Phnom Penh, four year student.
- How do they cook?
Recently he uses only biogas from the bio digester for cooking food but sometimes he also use wood, when he has a party he has to require a lot of energy.
- Where does he get the wood from?
He buys wood from this household, and also go to collect wood around here, in the village, near the residence.
- How long has he been using biogas?
Three years ago he uses the bio digester.
- For how long has biogas been promoted in the village?
He is the first household to adopt biogas in the village.
- What made him make the decision?
He explains it in the first time there is no electrical cable in the village. So when he goes to participate in the training curse from the NBP he is strongly interested in the benefit about the biogas. After that he also visit a household in another village with a bio digester and saw clearly how to use and how to get benefit from the bio digester. He decides to adopt the bio digester for the household because the bio digester can produce the gas for cooking and for lighting and fertilizer for the agriculture production.
- For him, what is the most important benefit?
The fertilizer. In the first he use only manure, provide manure directly to the corp. And after that he uses the fertilizer from the bio digester and it increase. Another hand the fertiliser also can reduce the insects and protect against the insect.
- What does he use for lighting?
Recently he stop uses the biogas lamp anymore, just use only electrical lamp for lighting.
- For how long have they had electricity?
He decided to connect with the electrical cable for two years ago. He uses the electricity for sewing machine, electrical pumping water, television, DVD-player, speaker, phone, iron. He has four sewing machines.
- Is there anything else he wants to use electricity for?
In the future he wish to use another electrical material, for example refrigerator. He has to spend around 70 000 riel for electrical cost.
- What does change his lifestyle?

He explains that even if the electrical cost can be so high but it still more affordable if you compared to the battery because if you use the battery you have to charge it every week. And the battery we can use only six month after that we have to buy a new one because after six month it will be broken. The price for battery is so expensive, 50 dollar for one so when they change to use the electricity cable they can use the money for the electricity.
- Can he use electricity to improve his income?
He explains that it can improve their livelihood to the vegetable production because he uses the electrical pumping motor. The price of electricity per kilowatt-hour only 720 riel, more cheaper. So if they use the pumping engine the have to spend a lot with the fuel price. When we change to use the electrical pumping motor we have to spend a little with the electrical cost, only 720 riel. On the other hand the electrical motor can improve the activity of sewing.
- Does he use that electrical pump to pump his drinking water as well?
About the drinking water he has to buy from the truck, cleaner water for drinking. In the first time he use the filter for drinking water but recently he stopped using it any longer because sometime in the first time of raining season there are a lot of dust in the water so the filter can not clean enough. The raining water he use only for household requirement and drinking, not for arrogation.
- What do they do with household waste?
They use for fertilizer, for slurry. The plastic bags they burn.
- How do they wash their clothes?
Just by hand. They wash every day. Every member in the household maybe they washing clothes every day. For example today him, and tomorrow his son, and next tomorrow his wife every day change of member.
- What engines does they have in the house?
They have thrusting machine, generator and sewing machine. Pumping machine and motorcycles.
- The thrusting machine, does he share it with the village?
In the first time another villager also hired the thrusting machine to thrust the rice grain but recently they stopped renting out anymore because the household there's no any labour. Because his son also work and study in the Phnom Penh so no labour especially for thrusting rice. He just uses the thrusting for the household requirement.
- When does he use the generator?
He use the generator before the electricity cable but now he stopped use any longer.
- How often are there blackouts?
Electricity cable here is okej, maybe only one time a month of black out, and it's just for short time maybe only five minutes.
- His children in education, when they are finished, will they stay in the village or will they move away?
He doesn't know about his son plans.
- Will he divide the land to his children?
He cannot divide to his children, his land size will be smaller and smaller.
- Is it easier to save money since he started to us electricity and biogas?
He explains he can save money more then before. Because he can improve the job with the sewing machine and agricultural production. Because when availability of electricity cable can improve the sewing machine.
- How much labour does it take to run the biogas digester?
Only two member in the household take responsibility to maintain and provide the animal manure to the bio digester, his wife and his son.
- How long do they spend doing that?

Maybe around 10 minutes per day to provide the animal manure to the bio digester.
- Have he experienced any problems with the bio digester?
He has never had any problems with the bio digester.
- Who made the decision?
His wife is the main decision maker to build the bio digester.
- Do they get enough gas for the household?
The large number of the household members so the household needs a lot of gas for cooking so the biogas digester cannot provide enough gas for the family. They would like to have more. Ten members in the family. He has to use wood sometimes, the gas is not enough.
- Have they got any training in the maintenance for the fertilizer?
He has never participated in the training but there are NBP agency they come and explain how to use biogas in the household.
- Have biogas saved them a lot of time?
He said that the bio digester could save them a lot of time, especially for cooking.

Interview 6: Chem Li

Date: March 26, 2014
Area: Kampong Speu Province, Cambodia
Organization: NBP
Household: Household with biogas digester
Present: Nathalie Hansson – Student of Chalmers
Cecilia Johannesson – Student of Chalmers
Jacob Gower – Sheffield University, England
Bunat Pok – NBP representant
Chem Li - Farmer

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- For how long have they been using a biogas digester?
They start to use the biogas digester in 2010.
- How many are they in the household?
They are eleven members in the household.
- What is their main source for income?
They can earn their living from the vegetables, rice cultivation and animals.
- How many animals do they have?
Three cattle. Two is cow and one is ox.
- Is that enough for the bio digester?
It's enough for the bio digester. The biogas is enough for cooking food and heating water.
- What did they use for cooking before they had the bio digester?
Only wood for cooking before the bio digester installation. She bought it from the market and sometimes she go to collect the wood from the rice field. 35 000 riel per trail. One trail they can use for two month.
- What's the biggest different between before they had the biogas and now?
She say it's very different. After she had the bio digester it's easy especially for cooking. To pay much money for wood. She confirm that maybe save 30 % if we compare before biogas digester. 30 % less time.
- Were did they get the information about the biogas?
She can learn how to use the bio digester and she know the benefit of the bio digester because the NBP they got a training course in the village. Biogas training, how to maintain, how to repair, how to work with the bio digester.
- Who is responsible for the biogas digester?
Every member in the household knows how to use the biogas digester but recently only her take the responsible to provide the animal manure to the bio digester. But sometimes when she has busy anywhere, her son take responsibility to take care.
- Have they experienced any problems with the biogas digester?
About the biogas digester she never had a problem but she had a problem with the biogas lamp. When it was broken she had to buy and repair the biogas lamp by her self. To change to a new one, inside the lamp. The biogas lamps are quite fragile, a lot households have problems with them broken. In this household they use the biogas both for lighting and cooking. She has two biogas lamps. The biogas can support more then two lamps but she just use only two.
- What did they use before for lightning?
She used fuel lamps.
- How much did it cost when the lamp broke?
5000 riel when it was broken to buy a new one.

Interview 7: Ri Supche

Date: March 26, 2014
Area: Kampong Speu Province, Cambodia
Organization: NBP
Household: Household without biogas digester
Present: Nathalie Hansson – Student of Chalmers
Cecilia Johannesson – Student of Chalmers
Jacob Gower – Sheffield University, England
Bunat Pok – NBP representant
Ri Supche - Farmer

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- How does she make her livelihood?
The source of income from the rice production, her daughter works in the government factory. She also sells Khmer noodles every morning and animal husbandry.
- Does she have a rice mill or thrusting machine?
No, she doesn't have. She just buys the noodles from the market.
- How many people live in the household?
8 members in the household.
- How do they cook their food?
She use only wood, she buy wood near here. She has never buy gas from the market.
- How much does it cost?
71500 riel per day.
- Does the quality of the wood vary?
It's the same quality, it's a average cost and the wood seller is also a sibling, a relative.
- How does she light her home?
She uses the electrical lamp for lighting, with electricity cable. She has to spend 20000 riel per month for the electricity. 220 000 riel for connection service the first time.
- What else does she use the electricity for?
Just use electricity for lighting, fan, television, DVD-player and first time also the sewing machine.
- When does she use the fan?
She just uses the fan during the night, maybe three or four times.
- How do they get their water?
She says that she pump the water from the canal. She use electrical motor from his household but use the energy from her home. Just borrow because the household and her also are relative. They also share the thrusting machine, but only the relatives.
- How many animals does she have?
Four cattle, two big and two small.
- Is she interesting in having a bio digester?
She is also strongly interesting in having a bio digester but she needs to have an agreement from her younger brother. She has to discuss more, approval from her younger brother. He lives with her.
- Does she do anything with her animal manure?
The animal manure for fertilizer with the garbage and keep it and provide for the rice field.
Does she ever give her manure to household with the bio digester?
This household also ask her for animal manure to provide for their bio digester. Because this household the animal manure is not enough, they have to provide more manure.
- What is the difficulty in convincing her brother to have a bio digester?

She said that he just not know about the benefit with the bio digester today. She has to wait until he comes from the government factory.
- What interest her most with the bio digester?
General information about the bio digester from him. Both of the benefits, the biogas and the fertilizer. She said that in the future maybe there's no wood for cooking.
- Would she consider using an electrical pot for cooking?
She doesn't want to use electrical pot because it spend a lot with electrical cost, it's expensive.
- Are there any other electrical materials that she wants to use?
For example washing machine, refrigerator.
- How does she think the electricity has changed her lifestyle?
She also explain it that electricity can change her life because her life is better than before. Because before they use the candle and fuel lamp is not easy. Now they use electrical lamp, is easy. But very difficult because has to spend a lot of money on electricity every month.
- Does she think it's appropriate price for the electricity?
She think it's an appropriate price if she compared to an another village.
- Does she know why it's cheaper in this village?
Because it's public electricity cable, in another village it's private electricity cable.

Interview 8:

Date: March 27, 2014
Area: Kampong Speu Province, Cambodia
Organization: NBP
Household: Household with biogas digester
Present: Nathalie Hansson – Student of Chalmers
Cecilia Johannesson – Student of Chalmers
Jacob Gower – Sheffield University, England
Bunat Pok – NBP representant

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- What is the source of income for the household?
Source of income come from rice cultivation, peanut production, cattle and her son works at a company in Battambang province.
- Who lives in the household?
The husband is the head of family. They have four children, another son is separated from her home because he got married.
- How do they cook?
Biogas from the digester
- How much biogas do they use?
She doesn't know clearly how much they spend but she thinks a little bit gas because the volume of the digester is 6 meter cub.
- How many animals does that take?
She got five cattle, the animal manure is enough for the biogas digester requirement and plus.
- Does she they do anything with the extra gas?
She get a number of biogas lamp, three lamps for they need to study at the night and they can use the biogas lamp.
- Is it easy to use the biogas lamp?
She explain that the three biogas lamp quality is better the electricity lamp
- Why is it better than electricity lamp, brighter light?
The bright from the biogas lamp is cleaner to look at paper due to the electrify lamp
- Is it safe to use biogas lamp?
Yes but they have to maintain
- How much maintain does it take?
They have to be careful when they use lighter because it can break material of the lamp.
- How does she get her water?
From the stream.
- How far away is the stream?
100 m
- Is it always water in the stream?
Four or five times in the dry season, drinking water they buy
- How long does it take to pump water from the stream?
Around 2 hours and every time they need 1.5 liter gasoline for the pump.
- For how long have she been using biogas?
Since 2011
- What influenced her to buy a biogas digester?
She decided to buy the biogas digester because it could benefit the household, the fertilizer could improve the rice cultivation.
- Does she think she have the right size for the digester?

Is it impropriety size for the household
- Who made the decision?
The whole family
- How much difference does the fertilizer that they use make?
The fertilizer increases the rice cultivation from 1.5 ton to 3 ton, double production.
- From where did she her about the benefits?
Her husband work and PBPO
- Have she got any problem with the digester?
She explain that she have never had a problem with the biogas digester because her husband provide the digester with animal manure.

Interview 9: Sman Khon

Date: March 27, 2014
Area: Kampong Speu Province, Cambodia
Organization: NBP
Household: Household with biogas digester
Present: Nathalie Hansson – Student of Chalmers
Cecilia Johannesson – Student of Chalmers
Jacob Gower – Sheffield University, England
Bunat Pok – NBP representant
Sman Khon - Farmer

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- How does he make his livelihood?
He can earn income from rice cultivation, vegetable production and animal hasamenturie. His daughter also works in the government factory in Phnom Penh.
- How many lives in the household?
He is head of the family, they are six in the family, four children, he and his wife.
- How much land do they have?
The rice land he has 75 a, but the vegetable land only 40 a. (100 a= 1Ha)
- What provides most income, the rice or the vegetables?
The best for income is the vegetable production. He can earn 700 000 rel per mouth for the vegetable production.
- How do they cook?
They use the biogas from the biogas digester for cooking food. They us gas to every meal.
- How many animals do they have?
At the first time they have three but it is dead, for disease infection. Now he has only one cattle. When they have one cattle it's not enough but he has relatives near here so he can collect the animal manure from his relatives, this house next door.
- What did they used to use before the biogas?
He uses the biogas for only cooking food. And the first he also use the biogas for biogas lamp but now it was broken. He only uses batteries for lighting. Before he used biogas lamp for light but now he change, only use batteries.
- What else does he us the battery to power with his battery?
He use the battery for lighting especially by the dinner. And he use the battery for watching television.
- Before he had electric lighting, what did he use for light?
Biogas lamp, before bio digester he use fuel lamp.
- What are the differences between the different lamps?
Very different between fuel lamp, biogas lamp and electrical lamp. Electrical lamp have to spend for fuel cost. But sometime there's no level fuel we will stay with black lamp, without lighting.
- How much difference does that make if they have to stay without light? How does it change their life?
Change especially the dinnertime we have to change. If we have no fuel we have to have dinner before six o'clock, because we don't have light. They can spend the time in the daylight to take care of the vegetable production and the animals.
- How do they get their water?
He use the water from the canal, from the main canal. He use a pumping machine. But recently there's no available water in the canal so he has to use the water in the pond

behind the house.
- What is the difference between the canal water and the pond water?
The quality of water is the same but the water from the pond maybe need to spend labour because quite far from the canal, it's easier from the canal. Because in the dry season the water in the canal not supply enough. He decide him self because there's no water to pump. The quality is the same; it's the same water.
- How long has he been using biogas?
Since 2010.
- Whose decision was it to adopt the biogas digester?
His and his wife was decision maker to decide to adopt the bio digester. It was a joint decision.
- Who take responsibility for the bio digester?
All the member in the household take responsibility to provide the animal manure to the bio digester but only his wife use the stove with the biogas to cook.
- Before the biogas they cooked with wood, what is the change in their lifestyle since then?
Before bio digester installation all the member take care about the wood, all spend time for wood collection.
- Does he recommend to his relatives to buy a bio digester?
He also recommends to another household to use the bio digester but they cannot because a little bit also of budget, money.
- What is the main advantage, he would say?
He also talks to them the benefit of biogas for cooking. It's easy to cook and saving time.
- In the time that they save, what do they do with that time?
They can use the time saving to take care of the animal, and to take care of the rice field and the vegetables.
- How do they transport the rice and the vegetables?
They use the motorbike to transport.
- Have they got any problems with the bio digester?
He has never had any problem with the bio digester. Never break.
- What is the reason that he doesn't have biogas lamp today?
Because he has built a new house, and this time the biogas lamp also broke, so they haven't repaired it yet.
- Have they got any training in the maintaining?
NBP agent also come to his home and explains how to use, how to maintain how to take care of bio digester in this home.
- How did they handle the animal manure before they had the biogas digester?
Before biogas digester he keep the animal manure and transport it to the rice field and sometimes he provide the directly to rice field and the quality of the fertilizer is not good. Recently he uses only the fertilizer from the bio digester but he also use a little bit chemical fertilizer. He change to use a little bit chemical fertilizer because he strongly confident about the quality of the fertilizer from the bio digester. And he thinks the chemical fertilizer can destroy the soil structure in the future, maybe remain to use more and more. On the other hand he thinks maybe the chemical fertilizer can increase the number of insects to attack the vegetables. Reduce the crop.
- What difference does it make in the labour for him?
Recently he can reduce the labour because before bio digester he has to spend a lot of labour to take care of the vegetables because a lot of grass in the land, in the vegetable land. He has to spend a lot of labour to take care of the vegetables because of grass. But after use the fertilizer from the bio digester no grass grow in the land.

- Do they have their toilet connected to the bio digester?
Yes, they hade their toilet connected.

Interview 10: Man Kim

Date: March 28, 2014
Area: Kampong Speu Province, Cambodia
Organization: NBP
Household: Household with biogas digester
Present: Nathalie Hansson – Student of Chalmers
Cecilia Johannesson – Student of Chalmers
Jacob Gower – Sheffield University, England
Bunat Pok – NBP representant
Man Kim - Farmer

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- For how long has he been using a biogas digester?
For 6 years
- What is his name?
Man Kim
- How does he make his livelihood?
The source of income come from rice cultivation, cattle production and tuck tuck driving and his children work at a garment factory. He just bought a tuck tuck about 1 month ago. He use the tuck tuck to transport people from the village to the garment factory. 200 US dollar a month for tuck tuck driving and retirement.
- How much land does he have for rice cultivation?
For the first time he got 1 hektar but now he only 30 A
- How many people live here?
Four members, two children
- How do they cook?
He uses wood and biogas from digester, because his digester only 4 meter cube. He doesn't have manure enough because he doesn't have cattle so he need to ask another household and the biogas is not enough. He uses the wood for heating water. Two stoves for two household and the biogas is not enough. His son support him with manure.
- Who do they ask for extra manure?
His son in another household brings the manure to the household by himself.
- Where does his son get the manure from?
They have cattle, he doesn't have cattle but his son does
- What does he use for lighting?
Battery for lighting, they have no electricity cable
- What else does he use battery for?
He use only for lightning and television
- How big is the battery?
20 Ampere
- How does he get his water?
Come from the stream, from the water pipe
- Does he have his own pumping machine?
He also has a pumping machine
- Why did he buy the biogas digester?
He decide to buy the biogas digester because his brother in law is the first person to buy biogas digester and when he go to his brother in law he saw the biogas digester and he know about the benefits from the digester and it is really easy to use.
- For him what's the most important benefit of the digester?

He explain that the main importance from the biogas digester is saving time, from the digester he can spend time for tuck tuck driving, if he don't have digester he spend time collecting wood.
- Have the digester saved him a lot of time?
From 40 % to 60 % saved time, spend this time to earn many for income
- Have they got any problem with the digester?
They have never got a problem, has never break, he can fix by himself
- Have they got training?
He also got the training from the NBP
- How many animals did they have from the beginning?
He had four cattle but he sold all and decided to make pension
- How many animals does his son have?
Two cattle
- Did they only use wood before?
Before biogas digester he only used wood and he spend 2-3 days a month to collect wood 20 km from the village.
- Has he considered getting a biogas lamp?
Before he used a biogas lamp but he don't used that any longer because the biogas don't provide enough for lighting it just provide for cooking food.

Interview 11: Hem Sol

Date: March 28, 2014
Area: Kampong Speu Province, Cambodia
Organization: NBP
Household: Household without biogas digester
Present: Nathalie Hansson – Student of Chalmers
Cecilia Johannesson – Student of Chalmers
Jacob Gower – Sheffield University, England
Bunat Pok – NBP representant
Hem Sol - Farmer

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- What's her name?
Hem sol
- How does she make her livelihood?
The source of income come from peanut production, rice cultivation, cattle and one daughters work at the garment factory another study at school.
- How many people live here?
6 member in the household, 3 children her and her husband and her father
- Who is the head of the household?
Her husband is the head of family
- How much land do they have for cultivation?
50 A half of hectare, at dry season they cultivate peanut and rainy season they cultivate rice in the same plot.
- Does she have a plan to obtain a biogas digester?
She doesn't have a plan, she wish to build one but she can't afford one, she discus more with her husband to install one, but she doesn't know when.
- What does she think is an appropriate price to pay?
200 US dollar
- What does she use for fuel for cooking?
She does only use wood
- Where does she get the wood from?
To the forest, 5 km from here
- How does she light here home?
Battery
- What else does she use the battery for?
She also use fuel lamp for lighting, she use battery for lightening and television
- How does she get water?
She use pumping machine to pump from the stream
- How regular does she use that?
One time a month, 2 liter fuel per time
- Apart from the price, what the most important thing about a biogas digester?
She wants to build a digester because she thinks biogas digester would make her life easier than before in cooking food.
- How confident is she that the biogas digester would make her life easier?
She is strongly confident that the biogas digester can make her life easier
- What evidence does she have?
According to her looking at another household
- Is she interested in a electricity connection?
She is also strongly interested in electricity cable, but she doesn't know when it is

available in the village.
- What difference would that make in her livelihood?
She can lose the cost of battery
- What the most important of biogas, water pipe and electricity cable?
She thinks that water pipe and electricity cable is more important than biogas.
- Why is that?
Because she can use the electricity with a lot of material, cooking material, entertainment material, television dvd-player
- How many animals does she have?
Three cows
- What does she have for animal food?
In the rainy season it is ok the grass provide animal food it is problem in the dry season they can use the peanut for animal.
- How much does it take to irrigate during the dry season?
Three times a month they have to irrigate the peanut, three hour per time
- How do they handle the animal manure today?
The animal manure she keeps saving over there for rise field
- How is the toilet working?
When is fuel they use a pumping machine and use it as fertilizer
- Is she worried about the deforestation?
She clearly knows about the deforestation but she has no chance she has to go to the forest.

Interview 12: Bun Han

Date: March 31, 2014
Area: Kampong Speu Province, Cambodia
Organization: NBP
Household: Household with biogas digester
Present: Nathalie Hansson – Student of Chalmers
Cecilia Johannesson – Student of Chalmers
Jacob Gower – Sheffield University, England
Bunat Pok – NBP representant
Bun Han - Farmer

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- What is her name?
Bun Han
- How does she make her livelihood?
The source of income come from rice production 6 ton per year, animal and her son also work in Phnom Penh as construction worker.
- Does he send money home or do they send money to Phnom Penh?
He stays in Phnom Penh and only visit home sometimes.
- Who lives here?
She is the head of family, four members in the household, two children in the household.
- How much land do they have?
Two hectare for rice cultivation
- How do they cook?
According to her requirement of energy the biogas digester can't provide enough biogas for cooking so she has to use wood for cooking.
- Where does she get the wood?
She goes to collect wood near the stream, she spend time to collect wood, two or three times a month.
- How long is each trip?
Two or three hours per time
- How often does she need to use wood?
She uses biogas for cooking rice and soup, for heating water she use wood.
- How many animals does she have?
They are also sharing the manure between the household, 6 cattle but they are small, they share biogas digester.
- How much biogas do they use per meal or per day?
Maybe around 8 kilopascal one day because they are sharing between household
- Do they also use fertilizer from the biogas digester?
She also uses the fertilizer from the biogas digester and also share between the household.
- Can she say how much difference the fertilizer makes?
She doesn't know clearly how much difference that makes but liquid fertilizer is better than dry fertilizer.
- Does she still buy fertilizer?
She still buys a little bit fertilizer for rice production because fertilizer from biogas digester is not enough.
- Does she buy less fertilizer than before she had a digester?
She buys less than before, before she used 400 kg of chemical fertilizer but now she

only use 100 kg of fertilizer per year.
- What do they use for lightening?
She use electricity because this household is connected to a cable
- What else do they use electricity for?
She also uses the electricity for cellphone, fun, television, pump water for household use and irrigation.
- What does she think is the most importance electricity or biogas digester?
They think electricity cable is more important than biogas digester because biogas digester can only use for cooking, not for other material.
- Do they always pump there water through the electric motor?
She often uses the electric motor to pump water for eating, washing maybe three or four day a month.
- How long does it take each time?
She explains one or two hour to pump for the household requirement only one hour but irrigate maybe she has to spend two hour.
- Is it difficult to pay the electricity?
She said it is an appropriate price for the household but she just explain that at the first time the companies promised that the price will go down if the household is connected to electricity cable for a long time but up to now the price is still the same never go down.
- How big is the biogas digester?
6 meter cube
- Is that an appropriate size for them or do they have manure for a bigger one?
She explain that 6 meter cube is not enough for two household, she think that 6 meter cube is good for one household and there cattle can support for 8 meter cube digester.
- For how long have they been using a digester?
Seven years ago
- What was the reason for getting a digester?
Because from the difficulty from wood collection, the wood is not provide enough for household, biogas is a clean energy no smoking and it is cleaner in the kitchen.
- What is the reason to not buy another one now if they have the manure and don't have enough gas?
They can't afford another one
- Where did they get the information?
She doesn't know clearly but the first time a promoter come to inform about digester to the village so she could know the benefits from the biogas digester but she doesn't know clearly if they work for NBP or another organization.

Interview 13: Tun Veng

Date: March 31, 2014
Area: Kampong Speu Province, Cambodia
Organization: NBP
Household: Household without biogas digester
Present: Nathalie Hansson – Student of Chalmers
Cecilia Johannesson – Student of Chalmers
Jacob Gower – Sheffield University, England
Bunat Pok – NBP representant
Tun Veng - Farmer

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- What is his name?
Tun Veng
- How does he make his livelihood?
The family earn their living from rice cultivation, animals and his wife also work at the garment factory and her daughter also work at the garment factory his son also work as driver in Kampong Sam province.
- How many people live in the household at the moment?
The member of this house only him, his wife, his daughter and two grandchildren.
- How much land do they have?
One hectare for rice cultivation
- How many animals do they have?
Five cattle
- How do they cook?
He use only wood for cooking
- Where does he get the wood?
Recently he only buy wood from the market because the household can't go to collect wood in the forest because recently the government keep wood under protection so nobody can go to the mountain to cut the forest.
- Has he noticed that the forest become smaller?
Yes he clearly knows about the deforestation and from previous year the number of forest become smaller and smaller and recently they can't collect wood anymore.
- Is he interested in getting a biogas digester?
He also quite interested in a biogas digester but he doesn't have enough money to install it.
- How much does he think is an appropriate price to pay?
He can't determine how much because he need to discus with his wife, he wants to get an approval his member in the household.
- What motivates him to get a digester, why he thinks it would be good?
Because he think he have potential enough for biogas digester because he have five cattle it is enough to provide manure to the biogas digester in another hand it would compared to wood make the life easier than before because recently the price for wood is higher than before and they can't go to the forest anymore.
- When does he think he buy a biogas digester in the future?
Maybe around one year later because he plan to expand his house to build a home so he want to build his house first and after that he will build a biogas digester because he want to build an appropriate kitchen and after that he will build a biogas digester.
- Who makes the decision?

He is the main decision maker but all the member in the household also agree with them.
- What does he use for lightening?
He uses the electricity from the electricity cable for lightening.
- How long have he had the electricity cable?
Five years ago
- What else does he use electricity for?
He uses the electricity for flash light and fun, television, DVD-player, speaker and cellphone.
- What did he use before?
He used battery
- What is the difference in his lifestyle when he using electricity instead of battery?
The electricity can improve their livelihood better than before because electricity cable is easy to use. In the first time maybe he had to spend more than 20 000 Riel per month for charging battery, they have to buy a new battery when the battery was broken and the ordinary around 15 000 Riel per month so the spend is lower than for battery.
- How does he get his water?
He use the valve
- How does he get water from that?
He also use the electric motor to pump
- How often does he pump water?
Three times a month
- How does he irrigate his fields?
It depend on the rain fall but for the mung been it don't require irrigation but rice field require irrigation system so when the rain fall is not enough he had to provide more water but just some time, with the irrigation he has to use engine machine, fuel engine.
- Are there any conditions that can change his decision to get a digester in a year?
He estimate that in the future we don't have enough wood for cooking so we have to find another energy instead of wood so biogas digester is improper material for cooking food.
- Does he use any fertilizer?
Recently he only uses animal manure and chemical for fertilizer he wish to use fertilizer from biogas digester in the future because the fertilizer from digester can reduce the amount of chemical fertilizer.
- How much does chemical fertilizer cost?
Around 4000-5000 Riel per kg
- How much does he need in a year?
Maybe around 200 kg per year, if he have a biogas digester he only have to use around 100 kg of chemical fertilizer per year
- Do they have enough cattle to run a biogas digester?
Yes, he is not worried about manure to provide because he thinks five cattle is enough for biogas digester but he just confirm that in the first time they have to getter a lot of manure to provide biogas digester maybe around 1 ton in the first time of installation but after that only 10 kg is ok.

Interview 14: Shun Siamli

Date: April 1, 2014
Area: Kampong Speu Province, Cambodia
Organization: NBP
Household: Household without biogas digester
Present: Nathalie Hansson – Student of Chalmers
Cecilia Johannesson – Student of Chalmers
Jacob Gower – Sheffield University, England
Bunat Pok – NBP representant
Shun Siamli - Farmer

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- How does she make her livelihood?
The source of income from rice production, animals, her husband also works as head of village. Her daughter also works in the government factory.
- How many people live here?
Her husband is a head of family and recently they are eleven members in the household.
- How much land do they have?
60 A (0.6 Ha)
- How many animals do they have?
Three cattle.
- How do they cook?
She also uses wood, and gas from the market. The gas costs 1500 riel per can. She just uses gas sometimes, for example if someone in the household gets sick, they have to cook on time.
- How is gas different from wood?
The gas is more better then wood but sometimes we cannot affordable with the gas.
- Where does she get the wood from?
She goes to the forest.
- Have she seen any evidence of deforestation?
She know clearly about the deforestation but the forest is for cutting wood for cooking, the quality of the wood is not for furniture, just for firewood.
- How does she light her home?
She uses batteries for lighting.
- Does she use the batteries for anything else?
For lighting and cell phone. She doesn't have television.
- Do any of these neighbours have television?
Her neighbour somehow also have television because they have more money, maybe their livelihood is better, somehow doesn't have television also.
- Is she interesting in television?
She is strongly interesting in television but recently there is no electricity cable in the village so it's difficult if they use with battery.
- How often does she have to recharge and replace the battery?
She has to charge one week, one time. They use only with lighting and the charge of charging is 1500 riel per time. The battery they can do only six month and sometimes one year have to replace with a new one.
- How big is the battery and what does it cost?
40 ampere, 160 000 riel to buy a new one.
- Does she have a radio?
No, she doesn't have.

- What do they use the electric lighting for?
They use the electrical lighting for having dinner and for sleeping.
- How do they get their water?
Pumping vale, since two year before the pumping vale is not supplying the water enough so she has to buy water. She buys from water truck. No problem in the raining season, only in the dry season.
- Does she have problem with wood in the raining season?
No problem with the wood in the raining season because she store under the house during the rain and the available of sunlight she can move to dry.
- Does she still collect wood during the raining season?
We can collect in the dry season and keep it for the raining season.
- Have she considered having a bio digester?
She is also interesting with the bio digester but the main problem she doesn't have enough money to buy it. She doesn't know how many years of saving for buying a bio digester.
- What is the main attraction with the bio digester?
In the first time she have never seen before bio digester but she just saw her brother install a bio digester and he is also interesting with the way they cook, very easy to cook, and use fertilizer for rice production.

Interview 15: Pong Pen

Date: April 1, 2014
Area: Kampong Speu Province, Cambodia
Organization: NBP
Household: Household with biogas digester
Present: Nathalie Hansson – Student of Chalmers
Cecilia Johannesson – Student of Chalmers
Jacob Gower – Sheffield University, England
Bunat Pok – NBP representant
Pong Pen - Farmer

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- What is his name?
Pong Pen
- How does he make his livelihood?
The source of income come from rice production, animal hesimentry include cattle and poultry production and palm juice.
- How much land does he have?
1,5 hectare
- How many people live in the house?
He is the head of family and recently the household nine members, four children, one grandfather and his wife and two relative live tighter in this home.
- How do they cook?
Recently he use biogas from the biogas digester and he also still keeping using wood because the biogas only support for the household requirement but he has to cook some food for the guest to eat with palm juice.
- How much wood does he need and where does he get it from?
About the wood he go and collect in the rice field near the stream, had never bought wood from the market because he has not enough money to buy from the market.
- How long does it take to collect it?
Five to six time per month. Two or three hour per each time
- How many meals per day do they cook with biogas?
Three meal per day, he also use the biogas lamp for lightening
- How long has he been using a digester?
Only one month ago
- How has that change the lifestyle of the household?
He explain that after he used a biogas digester they can save time especially heating water in case someone in the household is sick he can heating water and cook food one time.
- Who in the household make the most benefit from the biogas digester?
He said that his wife work every day with the biogas digester but the whole household the whole of member can get benefit from digester especially his children can study by using biogas digester at night.
- How big is the biogas digester?
4 meter cube
- How many animals do they have?
Six cattle
- How much biogas do they need every day?
He doesn't know because he never made an observation with the biogas.
- How much did it cost?

He spend 500 US dollar but after that they offer him 150 dollar back
- How did he save that money?
He say that the biogas can save money in the household so that biogas lamp because he doesn't use biogas lamp he has to spend more money on battery charging. He just sold the cattle, his right cattle is enough for biogas digester.
- Does he use electric lightening?
He just use biogas lamp and battery for lightening
- Is he interested in connecting to electricity grid?
He also strongly interested in electricity cable, he said that in the first time they asked the local authority about the electricity cable and the authority said that the electricity will coming soon but he keep waiting for a long time and still no electricity and he does not know when electricity available.
- What electric material will he be interested in using when he gets electricity?
Available he will use television, fun and lighter
- How do they get their water?
He gets water from the well
- Does he have any engine?
He also have a pumping engine but the pumping engine only used for irrigation to the rice field he pump from the canal to the rice field.
- Where did they here about the benefits?
The benefit from the biogas digester the first the household obtain the energy for lightening especially for the children study and second energy for cooking food and third the household get fertilizer to provide the household.
- Did they finance the cost by loan or did they save the money?
They sold one cow, he also go to loan for building the kitchen, 1000 dollar
- Where does he go for loan?
Microfinance institute in Kampong Speu
- How long is the payback time?
24 month, two year
- Is it appropriate for him?
It is an appropriate period for him,
- How much money does he earn from his livelihood?
He cannot determine he doesn't think about what he can earn about the palm juice maybe around 500 000 Riel per month. About the rice production around 700 000 Riel per year because he have to keep some production for household requirement.
- Who made the decision?
His wife is the main decision maker in the household, about the biogas digester she is also because she is house wife and spend time cooking food.

Interview 16: Mang Sokom

Date: April 2, 2014
Area: Kampong Speu Province, Cambodia
Organization: NBP
Household: Household with biogas digester
Present: Nathalie Hansson – Student of Chalmers
Cecilia Johannesson – Student of Chalmers
Jacob Gower – Sheffield University, England
Bunat Pok – NBP representant
Mang Sokom - Farmer

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- What is his name?
Mang Sokom
- How does he make his livelihood?
He can earn living from sell fruit for the garment workers, agriculture, rice production, poultry production, animal husbandry and work as village leader.
- Who lives here?
He is the head of family, eight members in the household, three children, one grandchild, two relative and his wife.
- How much land do they have?
Residential land 10 A, rice land 1 hectare, cattle land 40 A he also get income from cattle production.
- How many animals do they have?
Five cattle
- How do they cook?
Recently he uses biogas from the digester and wood because he have to cook some rice and food for garment workers and biogas digester cannot provide enough gas to cook.
- His he interested in a bigger biogas digester?
He said it is not possible to buy a big one because he have only five cattle it is not enough, if he buy a big one he have to rise more pig or more cattle.
- How does he light his home?
Now they are available electricity cable so recently he uses electricity for lightening.
- Does he use electricity for something else?
He uses electricity for television, lightening, cellphone, fun and computer because his son has a computer for his work.
- For how long have they have electricity?
Two years ago
- How much electricity do they use?
He doesn't know how much kwh he spend but he just know about the cost of electricity per month around 13 000 Riel per month.
- What difference has electricity have for the household?
He thinks electricity cable can improve their livelihood because before electricity he used battery and fuel so he had to pay more because the price of battery charging and battery cost still high compared to electricity cost per unit.
- What does he think is more important electricity cable or biogas digester?
He think the importance is the same between electricity cable and biogas digester but he confirmed that biogas serve more money than electricity because they just spend a lot of money only the first time and after that they don't have to spend anymore but electricity have to spend every month.

- How does he get their water?
He uses the water pipe, he uses 10 or 12 meter cube per month and the cost per unit 1600 Riel per meter cube.
- How long have they been using a biogas digester?
He used they biogas digester since 2008
- What does he think is the most importance benefit with the digester?
He explain that main benefit of biogas digester is biogas for cooking food but he said that there are a lot of benefit with biogas digester not only biogas but the most benefit are gas for cooking but in the first time he also used the biogas for lightening and another hand the quality of fertilizer also good for rice production. About the cattle production everyone prefers to buy his cattle because there are no chemical pesticides.
- Have they got any problem during these years with the biogas digester?
Sometimes he also got problem with the biogas digester especially with the valve but it is okay because he can fix by himself.
- Because he got training?
He also got training from PAM Maybe in the future he can repair the biogas digester in another household because he got the training cost from PAM he can repair biogas digester in the whole commune.

Interview 17: Jah Sam

Date: April 2, 2014
Area: Kampong Speu Province, Cambodia
Organization: NBP
Household: Household with biogas digester
Present: Nathalie Hansson – Student of Chalmers
Cecilia Johannesson – Student of Chalmers
Jacob Gower – Sheffield University, England
Bunat Pok – NBP representant
Jah Sam - Farmer

……

- What is her name?
Her name is Jah Sam
- How does she make her livelihood?
They can earn their living from, the main income from green cultural production, rice cultivation, animal hesimentry, poultry hesimentry and cattle production under the dry season they grow the peanut and pumpkin and her son also work at an rice milling company and another children studying in high school and secondary school.
- Who lives here?
Her husband is the head of family, her husband also work commune comity member. Recently they are eight members in the household.
- How much land do they have for agricultural production?
She have rice land 2 hectare and cattle land nearly 2 hectare so the total for agricultural 4 hectare.
- How do they cook?
She uses the biogas for cooking food and wood for heating water.
- How big is the biogas digester?
4 metric cube
- How many meals can she cook per day with the biogas?
Three time a day, breakfast, lunch and dinner
- What is the biggest difference cooking by wood or gas?
Biogas more convenient than the wood and sometimes we cook some food with biogas and we can do everything, do anything else
- Has biogas changed her routine?
She can save time and she use they saved time to take care of the animal, because in the first time she spend time to collect wood, wood collection but now she never spend time to collect wood but she spend the time to take care of animal.
- How does she light their home?
They use electricity for lightening
- How long have they have electricity?
2 years ago
- Did they use battery before?
Yes before they used battery and biogas lamp for lightening
- What else does she use the electricity for?
She use the electricity for television, cellphone and lighter, flashlight and fun
- What does she think is most importance biogas or electricity?
She think the electricity lightening better than biogas lightening but she think biogas more benefit more than electricity because they don’t have to spend money every month, only spend one time.

- Does she use the slurry from the biogas digester?
She also use the fertilizer from the biogas digester for rice production and ? production especially peanut and she have to buy animal manure from another household every year, because biogas digester cannot provide enough fertilizer for rice production and cattle land production.
- Have she noticed how much difference the slurry have?
She explain the quality of fertilizer more better then manure and rice production increase after they start using the fertilizer from the biogas digester and especially they have no grass in the rice field after they use the slurry.
- Have they got any problem with the digester?
No they have never had a problem with the biogas digester because it have never broken.
- Have it saved them a lot of time?
Yes she can save a lot of time with biogas digester, recently she just spend the time for take care of her grandchildren and animal.
- Which one in the household is responsible for the digester?
Three member in the household take responsibility to maintain and provide animal manure for the biogas digester, her husband her and her son
- What does she believe is the most importance benefit with the digester?
The most important is fertilizer and the second biogas for cooking.

Interview 18: Kap Kimn

Date: April 2, 2014
Area: Kampong Speu Province, Cambodia
Organization: NBP
Household: Household without biogas digester
Present: Nathalie Hansson – Student of Chalmers
Cecilia Johannesson – Student of Chalmers
Jacob Gower – Sheffield University, England
Bunat Pok – NBP representant
Kap Kimn - Farmer

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- How does they make their livelihood?
The main income from rice cultivation, animals and he works as a constructor worker.
- Who lives here?
His mother is a head of family, four members in the household.
- How much land do they have?
15 a (0.15 Ha)
- How many animals do they have?
Three cows
- How do they cook?
He uses wood for cooking.
- How long time does it take to get the wood?
He just buys the wood.
- Is it a good price for the wood?
30 000 per m3, can use for one month or two months.
- How long time does it take to cook?
Around one hour.
- Have they considered using a bio digester?
He is not interesting in bio digester because there is no any labour to work with the bio digester. He has to go outside in to work with the construction worker, no spear labour.
- Would he be interesting in buying gas, instead of wood?
No, he doesn't want to buy gas from the market for cooking because he thinks it's not safe. Sometimes you can get accident from gas can. Wood is safer then gas.
- Is he interesting in using electricity to cook?
She doesn't want to use the electrical to coo, because they don't know how to use it, and wood is safer.
- How many meals does they cook per day?
Only two times per day, lunch and dinner. For breakfast they go to buy some food at the market, or somewhere near here.
- What do they do for lighting?
Electricity lamp. The price for electricity more cheaper. Even if she uses the electricity lamp a whole night she just spend 10000 riel per month, more cheaper. More cheaper then battery.
- What else do they use electricity for?
They use electricity for television, fan, cell-phone and light.
- How much difference does the fan make?
The benefit from the fan is more cooler.
- How long have they been connected to the electricity grid?
He just connected with electricity cable, only five months ago.

- What difference has it made to his lifestyle?
His living more better than before. He can light their house in the night, can use fan, can watching television.
- Is it just comfort or is it any other benefit?
The electricity just make their living more comfortable than before, but cannot increase their income.
- How do they get their water?
They use the vale water and this household and that household is not connected to the water pipe. They carry buy hand.
- How much wood does it take to boil water, in compare to food cooking?
They have to spend wood more when heating water then cooking rice, or soup.
- Have they any attention to connect with the water pipe?
She is also interesting to connection to water pipe, but they don't have enough money to connect it.
- What do they think is the main benefit with connection to water pipe?
They can grow more vegetable because we can connect with the pipe behind the house and cultivate vegetable.
- What do they use the animal manure for at the moment?
They use the animal manure for agricultural productivity every year. They use the manure for fertilizer.
- Would they be interesting in using a communal bio digester to turn the manure into slurry?
He is not interesting with the fertilizer, slurry, from the bio digester.
- Have he seen the benefit from the bio digester?
No, they haven't seen the benefit from the bio digester.
- How far away are their rice fields?
500 m from the house.
- What to they think they can increase their agricultural productivity?
Maybe he can't improve his agricultural production because he has only a small size land. He doesn't have money to buy more land.
- What would he do if he couldn't buy wood, or if the wood was very expensive?
If the wood was very expensive he would have to fins would by them selves.
- Have he heard anything about the deforestation?
He know about the deforestation but he never asset to the forest. Especially in this village the forest is belong to private, so they can't asset. In the future if the wood price more increase he just go to collect a small wood in the field.
- In the dry season, what do they do with their field?
Nothing, no cultivation. They just cultivate rice one time. He wants to cultivate vegetables, when he has money enough for water pipe.

Interview 19: Wong Sokher

Date: April 4, 2014
Area: Kampong Speu Province, Cambodia
Organization: NBP
Household: Household with biogas digester
Present: Nathalie Hansson – Student of Chalmers
Cecilia Johannesson – Student of Chalmers
Jacob Gower – Sheffield University, England
Bunat Pok – NBP representant
Wong Sokher - Farmer

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- How does he make his livelihood?
His job is rice alcohol production, agricultural production, pig and cattle retention.
- Who lives here?
His brother and mother is head of family. Ten members in the household, include the children, grandchildren and brother in law.
- How much land do they have?
He is not sure how much land the household have. He says maybe around 1 ha but she say maybe 3 ha.
- How do they cook?
They use the biogas from the bio digester for cooking.
- How big is the bio digester?
He said his father knows clearly about the volume of the bio digester but for him he is not sure.
- How many animals do they have feeding the bio digester?
He has seven cattle and 14 pigs.
- Is there always enough biogas to cook for everyone?
He said he only use the biogas for cooking. He uses wood in case the household have a party or they are many. Only for household requirement the biogas still supplies.
- For how long have they had the bio digester?
Since 2003
- Before then how much wood did they have to use?
Before bio digester he went to forest to collect wood. Three or four time per week and every time he has to spend 3 hours to transport to the household.
- What is the biggest change in his life since using biogas?
The bio digester can save time and easier to use than before. We can spend more time for alcohol production and transport alcohol to the retailer.
- How much fuel do they use for alcohol production?
Recently he uses only wood for alcohol production. He goes to forest to collect wood. Only Sunday, one week one time. Maybe three or four hours.
- How did they learn how to produce alcohol?
He can learn from his father and his father also work at the agricultural provincial department.
- Do they use their own rice for the alcohol production or do they buy rice?
He only buys rice.
- How do they light their home?
He uses the electricity from the electricity cable for lighting home.
- For how long have they had the electricity cable?
Three years ago.

- What else do they use the electricity for?
He uses electricity for fan, light, television, electrical motor, pumping motor.
- Is there any more electrical material that he wants to use?
In the future he wish to use the refrigerator.
- How does he think that will benefit his livelihood?
He can keep the water or meat or food for a long time.
- In what other way can electricity benefit someone livelihood?
The electricity use more better then battery use. We had to charge the battery two times per week. Have to pay a lot of money for recharging.
- How does he get his water?
He pumps water from the vale, with electrical motor.
- How much does it costs to pump the water?
He doesn't know hoe much they spend on electricity but he has to pump one hour every day.
- What do they do with the wastewater?
About the pig production, when we watering the pigs the wastewater also flow between the pig manure. We store it and use the wastewater to provide the bio digester.
- What do they do with the household waste?
For the kitchen waste we can use for animal feed. The leaf of the tree they can connect to the fertilizer. The plastic bag they just burn it.
- What does he think is more important, the biogas digester or the electricity cable?
He thinks the bio digester and the electricity more important the same. He needs all of them.
- Does he think that's the same for all households?
He doesn't know but he explains it in the village it's only three households with bio digester. More the household they tend to use the electricity more then the bio digester.
- What does he think is the most important thing to improve the farmers livelihood?
He thinks we have to improve the technology how to use the chemical fertilizer with the slurry.
- How much did the biogas digester cost for him?
400 dollar.
- During how long time did he save to get the money?
His father build the bio digester by his own money. Is not set to loan but he don't know how long they saved to get the money.
- How long time have they used the bio digester?
Since 2003.
- Have they had any problems with the bio digester?
The bio digester a little bit problem with the valve but his father could repair by him self.

Interview 20: Heng Komsoa

Date: April 4, 2014
Area: Kampong Speu Province, Cambodia
Organization: NBP
Household: Household with biogas digester
Present: Nathalie Hansson – Student of Chalmers
Cecilia Johannesson – Student of Chalmers
Jacob Gower – PhD. Sheffield University, England
Bunat Pok – NBP representant
Heng Komsoa - Farmer

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- How does she make her livelihood?
The household job is rice cultivation, her husband also work as a director of primary school and her children work in company and study at university in Phnom Penh. Recently they are five members in the household but another children they just spend most time in Phnom Penh. She said she is the head of family.
- How do they cook?
They only use biogas from the bio digester for cooking.
- How long have they had the bio digester?
Four years ago.
- What motivated them to get the bio digester?
She explain that first time she go to participate with a wedding party she also saw another household in another village they had the bio digester and she also strongly interested because the bio digester easy to use for cooking. After come back from wedding party also discuss with her husband and decide to buy a bio digester.
- Now when she have a bio digester, how does she think it benefits her livelihood?
The benefit from bio digester is biogas for cooking food and fertilizer for rice field, rice production.
- How big is their bio digester?
6 m3.
- How many animals does she have?
She have 13 pigs but she doesn't have cattle.
- Where does she get the feed for the pigs?
She have to buy the animal feed from the market.
- How much does that cost?
65 000 riel per bag and the bag equal 35 kg. In the first she had a lot of pig she just sold it to the market and before she buy animal feed every day but the amount of animal feed around nearly 1 ton per month, because before she have a lot of pig.

Interview 21: Hol Seken

Date: April 4, 2014
Area: Kampong Speu Province, Cambodia
Organization: NBP
Household: Household without biogas digester
Present: Nathalie Hansson – Student of Chalmers
Cecilia Johannesson – Student of Chalmers
Jacob Gower – Sheffield University, England
Bunat Pok – NBP representant

……

- What is her name?
Hol Seken
- How does she make her livelihood?
This household can earn their income from garment factory worker because she is a garment factory worker, her brother, half brother and mother work with rice production.
- Who lives here?
Her father is the head of family, seven members in the household
- How much land do they have?
The rice land around 1 hectare
- How many animals do they have?
Five cattle
- How do they cook?
She use only wood for cooking food
- Where do they get there wood from?
Buy from the household
- How much does that cost them?
10 000 Riel per three or four days
- How long time do it take them to cook a meal?
30 min per meal
- Has she ever thought about getting a biogas digester?
No she is not interested in biogas digester
- Is she aware of the benefits of biogas digester?
No she doesn't know the benefits of biogas digester
- How does she light their home?
Only electricity for lightening, electricity cable
- How long have they have connection to the grid?
Less than one year
- What motivate them to connect to the grid?
It is better than battery
- Why?
The battery has to charge three day one time, sometime more with the charging
- How do they get water?
Pumping water from the well
- What do they do with the animal manure?
Recently the household gather animal manure to provide rice field
- Would she be interested to use slurry?
She doesn't want because she doesn't know about the benefits of the slurry
- How do they handle the household garbage?
About the household manure they just gather and put it in the ground

- Does she know anything about the deforestation?
She doesn’t know about the deforestation.

Bilaga 3. Transkriberade intervjuer, Kenya

KENAFF

Intervju 1: George Nyamu, programkoordinator.
Intervju 2: Bernad Mulandi, ekonomi- och administrationsansvrig.
Roda Kilonzi, utbildningschef.
Philip Mindri, biogastekniker.
George Wakesho, övervakning- och utvecklingschef.

KENDBIP

Intervju 3: Andreki Wambuga Gikuhi, B.C.E. och murare.
Intervju 4: Duncan Muchiri, B.C.E. och murare.
Intervju 5: John Thuku Macharia, B.C.E. och murare.
Intervju 6: Stephen Macharia Kimenyi, B.C.E. och murare.
Intervju 7: Charles K. Ngémo, B.C.E., murare och bonde.
Intervju 8: Peter Wangendo, bonde.
Intervju 9: David Wawsrú Kahenya, bonde.
Intervju 10: Brenda Nabtutu Wekesa, bonde.
Intervju 11: Felister Mumbi Kimunja, bonde.
Intervju 12: David Too, bonde.
Intervju 13: Mary Wanja, bonde.
Intervju 14: Grace Gathungu, bonde.

REFCEL

Intervju 15: Daniel Gichuhi, administrationskoordiator.
Intervju 16: Peter Githuka, bonde.
Intervju 17: Moses Ngugi Gichuhi, bonde.
Intervju 18: Simon Gitura Mwangi, bonde.

Takamoto Biogas

Intervju 19: Graham Benton, markandsutvecklingschef
Intervju 20: George Waithaka, murare.
Intervju 21: Francis Mburu Kamitha, bonde.
José Kamitha, bonde.
Intervju 22: Jane Nungari Ngonga, bonde.

Simgas

Bakgrund om företag
Intervju 23: Moses Ogeto Gekara, chef.

Tolkning av symboler i transkriberingar

Rött ord:	Om ett ord är rött betyder detta att det inte är säkert att det är just detta ord som sagts i intervjun.
Blåa ord:	Blåa ord har inte sagt i intervjun, men förklarar saker som hänt, exempelvis om någon pratar om något och pekar på det utan att nämna vad det är. Även valuta ändringar till USD har gjorts i blått för att underlätta förståelse.
--- :	Tre röda punkter i en intervju betyder att det inte har gått att höra vad personer säger.
… :	Tre svarta punkter i en intervju betyder att ett stycke saknas. Hela stycket skulle ha gått att transkribera, men stycket inte är relevant för projektets syfte.

Interview 1: George Nyamu

Date: March 27, 2014
Area: Headquarters in Kikuyu, Kenya
Organization: KENAFF
Interpreter: -

Present: Jennie Boérius – Student of Chalmers
Sara Helmrot – Student of Chalmers
George Nyamu – Programme Coordinator, KENAFF

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Jennie: What's the different tasks in the KENAFF and KENDBIP?

George: So we have two different --- We have KENAFF which is the Kenya National Farmers Federation. That's a new name, we re-branded end of last year I believe it was mentioned to you. And we said are gonna --- and we are going to a new office we need to have a new name and we felt that the old name was kind of loosing the lead between ourselves and the farmers. Because we are actually a farmers organization. So we re-planned to KENAFF. So KENAFF is a legal institution and a farmer ship organization that has a long history, 75 years.

KENDBIP on the other hand, KENDBIP physically stands for Kenya National Domestic Biogas Program, so that is a program that is implemented by KENAFF. So we are a program within KENAFF. KENAFF has many programs. I think we have some like 13 or so programs, all of them addressing various issues and trying to improve enlightening for the farmers. We are a program within the environment underneath the energy department, or the vision of the organization so it's just a single program. So there are other programs that has targeting things like coffee businesses, green businesses, or those other things. So in our case, here we are focusing more on environment, plant change and of course renewable energy is a part of that.

You have the background of course and we were founded by the Dutch government through SNV and Hivos. So they are our key partners in the implementation, but we are the people on the ground so I have a visit or from this case once in a while and we do a lot of different things together on paper. And then in the field, we actually drive their activities in the field.

We use the infrastructure of KENAFF in the field to drive this program. So KENAFF has regional offices at county level and district levels, so we have our people there who are doing that. As a program we have stations engineers, biogas engineers, we have mapped up the country and we have statured about 11 biogas engineers across the country. And their main roll is the technical backstopping for the BC's, providing technical support. Training them and when necessarily actually providing likeness for upcoming partnerships and then we've also worked a bit hard to trying to get these constructors to form associations to find it easier. So we have regional contractors associations and this platform is able to have regular contacts and

communication with them when the essence cut across the sector we are able to get quick feedback and when we have communication directly with them we are also able to do that fairly fast.

As a program we are a PPP, public private partnership, we have a heavy sediment present in our program in terms of policy making and implementations. We are hosted by the ministry of energy so we have the Kenya, the director of biogas in Kenya sharing with this program stirring committee. And the stirring committee brings a personal board like ministry of agriculture and the ministry of livestock. We also have other committees like energy renewable committee on board. So we try to bring as many actors as possible that we think have a roll that can help us push the application of the technology. The roll of the stirring committee is to oversee the planning, the implementation and reviewing, that's mandatory, what we do. But then the actually action of implementation lies within KENAFF and we are a program team now within KENAFF. So I am the program coordinator and have a big team of people here, some are engineers, some are not engineers, depending on what they are doing. And more or less this is the relationship between KENAFF and KENDBIP.

Jennie: And what do you do? What is your specific tasks?

George: I am the program coordinator. So as a program coordinator I am responsible for the planning, implementation and management of the program.

Sara: What are the main reasons for this program to be so successful compared to other biogas domestic programs?

George: I think we recognized that the private sector is actually the center pull for this in successful developing program. I think that is something that we took notice of pretty early and we embraced that as an approach and therefore has our focus has physically been to empower the private sector to activity take up the rules effectively so whether there is a as private entrepreneurs constructing biogas plants for their private organization, we see it as extensions, providing or stocking or importing various of plants even feedings. So our roll was to strengthen those particular actors so that, as they grow their business, as they expand it, as they develop capacity, then we automatically have our word spread. There is a positive site of biogas, it was that we grew very fast and we took it up on ourselves to retain the roll of a developing demand. So especially in phase 1, we did a lot of work on developing the demand, a lot of promotion and marketing and that kind of things. And then gradient we have been transferring these rolls. Then private sector also. So operation now is we concentrate more of the above light marketing as we leave the actors, the entrepreneurs to do the below marketing.

Sara: And the entrepreneurs are the masons?

George: Masons and contractors. So we have different. Masons are physically a individual person who install the biogas digesters more or less on his own, alone. A contractor is on the other hand a transition of a mason towards an institution. So a contractor may have improvised other masons so he can have a team of 3, 4, 5, 10 or 12 masons working for him. He is more of a company, actually a biogas company.

So our wish is to see many masons drift towards becoming contractors because that accounts their compactly and they will be able to plan and

organize their own business. So they take the roll of managing their team of masons and therefore they can actually be able to survive flirtations and distributions in the market.

Jennie: During these 5 years, what have been the main challenges?

George: I think the biggest challenge has been quality management. Because biogas as a technology you are pretty award that it's involves fairly simple but complicated engineering principles. The issues about levels, volume and highs and that kind of things. SO when we select mason or when we train masons, what you realize is that you bringing a total new concept, you introducing a totally new concept to these people. This is not bricking. It is more than bricking, because a brick provides balances on the other. The building will stand. With biogas there are intrigues that need to be seriously focused on and looked at so if you are not able to get these things right lets say pressure, high, its volume then the whole thing gets messed up. So the biogas digestion has three components: the inlet, the digestion chamber and the expansion chamber. If something goes wrong with any of these tree, in terms of their relative high to each other, in terms of volume to each other, in terms of anything that can result in problem. Pressure yeah if any of them especially the gasoline chamber. Then the whole thing does not work. SO you end up with a facility which is there but doesn't work or even if it works it doesn't subentry the farmer as expected. So that was a big challenge. And then when the mason go there, the first plan they are doing --- some of these thing. So initially you have a lot of errors. So in most of them they are not intended. But maybe I can assume an extra. To enchase we do not cause a bit of issue or of the mortise becomes to thick now so I loose 3 inches in the process the whole thing becomes complicated. And then you have poly functions in plants or totally non functions plants. That makes it very difficult for you to get the next client. Because if the neighbors see that their neighbor has invested time and recourses and the thing is not functional, then why should I invest?

So during the first year of the program we had a big challenge on sorting out non functional plants. We even had to do a lot of repairs ourselves because what we did is that all along we have maintained a guarantee for the plants. So we are assured the costumers are provided the plant in done by the person by us we take responsibility in case it doesn't work. So initially we had --- let's say something that masons and contractors polish as they get one more experience so that they can realize if this is a missed point, you are in trouble. If you kept this the wrong way they you are gonna start the whole plant over again. So gradually, because that has involving the last 2-3 years we haven't had too much about that. I think that the big challenge that we had is subsidize, these one had subsidizes. Subsidize are a nice thing, if you give subsidize in anything, of course it will be very welcome. The advantage of subsidies of course is also quite clear because one thing that develops and carries some dependency syndrome in the market but also it lowers the market prices. Because you realizes that since you were given a subsidy about 250 euro you will find that most targets are also paying, that's in figure.

As much as we were saying we are a free market kind of playfield that was

not really true because we had that subsidize coming in and starting the market. We were only giving subsidizes for a specific design. So it made that if a farmer is going to benefit from the subsidize, then he had no choice but to take the design we were promoting. In phase 2, we have re-looked at that. We don't have subsidizes and we are promoting a sorted digesters now. We took the first phase as a trial phase and we evaluated several designs. We have approved 3. So we are telling the farmers now that we are giving them options, we are here as a program and the same guarantee which is provided for our Fixed Dome, we also provide fro these other ones. So we are saying, weather you are going for design A, B or C we are still confident of the performance, that they can actually take responsibility for its non performance or performance.

Sara: But you said when you have a subsidy you become reliant on the subsidies. What do you mean by that?

George: What happens is that the farmers, they are the costumers they are actually, they will invest in a digester on that the subsidy will be given. If there is a chance of subsidize, like we removed the subsidies now, they feel like things are not right. They are looked down to, to get the whole amount from their own pocket.

Jennie: You had a few collaborations with other organizations and companies, which are they?

George: I think there is a total about 160 or so partnerships. So we cut a couple public intuitions like Kenya br-standards, Kenya Industrial Research Institute, universities like Yomkinmata University. We have form the private sector many many many partnerships. I don't even know where to start. Some are very localizes, because when you go you an area then you get an institution which can be useful in that area and we are good to go. Also, a slighter higher regional and that is good to add, they are actually national.

Sara: So do you have any collaboration with other biogas programs within the country?

George: Currently actually there is no other biogas program in this country, currently. But then the institutions are to establish in deeply biogas programs like for example there is an association for biogas contractors. Yes, or actually there are part of program and actually they are represented in the program committee. But we don't have another National program. But we have, I don't call them program, but we have small initiative community initiative on biogas, a few founded by UNDP, specifically targeting preservation of the environmental among Kenya. Yes we have proper partnerships with them. We have another one founded by the European Union through South Africa, that is working in some parts of Rift valley, the mountains.

Sara: But do you have international collaborations?

George: International yes, very much. Because as I mention we are an African biogas partnership initiative. So we have very strong collaborations with country programs in Tanzania, Ethiopia, Uganda, Ruanda, Senegal, Cameroon. Also coming up Mali now, in fact they are visiting us next week. And Zambia, Zimbabwe.

Jennie: So it's only in Africa?

George: Yes only in Africa. Then of course we have the SNV. We have a lot of linkers with Nepal and Vietnam.

Sara: So are the other countries in Africa as successful as you?

George: No, we are the best in Africa. We are proud of that.

J/S: You should be!

George: Actually from last year I think Africa did about 30000 or so digesters, and we were responislbe for almost 12000of that. So we outshine the whole list of countries I've already told you. We are comfortable more than 1/3 of it. So the other shares the rest of it, yeah about 10 or so countries share the rest.

Sara: Have you noticed any special results from these collaborations?

George: Yes, a lot. Especially in times of capacity of some wonderful experiences across. Because everybody operates fear automatically. But then the experience sharing has been very very useful. There is something to pick from everybody. There may be slowing times of getting the numbers coming and there may be slowing times of quality. But then you also get something nice, something beautiful, for example about slurry translation. In one country you will get another idea from another country in times of partner management. So you get something from another country in times of ecological developments like Tanzania says "Hey, our country is very drought, we need a digester that uses less water". And then we say "That's a good idea". It's been down there, ¾ of Kenyan --- are also agreed sowe can borrow that technology and bring it here. So there is a lot of that. We physically have a minimum of at the last I think 3 interacting sections per year across these countries.

Jennie: Do you think that is a factor, so you can help them to be come more successful?

George: Yes. In fat we are a point of referent to many of them. "How does Kenya do this?", "How does Kenya do that". And then on the other had we also ask them "How do you guys manage to get.." something that we are not doing so well here and somebody else is getting it correct.

Interview 2: KENDBIP responsible

Date: March 26, 2014
Area: Kikuyu, Kenya
Organization: KENAFF, KENDBIP
Interpreter: -

Present: Jennie Boérius – Student of Chalmers
Sara Helmrot – Student of Chalmers
Roda Kilonzi – Promotion and Training, KENDBIP
Philip Minrdi – Biogas Engineer, KENDBIP
Bernard Mulandi – Finance and Administration Officer, KENDBIP
George Wakesho – Monitor and Evaluation Manager

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Sara: Ok so just to get the picture, how does the journey from when a farmer wants a plant to when it's installed and working look like?

Bernard: The program is built by ten components of which promotion is one of them, training is one of them, quality control is there. So when a farmer wants to install a biogas plant there are artisans, or masons, which we have trained who are out working in the field to be able to give information to the farmer and to initiate the installation of plant. So there are steps in in the installation of biogas one of them being sighting. So for example when a farmer informs a mason, so we link them to the mason and the mason visits them and this mason is an extendage partitionare. So they go to the farmers homestead and they try to find which is the best area where the biogas plant can be built. And then from there now the farmer is advised accordingly. They watch if this farmer has the capacity to install biogas in terms of, for example you must have cows, that is two cows. If you also have other animals it's ok but they are not so supportive. We are purely promoting biogas that uses cow dung. So if that data is collected and it is analysed and it is fixed, then I mean the biogas plant, the design of the biogas plant, the farmer wants to install then they sign a contract with a mason. After signing that contract, now the farmer is given what you call a bill of quantity. The bill of quantity depends on the farmer to supply the material that are needed by the mason. Then the mason starts constructing the biogas plant.

Sara: So the farmer gets all the materials?

Bernard: The farmer is supposed to get all the materials, otherwise the farmer can still contract the mason get the materials. But for ease of cost management we want the farmer to provide the materials so that they don't complain that it is expensive cause of. We're also working towards minimizing the cost of the biogas. And sometimes the farmer may be able to reduce the costs in terms of labour. Some of the farmers carry sand, carry the stone which can also reduce the direct expensure.

Jennie: What kind of digesters do you use, do you use the same all over?

Philip: Yeah, initially we've been using the same all over.

Sara: What's the name of it?

Philip: There is one model we call Kenbim.

Roda: Kenya National Domestic Biogas Programme.

Philip: Those are fixed dome which you build with bricks and water. Currently

there are entwelves of biogas plastic bag as manufactures in the field. So you also have the plastic digester in the field so those are the two major models that we can talk about. We have the Kenbim, but the Kenbim is not a fixed dome which uses the bricks and water. And then we also have the plastic digester, this type of digester in manufactured industrially.

Sara: And the plastic one, is that underground or above ground?

Philip: It is above.

Sara: Why do you have the plastic one, is it better than the other one or?

Philip: It's to increase the options for farmers. Because some of them would want to, ok and so it depends on first of all the cost and also on the usage and of the space and mobility. Cause the plastic one, if you want to shift it from one place to another, for example the pastorories you can be able to and walk with the digester [laugh]. --- The other thing is that plastic manufactures would want to just copy business. We see an opportunity in biogas so they want to manufacture and sell. The other option is that credit institutions find plastic digesters more affordable because they can easily be attached. These factors combined are actually seen as consideration of installation of plastic digesters.

Bernard: And even the cost of waiting for the other fixed dome. You know when you do brick, you have to brick two inches all around, for three weeks. By this time maybe somebody, they're eager to start losing the costs. So people may opt to go for that instant one, which is the plastic one, and then wait for the brick one to be done. Then the other will take you one month.

Sara: The brick one?

Bernard: Yes, for you to start. By the time you make the decision that you need biogas, by the time the mason is on sight, by the time you can start using it then it will take one month. So in particular to go for the plastic one you just need to organise the shop and maybe tomorrow evening you're cooking.

Sara: Which one do you sell the most, the plastic one or the brick one?

Bernard: So far the fixed dome. We have around 11 600 plants so far, up to December 2013. We have 400 more for January so we have almost 12 000 plant. Still most farmers will go for the fixed dome, but remember the plastic one are relatively new to the market and like the fixed dome, which are almost five years, the plastic ones are relatively new in the market.

Roda: And most likely for someone the plastic one is convenient, to have the plastic one. Because with that one you will not be involved in bringing materials, the masons in your homestead for a week or so, even two weeks, so if you feel like the plastic will do better, you go for the plastic.

Sara: So it's quite easy to go for the plastic one?

Roda: Yes it's quite easy. Actually it takes some hours to install when the other only take some days and there's also time for the for curing before you start fitting.

Sara: So it's more like buying a new cooking machine?

Roda: Yes.

Jennie: And the lifespan for the plastic one, do you know that?

Philip: One of the technicians who are at the company manufacturing plastics that were saying that the lifespan is 40 years. But the operational lifespan for the digester is about 20 years. Usually we say 20 years for the masons installed the digester, after you need to renovate and put it back into use. But then we spread the steadied lifespan of plastics. The pioneers in digesters they started with, most of the plastics had one fault or the other. So it cannot be

proven that it will be that long. Although in Kenya the first digesters was installed in 1954 and some are still operating. So you can't tell how long it will last.

Sara: The plastic one, what kind of plastic is it made of?

Philip: They say that they use UV-treated plastics. I am not familiar with the chemical nature of this plastic they use but every time I hear about the plastic I hear it's UV-treated.

Roda: And that's what they, the plastic that they use can last for 40 years.

Sara: Does the plastic and the brick one have the same design?

Philip: The design principle is the same.

Jennie: Are there a certain part that usually breaks first on the digester?

Philip: Usually the dome, but only if the proper construction procedures are not followed. The kind of digesters we build, they can be fixed by a mason. There's usually a lymping in the interface between the digester wall and the dome the constantly part. Most of the digesters which have had weaknesses in the dome, we realise the rain beam was not installed. But where the rain beam have been installed there are no issues.

Sara: Is cow dung the most common feedstock?

Philip: Yes.

Sara: Are there other feedstock that they use as well?

Philip: Mostly we have cow dung and pig dung, the two are the most common. Ican say about 95% of our digesters use that. When you do to other options like plant materials, we have not yet explored such options because they require some treatment aspects before you can use them in the digesters. Like one, our design requires that we mix with water and the substrate pipe is a four inch pipe, a plastic pipe,that really feel the cow dung aspect than the plant material. But we have adopted the other digester called the Solid State Design where that four inch pipe is changed to about eight centimetres, so that one cannot be absorbed chopped plant materials.

George: Actually we've also tried to get people to connect their toilet, the latrine. But because of the culture people don't use it. That's the main reason.

Sara: Is it because of the fact that you don't want to use it or because you don't think it's usable?

George: They know it's usable but in their mind they don't think it's clean, once the pipe is connected to the toilet.

Sara: So that's not a future option, to apply toilets as well?

George: Over the last five years, is there any plant?

Philip: Yeah, we've actually, the design was prepared to put that as a future option where there is an extra pipe for the toilet connection. Maybe the perception will have changed and therefore somebody will feel that now I can use the toilet and they connect. So some of our digesters are prepared with an extra pipe for future connection. A few are directly connected to toilets and are using the cow dung waste.

Sara: Is there something that you do to the cow dung before putting it into the digester? Is there some kind of process or do you just put it in?

Philip: In the cowshed there are cows that go into a willow barrel then transferred into a constructed mixing chamber close to the digester. Once it is placed in there, then you put an equal amount of water, or urine, and then it is mixed with a stick or a garden rick. This garden rick will help sort the materials and then the pipe is opened and then it's released to the digester. That is the only preparation required.

Jennie: How long does the part of the process for the digestion take?

Philip: We usually say the attention period is about 40 to 60 days, depending on the climate. Realise we're in the equatorial zone but know equatorial climate, so various regions has different temperature ranges. So best one is the Braso Felick temperature range which is between 25-33ºC, that's average. That complies with good detention time of 50 days average.

Jennie: So you refill every day?

Philip: You refill every day. But we expect the resting time in the digester to be about 50 days.

Sara: What kind of maintenance is important for the plant?

Bernard: That is first of all the after sell service that we normally give farmers to make sure that it's working on daily bases. Because if the plant is not working on a daily bases they don't feed it for like one week, the substrate may solidify, it makes the gas not to come out. So it has to be maintained almost every day by adding, so feeding is a major task.

Sara: And you have to do it every single day?

Philip: You don't have to do it every single in case you don't have enough feedstock but two days at most. In those areas where people are not producing enough you don't have cows that can give you enough dung. Most of the plants we have done in a potential area, biogas potential areas. That's where the farmers have cows and can maintain on a daily basis. Then the other maintenance work is to make sure that, now the slurry which is coming out after it has been digested and the gas have already been used, then you also need to provide some compost pit for it. So you have to make sure that the plant has no block, because of, for the by-products.

Roda: Generally we also train the farmers with the digesters on operational maintenance, we have a poster that we issue to them. As the owner of the digester you are given a manual or a poster so that you see what you're acquired to do every day on your digester. They are now also trained on now to some technologies of utilising the slurry; either use it direct in the farm, make compost, kitchen garden, many things that they can do to produce food, organic food.

Sara: So when they've decided that they will have this kind of plant, then you supply them with this poster?

Roda: Yeah. After the plant is finished you are given a poster on operational maintenance. Actually the other designs of digesters are starting them this year. In KENDBIP oan we are promoting the fixed dome Kenbim and we had the poster for them. So even this one we are preparing to be able to give them, depending on which design you have decided to go on.

Jennie: And the poster, is it like pictures or are there words?

George: It is pictures because the class that you are dealing with, they're not all at the same level. Some may not know how to read technical things so it has just been simplified in a pictorial form so that anyone, despite of education, is able to understand.

Sara: Then the whole family can read it as well?

George: Yes.

Sara: Which are the most common technical problems you have with the plant?

Philip: The most common technical problem we have is the high farmer expectations, especially when the plant is new. You find that in the marketing state when the masons sell their ideas, or the biogas, to the client you overstate that this plant will make you see TV, many of those things. So

when you look at the details that the farmer requires out of a biogas plant, the gas can only be used for cooking and maybe one biogas lamp. So when the aspect of the electricity part is brought in then now you have to tell the farmer how much quantity of gas that is there, or expected by day and what it can do, especially the running time on the stove and on the lamps. That is one. The other one is plants failing due to bad clough preparation and maintenance. You find that the structural root by then the farmers won't have enough waste. Or sometimes due to drought the animals migrate and therefore the feedstock gives down and the plants don't operate optimally. The other one, which is the major one, is the cracks as I said. You realise that in the construction aspect a trained mason can use a skilled conduce in the village where the plant is constructed. When the guy has done his work and is gone the unskilled one will blame the other people. Then skilled workers, the casuals, will claim that they are the people who constructed that one. They will be marketing themselves to the neighbours, that they are the people with the skill when they take a job or attempting they do. So cracks, operation and expectations due to poor workmanship.

Jennie: Is it possible for you to solve them, the problems?

Philip: Yes, all the problems are solvable. Like one: which it comes to expectations we prepare the brochure with how many hours of gas you can expect from each biogas haze (digester). Then the operational maintenance you've posters with the dos and the don'ts. With the issue of cracks, appearing due to poor workmanship, sometimes I am forced to go to the ground, empty the digester, inspect it. If their specifications were not met we redesign and then demolish a few parts and reconstruct and put it back in use.

Jennie: Then you have the rain season, does that effect the biogas plants?

Philip: For the fixed dome, the rain season does not make a difference since most of them are under ground. Especially in Kenya, even if it rains in some way within the day the sun will appear. What it means is that the soil can pretase almost constant. Therefore that heavy fluctuation performance is really not there. But there are also some very cold regions, especially the Abardares, Abardares is some highlands near Mount Kenya where it can get very cold. So that one you will aspect at least reduced production.

Sara: The biogas stove and the lamp, is that something that's included in the package? Or do you sell that, or do they buy it from another place?

Philip: As a program we only promote, but we allow the sector to actually bring out the forces of supply and demand to our market place. This is to say, the entrepreneurs we import all make the stoves. The lamps are all imported from China which is the source of most products. But now we have actually demarketed the lamp. Simply because the solar lamp has many more advantages over the biogas lamp, so therefore we enfaces that. Instead of a client purchasing a biogas lamp he should actually take the option of the solar lamp. One, the fire risk in a biogas lamp is very high compared to a solar lamp which is zero. The second one is the lifespan, the glass in the biogas lamp can break any time, replacement is a challenge. That risk is not there with a solar lamp. The third one is the portability aspect. Solar lamp, you can use it anywhere but the biogas lamp will be fixed somewhere. The fourth one could also be on the aspect of maintenance cost. The solar lamp has zero maintenance cost, at least for six years. A biogas lamp you may have to replace the glass and the mantle as often as they break down. And then also the efficiency, a biogas lamp is only 3% so we prefer the clients to

use the biogas for cooking. Unless in extreme cases where the client is insisting that they has to have a biogas lamp. Pricewise they cost the same.

Sara: The biogas lamp and the solar lamp?

Philip: The biogas lamp and the solar lamp. Then in the plans, apart from cookers, our major products come from China but also, there are also many modified LPG burners which people prefer to use. Because at the time as somebody has spent money on construction there may be little funds left to buy you a burner. Therefore they prefer the LPG type to remodified before you use the biogas. Those are the two main appliances that we have.

Sara: So the biogas plants are financed by the farmers but we read that you have a subsidy?

George: Initially when the program was in phase one there was a subsidy of 25 000 KES. The main aim of the project, of the programme, initially was to stimulate a market oriented biogas sector. So for us to do that the subsidy came in, for the initial stages for the first phase of the program. So the subsidy went on up to last year. It was reduced, we were starting dwening (fr dwindle) it off when we saw that the demand for biogas went up. From this year, in phase two, there's no subsidy. We're just promoting it when the farmer meets all the costs.

Sara: Then you have all the credits that you can use?

George: There are financial institutes. So what we do is that we just link the farmers to the available credit in the market so they are able to access the credit if they're interested. We also worked with them for them to be able to develop a biogas forecast credit.

Sara: If the biogas plant breaks the first year, you'll come back and fix it?

Jennie: Like a guarantee?

Philip: Yes it is actually the masons who go back and fix. There may be cases where they're unable so we provide the technical assistance. Our part is just to enforce the guarantee.

Jennie: But it doesn't cost anything to maintain the biogas plant during the first year?

Philip: Actually the maintenance cost is about maybe the price of a biogas lamp. The other one could be the payment of the workers who actually have to feed. But we realise that in order to not increase the salaries of a worker because of the new added job of maintaining the biogas plant, we also pipe the biogas to the residents. So when they train the clients we actually maintain without thinking of being paid. The other costs when a gas pipeline has broken down, for any other factors, especially when there may not be the PVC pipes then the client can spend money to actually repair.

Roda: And on the side of the mason the cost will be maybe for going to say the plant sometimes they can drain them just to make sure the plant is working well that's part of the after sell service for the customers.

Sara: The PVC why dose that break?

Philip: Many things can lead to the breakage of the PVC. It could have been installed incorrectly, or somebody is driving a heavy vehicle on it when it passes or somebody was digging a dredge and breaks it when they dig, those factors.

Jennie: We read on a few places that they can sell the slurry, the by-product?

Roda: Yes that's one of the things we're expecting happening in the field. Already we have some groups that have started marketing organically grown products, on the organic market, which of course the cost is slightly high.

We have some farmers also that sell to their neighbours, the slurry, their family. We also have some people draining and packaging as fertilising the market. Those kind of things are coming up slowly.

Sara: Is that something that you promote from the beginning, that you can sell the slurry?

Roda: Yeah. We've been doing that with some service providers, people from the sustainable agriculture institutions, and those are some of the things they do. But we aspect of course for somebody to feel the importance, or more benefits, of the biogas digester than you have to fully utilise forth comes with it. Part of it is selling the slurry, sometimes we have too much. Actually it can even be a menace in the home if it's not handled properly.

Jennie: So let's say a farmer takes a loan to buy a biogas plant, how long does it take for him to repay the loans?

Roda: Years.

Philip: This are things that are … by the finance institutions. Some they take one year others two years, depending on the arrangement between the farmer and, and even the ability of the farmer to pay the loan. Because some are able to service the loan in one year and some even up to three years.

Roda: Yesterday I saw a service provider with a credit who can give up to 300 000 KES, but you pay in three years.

Sara: How much does a plant cost?

Philip: Here in Kenya the direct cost is around 765€.

Sara: Are there any government agencies involved in this, in the finances?

Philip: Not directly, but the programme is designed to partner with the government in terms of direct partnership. From the background the government also supports the programme. For example the crafting of the regulation of how the sector is supposed to be working. For example the biogas standards have been steered by the government department. We also have training institutions that now are supposed to be doing biogas and they're also government based. That is the kind of support that the government has done so far.

Sara: The feedstock, is it initially a problem for he farmers to get rid of?

Philip: The cow dung is supposed to be fed when it's raw. Immediately after it's dropped or if you do night stabling in the morning you collect the dung, put it in a bucket and also put an equal amount of water, you mix it properly. Then you put it in the digester.

Bernard: Now the by-product is ultimately been digested. What you get out of now is the bio slurry.

Roda: Before year we have some areas were the dung is an issue disposing. So when you tell somebody you can have a biogas which is going to use the dung then they do it. Especially around Nairobi, in Kiambu County, the land is small and they have many zero grased animals. In fact we even have some cases where you have the digester and still you have a lot so you throw it in the farm raw. In some areas you find it along the roads, because you don't know where to put it.

Sara: So this is a solution?

Roda: Yes, it's a solution.

…

George: Then from there, the next stage was, ones the construction is completed, the masons specs with the ones the plant has been fed. What has been working that is another form to be, to be signed to confirm that it is working. Then

the next stage, because of the subsidize of, the farmers will come to the office, so we have to confirm with the farmer the farmer that their plant is working or not and why it is not working. Ones we have confirmed that it is working, we will write it down in the form of subsidies. So in the form the farmers decides if the subsidy will go to him directly to --- cover the labour costs for the masons. So if he decides to cover the labour cots, the subsidize will go directly to pay the masons. Then after that, then what usually happens, after that we, as the plant is working there can be an issue. The farmer has all the contacts so he can report to us. We have our database where we save the information so we know which masons constructed the plant, so we are able to call. So for us to be able to give the finances, to that time defends work finance to do maintain answer. What's used to be done outside this subsidize, we use to subtract 10%. We don't pay them all. We retrain 10% of the subsidy, so that if there is a problem with the plant, that 10% are kept from them here. So that if there is a problem the mason who was suppose to be paid labour costs, and did do a good work, but there is a problem with the plant, this money can be used for the repairs.
In phase 2 things has changed, they are trained to, because of the private sector wants to be heads of the digester association. So, as I told you the biogas has associated, and we have tried to strengthen the net, so that masons can come and develop. One the curriculums to be national so that it can be used in all the institutions and for that curriculum you need a certification so that a farmer can ask when he wants to install a plant, she or he can ask for the mason if he has a certification to do that. Then also what we train, because some of the masons I've know they have had companies, we are trained to encourage them to help their own town and supervision, they can install their own plants so that we don't have to come. We can oversee, but we don't have to. That is how they are trained.

Sara: What was the other thing then? The criterion and certifications for..

George: The criterion develop with how they be taught and what somebody thinks to be expected from the masons. Then, ones this curriculum is completed we have a national agency for construction that is called ---. It's a national agency for construction in Kenya, so that one will be, it will be their montage. Once you've gone through that training, for them to give you the certificate to certify them, so that you don't just want them to do their own things, so that the second kind to be, can be guided. So, that in the future, if they join the programme, the vision will be that the farmers will be able to ask where the masons have a certificate or not, if there is an issue we hope that the biogas association will be strong, so that they will be able to backlist that mason! Currently the programme use to do that and what use to connect us to the masons use to be subsidizes. But now that, they know the idea that we have their money. But now that things changing, we try to strengthen this other institutions to be able to do that work.

Jennie: So right now if a farmer has a problem with the digester, does he contact the mason directly?

George: Yes, if a farmer has a problem, we are still there, we assist a transition, but we are not completely in touch ourselves, we are trying to wheel relay ourselves. But if a farmer still contacts the office here, we have all the contacts for the masons, we will be able to call the mason and then find out how the farmer can be helped so what we are doing to encourage them to construct, we are and also for us to get that our of them we are giving them

a small talk, just to help them in that direction.

Sara: The masons?

George: The masons. The mason also goes to the farmer, because now we don't have the subsidy, he goes to the farmer. If he is able to fill the other household on a shift, it's called "Biogas household on a form", so if he is able to fill it. Once he bring to us the form, the money that we are suppose to use for promotion, we give him a small part of, because the costs around, the facility and so. So that's the way we are able to help.

Jennie: So you give the mason money?

George: We give the masons money. It's a small amount of money for them, because we have to give them for them to collect information. If we don't somebody can construct and he doesn't have to you because he is not helping you. So that's what we currently are doing.

Sara: So, your big thing that you are doing is this certification for the masons? The certificates from the National agency construction will bring you?

George: That is the process. So, what we will do they will be certified from there they will be destiny funded, then there is a photo and a license for construction. They can just go through some process here, but all the masons will have to be certified. So that if there is a problem we can face, and then decide what should be done. Like face the law of the government and we don't have to initiate what is used to do, with the blacklist you, or inform all the people in this section, we are supposed to call the instructor. So if you got this, everyone will know. But for us it is just to stimulate. And now, as we look in the future, we will have those rolls to maintain a sate process.

Jennie: Do you choose the farmers or do the farmers come to you? How is the process going?

George: No, we don't choose. How we promote? There are very many ways. One of them is going on local radio stations; we talk about biogas at those radio stations.

Jennie: And all the farmers have access to radios?

George: They have access to radios. They can listen and then they contact us to find out what, then we connect them to the masons in that area. We also attend shows. In Kenya we normally have farmers who we directly display what they are doing, se we attend to display what we are doing. So from there we get farmers. Then there are also fairs, for those farmers who have the technology, they inform others, so others see. Then they also want and they inform us, and we have at least, there is a book lave, there is a least amount of masons in each region. So the farmers are able to contact them. Sometimes. Those are all masons that we have trained. Se we can be able to direct the farmers. Also there are other organisations. We partner with other organisations which we can not reach, for them the employment means to promote biogas. For us, we just facilities them, and give us their numbers they have that they have been able to construct. This business is what we do. But the most that has been working is the fairs. Also the masons promote. Because they can come to an area like this, they go to a home where they have seen at least two cows and they see that these are potential biogas users and they talk to them and say that this is a good technology and a good thing to take.

Roda: And also field days which they have meetings in public where we tell them and show them demonstrations in public, documentaries and newspapers.

Jennie: And when you talk about it, do you talk about how it works or more of the benefits it brings?

George : Yeah, because of the technology we don't go deeper in the technical. But we do is that we give them what it will benefit them, mostly what will benefit them.

Roda: Because it is also expensive.

George: If you take up this technology what are you saving yourself from? So one of the things we can talk about is instead of using firewood they will save a lot by constructing this biogas. We also tell them about the slurry. If you construct, you can be using this for production of the corps, so we tell them about that. We also tell them about health issues like smoke, that's the main things. We use a testimonies to metal where those ones that have, they are going to be able to talk so we can court how they are benefited.

Roda: Case studies.

Jennie: And you, do you have an education about biogas? Or is it more that you are interested in it?

George: We don't have an education for.. For us we have in the programme. In the programme we have, yes some, each person that is working with biogas has, yes orientated in biogas.

Roda: On job, not in college.

George: Only job. But now we have like 11 engineers.

Roda: Yeah, biogas technicians.

George: Now the learn was the only thing. Those are the technicians, those are for technical, and they are trained for, like design. Then we have the project management of course, who is going to manage --- making sure the activities are completed what we have planned. So things work and are organized for trainings and also on an extension and slurry, all those things. So we have different, and we also have the managers. So we are mixed. We have those who are trained technical but for us we have not got biogas training because we don't really design so we don't have that background of engineering.

Roda: Then we have those who asked whether we a lot of demands how we select. No we have not yet reached there because in fact we said we just removed the subsidies the other day. The subsidies are not there so from January up to now we are doing without subsidies and the target farmer, the person that we wanted to reach, even when there was subsidies, we don't think we will be able to reach for them because we found that most people of the digesters, they are also people who have some income. So there are still that persons down there who can not afford although they need it. And those are the people who do cause destruction in the forest who use the firewood more, yeah those kind of.

George: Because no subsidies, they can't afford. It is expensive so the subsidies were not enough all the times.

... (Showing a map of Kenya and in which areas they have the majority of biogas plants)

Sara: How come it is there?

George: Because most people here, they are federal, because most people have the right mixed conditions, they have at least two cows, and most of there because of launch, they don't have big farms, they are very close to their animals.

…

Jennie: We've seen a lot of goats, but you don't use their dung?

George: The problem with

Roda: The goats the dung from the goats you need to church them, it can cause, it can form some crust. So you need to crush it fast before feeding it into the digester. We don't use it much, because got the time. The people to collect the dung from the cow and chicken is very good, if you can get plenty of it. And I understand there is a farmer here in the area using that current.

George: So there are the difficult to the goad dung, because people don't have enough.

Jennie: Are you the only or the main biogas programme in Kenya?

George: Actually there are National implementing teams for domestic biogas located here in Nairobi. But we are the mainly, but there are other organizations working with biogas, but we are the leading.

Jennie: How come you are so successful compared to the other ones?

Roda: Because Kenya is actually leading Africa. Although we are almost last to come in from start. Tanzania started two years before us, Uganda too.

Jennie: And now you are the leading, why is that?

Roda: Maybe because of the farming system.

George: Also the farming system they are open. I think we had an aggressive promotion strategy. Because we started aggressively on promotion. In the first phase it was like be the best, we didn't care much about the plants that people were construction but to keep on pumping the message.

Roda: Also in the project to design, we were suppose to be doing seven counties in one year. It was a 4-5 year of programme, so that when we started and resolve all over we also went national. So we are no longer constraining them to phases just work full blast!

Sara: Because you numbers, they are quite high. If we compare you to others. We have read a lot of reports.

Jennie: We read that usually, to estimate, they bring out 30-100 digesters a year, and you've only been on the market for five years and you already have 10000?

George: In last December we had almost done 800 during 2013. I think also once you do, you focus on quality and a farmers sees that it is working they are ready to actually invest in it. But the problem for the other projects, that has not been successful for biogas in Kenya before us, the problem was their issue of quality and also they were dealing with the bigger digesters that were too expensive. You could only get in region one. If you adopt the big one and there is a problem, you don't know where to go. It's too big.

Roda: The people who adopted the big ones didn't require all that energy. We also trained a lot of masons in Kenya, so if you want a digester today you just look for a mason, they are everywhere in Kenya, so if you need a digester here in Nairobi there is someone here, they are everywhere and they are looking for businesses.

Sara: It starts strength as well. We read in many reports when it hasn't been working it's because some of the farmer, when the plants are broke they can't get any help because the masons are verify.

Roda: That's why the masons can not come back.

George: And even if the farmer could, he cannot waste. That what is used to, it used to, you go for like say maybe 300km to a farmer or if you are already at the farmer, you need the farmer to arrange for you that recommendation that he has to be prepared to pay that costs, and you are not alone, so by the end of the day it is to expensive. But distributing there masons has really helped us

to really train them in every area.

Jennie: And then they keep spreading the word?

George: Yeah, and they keep on promoting.

Roda: It is their business, it will be greater employing.

George: We are just helping them.

Roda: Some of them have even formed companies and we expect them to continue working even after the programme, because that is their co-businesses. They have employed others, making companies. So you find somebody doing a round-lines of tons because he has masons and he originally was a mason so he as grown, promoting others.

Interview 3: Andreki Wambuga Gikuhi

Date: April 4, 2014
Area: Kiambu, Kenya
Organization: KENDBIP
Interpreter: -

Present: Jennie Boérius – Student of Chalmers
Sara Helmrot – Student of Chalmers
Daniel Gichuhi – Administration Coordinator, REFCEL
Andreki Wambuga Gikuhi, B.C.E and mason

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Jennie: For how many years have you been in the program?
Andreki: For 4 years.
Jennie: How did you het in touch with the KENDBIP?
Andreki: We've started some biogas projects with the company I was working for. But later on as I was marketing biogas I came about KENDBIP. Then I talked to the people concerned in the KENDBIP and they enrolled me in their trainings.
Jennie: How were the trainings?
Andreki: I think it was good. It was 2 week training. It was practical and theory. So I did one week theory and then one week practical.
Jennie: Did you have a test or something?
Andreki: Yes we had a test, and then we were issued by certifications.
Sara: Regarding the different kinds of digesters, what life span do they have?
Andreki: The one we are currently building, they have a life span of 30 years. So far they are doing, performing, well. That's all we know, we'll know in the next 25 years if they get to 30.
Jennie: So, what is most important to have in mind when you construct a biogas plant?
Andreki: The first thing is costumer devotions. You have to be very close to your clients. When you are close to your clients now they tend to trust. So it tends, especially with the biogas, is the trusting in devotion something.
Jennie: How do you manage that?
Andreki: I have to keep very close contact to my one, my contacts to my clients, and then my clients. Because I have to go through a client to get a client. So I have to be very close to the contacts they have on the ground, the people who call me for the biogas digester.
Sara: Do you use you old contacts to market?
Andreki: Yes. What is when installing one more and referring. I had another --- which had reached biogas, but it will in the a sell as fast as what of hoped. I take it to the market place so people read through him about biogas. So I get inquired. But that does not sell as much as the work I've done. So once I meet, lets say I've got a biogas here, once they really know the type of biogas she'll come and see and she will also want.
Jennie: So she spreads the word?
Andreki: Yes, she spreads the word.
Sara: And you market? Is it you that do the marketing?
Andreki: Yes, I do most of the marketing. Also I have to give comities. Especially in

the coffe, green and tea area. When they get paid the ---, the process from tea. So they call me and tell me there is someone who wants biogas so we get them something, small talking.

Sara: Do they often know what biogas is?

Andreki: Yes. Most of them know about biogas.

Jennie: After you constructed the biogas plant, do you teach the farmer how to use it?

Andreki: Yes, conduce as training, we teach them how to use the biogas, we also give them a handbook, sort of manual, use of maintenance manual. Just in case there is a challenge they can trouble shift the plants.

Jennie: And the one you teach, which person from the household is that?

Andreki: Mostly I train the lady of the house. The wife. So she is able to go, mostly she's the one using the fire. So she can be able to tell when there is a problem from the kitchen. So I try, once I get, assuming that the husband is the one doing the financing, I'm trying to get really close to the lady in the house, so that she can investor of, so she can trying to get what goes on in the biogas. But they are also very good marketers. Because they usually go to those women farms meeting. So I try to get very close to the lady, the man wont say that he has a biogas, but the women they talk to their need person.

Sara: What kind of maintenance is most important?

Andreki: Maintenance is mostly feeding. Also to clean areas where by they really have to wash the inlet and also make sure the overflow is a good discharge. So these are the two most important maintenance.

Jennie: If the farmer gets a problem with the biogas plant, does he contact you?

Andreki: Yes, they contact me and I have to go back and assistance. So apart form my even client, I also get clients who have been for other people. So just in case there is a problem, I am open to anyone who is enquiry of that. I get a quite number of enquires.

Jennie: Which technical problems are common?

Andreki: Most technical problems are maintenance. Maybe there is dirt in the stall, poor feeding, piping – the cages is the piping. Like now there is this installation I'm doing so if someone had a biogas and we're doing such a --- and then they did not remember to tell the people who are doing the casually but that is a pipe. So they tend to puncture the pipe. So the client will end up getting no gas and they are wondering what has happened. So they can't, I'm trying to think where is your pipe. So those are challenges. I think there is more of use of maintenance, once you've started doing the gas you forget you had a problem of gas.

Jennie: Is there usually a part that breaks first?

Andreki: For the Fixed Dome you wouldn't have that. We don't have that problem. Especially if you use the PPC, you know PPR-pipes? The green pipe. It's more durable than the other plastic PVC one. So that when use the PVC there are very many challenges. Because assuming they trained and they ground settled, it can easily de-touch, become of use of something that tend to glue. By élans we use the electricity to band the dints. So that's the difference. Materials using the piping.

Sara: Do the rain season affect the biogas plants?

Andreki: The rain season are, I've built in the cold areas, places in very cold areas, mountains areas and I've not found that challenging. The only place I know you get a challenge, and which come to the sating is when you built in mushy areas. That one will definitely get you into problems, because it tens

to flood into the digester. But also that should be known that the problem for the person doing the work to advise the client not to use the biogas in the mushy areas because when you built the biogas in the mushy areas you will get problems with ---. Because to terminate the water. So you shouldn't have biogas.

Jennie: Does it cost anything to maintain the biogas plant?

Andreki: I would say it costs. But the cost should be minimal. What we do is that most of this work should be done by the client because he should be able to wash and make sure it is clean. Just like a house you have to clean. To fix a problem like pipe or something, the cost for fixing a pipe would be, lets say to trouble shoot a plant would cost you 5000KES, that's around $62,5 USD. That is to trouble shoot. Because what happens with the, you trying to think where is the problem, you might have to go to the client more than quite a number of times. Because you try this, it doesn't work. You try this, it doesn't work. You try this, it doesn't work. And then once you get into the problem, it might even cost more because you will have to remove all the slurry and repair the digester. But for the trouble shooting, that would be 5000KES, just to identify the challenges. Telling the client that this is the challenges, we need A, B, C, D.

Sara: Have you built other digesters than the Fixed Dome?

Andreki: No, no. I've concentrated on the KENDBIP-digesters. I did once. A quite different digester by GISE but the domestic ones is a more higher value for the domestic biogas than for the commercial biogas.

Jennie: What does your payment look like?

Andreki: The majority of the digesters I do are for the labour maybe $330 USD, average.

Jennie: Do you get all the money at once or is it divided?

Andreki: Spread, they have spread. A total construction would be around $1100 USD. Because I'm counting 330 for the labour, technical work, and the 770 for the materials which for the materials I should have bought from the clients. So, I get paid, lets say percentage, as we start the work they pay 50%, then they pay 30% when completion of the construction of the digester, then the 20% comes when everything works. But at temps I also built without getting paid. I tell the lady, because they have confident, I tell them when it's lightning in the kitchen you pay me in the kitchen.

Jennie: If something breaks, do you go back and repair it fro free?

Andreki: No, I repair for free. But now what they have to do, the labour part I won't charge, but they will have to pay the price of material that broke. And what happens depend on your relationship with the client. And also what we charged them. I usually tell them if I charge them too low it becomes quite expensive to go back, but if I had a very good relation with the client, maybe they got me one or two plants, I can even buy that piece and do it for free. It's on case to case.

Jennie: Who is responsible during the building process?

Andreki: I'm responsible during the building process. I am the supervisor. I have other masons. What I do is that I do all the supervising and all the marketing. And then I have 5 masons who help me.

Sara: Is it usually one person who builds the biogas plant or how many persons help?

Andreki: You have one mason, then the client gives me two casuals. Because one is the security of the home state and two the people it trust to be compounds so

they are able to see and get that speed from that stove, get the smith from this get the water from here. So I prefer having the casuals. And in a temp I also have the clients. The client would decide to do part of the work. Maybe the son or the father may assisting during the construction. So what I provide is only the mason, who does know interpretation of the drawing and the actual construction. Then I do the supervise whole work. Then we have the programme also coming examine, do the final part and checking what I've done. SO in that case we never have challenges with the digester.

Sara: How often do you come back?

Andreki: On average I'll have to go 4 times. First time I go to met the client and give them the quotation, the second time is when I'm doing the sighting, measuring the digester, the third time is when I'm taking the fending, the fourth time is when he is going to do the Dome. That's where we get most of the challenges. And then I maybe go a fifth time when it's completed to go and notice the whole work. And even a sixth, because I have to take the people from the program to let them se what I've done. So on average 6 times.

Jennie: So the last time when you go with the people from KENDBIP, is that only to show them or what do you do?

Andreki: They have to go into the digester and see what is going on. They have to make sure that everything is good. That it is actually built. If they don't come it won't be under the programme. They also do the GPS cording of the digester.

Jennie: What is your relationship with KENDBIP? How do you keep in touch with them?

Andreki: Before we had the subsidize in such a case we use to keep in touch through the payment. Because before we preferred the subsidize to be paid to the contractor. So the farmer had to pay very little, so that was a guarantee that I would get my money. When we started the programme we had a challenge because the client would have to pay me, then the programme would pay them. But what happened we did get a problem because once the farmer is paid, he decided that the money came in his name so he is not paying me. So we lost quite a lot of money. So we had to negotiate with the programme and have a document whereby the programme pay us. So that was the relationship come from. So for me to get paid, the biogas had to be constructed, it has to be constructed well so they checks our balances we are paid by the programme.

Jennie: So does the farmer need to go to the office to tell them that the biogas is working so you get your money?

Andreki: What is happen is that they, KENDBIP, come and check, they also do calls, they have a team who does the calls to make sure that the biogas is working and also the documents we fill with the numbers so they can also call the programme just in case of a problem. So that they are able to call the programme if it is not working, but most of the times I try to make sure that we don't get into that because we will not want to get into problems with the programme. So we don't want that.

Interview 4: Duncan Muchiri

Date: April 4, 2014
Area: Kiambu, Kenya
Organization: KENDBIP
Interpreter: -

Present: Jennie Boérius – Student of Chalmers
Sara Helmrot – Student of Chalmers
Daniel Gichuhi – Administration Coordinator, REFCE
Duncan Muchiri – Mason, B.C.E, biogas contractor, Central province
Henry - ……., REFCE

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Jennie: For how long have you been working for KENDBIP?
Duncan: Four and a half years. To correct you I don't work for KENDBIP, I'm an entrepreneur, I'm a businessman. I do biogas as a means of livelihood, so I'm not an employee.
Jennie: How did you get in contact with KENDBIP?
Duncan: Before the reception of the program I was still doing biogas, in a certain organisation from a place called Nakuru. So I started biogas work, it was ten years ago.
Sara: Have you built the same type of digesters all the time?
Duncan: A certain types of digesters, but the last two and a half years it's been relatively easy to construct the Kenbim. Because of a number of factors definitely being the provision of the financial subsidy to support the construction of that particular model.
Sara: So what kind of digesters did you build before Kenbim?
Duncan: There are many we used to have one called CARMOTEC and then there was ACOT.
Sara: Are they fixed dome?
Duncan: Both are fixed dome. They're different types of fixed dome. I've never really gotten interested in floating drum.
Sara: How come?
Duncan: Because of a number of inhibitions. One of them being the maintenance aspect of the floating drum biogas plant. That metallic sheet normally rusts so every now and then the farmer needs to, to undertake some maintenance which is not only labour intensive but costly. So I didn't get a lot of interest in something that will burden the farms every now and then.
Sara: Are the fixed domes all made of brick and stone or did you made it in something else?
Duncan: You know the bit with the fixed dome biogas plant is that you can localise it, you can use materials from different locations to put up one. Like you should go to the western parts of the country you'll find that we don't have these stones that are made under ground, you have some soil with clay with high --- content. So there is this the material that is moulded and then formed into bricks. It can then be used in the construction of a biogas plant, which make it even easier for a biogas plant to be put up in various regions of the country.
Jennie: When you got in touch with KENDBIP did they give you an education or

training?

Duncan: Of course. In fact when KENDBIP started even before they were starting up their offices I was very much involved in the formulation of the national program, through ETC an organisation called TEC and then the Shell foundation. So I had to come up with the data that was instrumental in the technical formulation of the program.

Jennie: Did you have like an education before that as well, about biogas?

Duncan: On sight training, I didn't have the, I didn't go to school to study biogas. So I just got to learn on sight.

Sara: Regarding the different kinds of digesters, what lifespan do they have?

Duncan: The fixed dome biogas digesters have a life span between 20 and 30 years. Depending more on the workmanship than the quality of materials that have been used. But in essence we give it 20 to 30 years.

Jennie: Is there a certain part of the digester that usually breaks first?

Duncan: From my experience I haven't noticed any digester, the ones that were constructed because even before I got into biogas there was some other people were doing the same. So the first digester I got to know was constructed in 1997, still working today and no one has ever gotten back for maintenance. So I wouldn't lie to say that this part break down first but from my own thinking when I'm looking at the technical aspect then the gas holder is likely to break down first.

Jennie: What is most important to think of when constructing a biogas plant?

Duncan: There are number of factors, it's not one, you can't say that this is most important aspect. Because like you say it's a biogas system so it's a system.

Sara: What factors then?

Duncan: One factor is, one, the number of animals. It is very critical because input is the --- to the output. So like if you have two cows then you can only do a digester of this size, if you have ten, if you have a hundred, if you have a thousand cows. So the input or the substrate that you feed into the biogas digesters or the feedstock, they eat dung, they eat human waste, they eat plant residue, whatever you used to charge the biogas digester, you have to be able to size that directly with the size of the biogas plant that you want to put up, that is one. The other factor is the materials, the materials that you use. If you want a biogas plant to last for long then definitely you have to go for the best quality materials and insure that the workmanship or the input from the technical people is as good as possible.

Jennie: Have you been working in different areas where for example the soil is different so you know it's different to work with it?

Duncan: Definitely, you have to undertake some sort of survive. We have the geological survive whereby you're able to tell the type of soil. The groundwater table and the other thing is factors like altitude. There are so many factors that can influence how a biogas plant is constructed or should be constructed. So if you go to a place like, in this country we have regions with certain types of soils. We find that not far from here we go to a place like Ngong you'll find places with black cotton soil. Yeah you know the characteristics of black cotton soil? Sometimes it swells, when it rains it swells, when it dries it shrinks and cracks. Yeah to put up a structure like that, like a biogas plant, then you have to be able to plant properly and be able to tell what to do that particular sight. Otherwise due to that expansion, contraction and what you'll find the experience with a lot of cracks.

Sara: What kind of maintenance is important for the digester?

Duncan: If the workmanship is right then biogas plants are not maintenance intensive.
The only kind of maintenance that might be important will be on the user end, you're charging the digester. To ensuring that from --- that point is clean. That's the only maintenance. And probably after a couple of years, like four, four or so years you'll need to check the stoves because it's affected by the hydrogensulfat that emanates from the production, the production process of biogas, so that corrodes, the valves, the control valves.

Jennie: How often do you go back to the households to check these things?

Duncan: It all depends. There are factors that influence me to go back to the household. For me, there are number of factors I look at: the age of the people who take up the biogas system. It is important because there are some people who even if you give them basic instruction they'll just forget.

Jennie: So if they're older you go back more often?

Duncan: Yeah, or I call them more often just to find out whether the system is working well. And in places whereby the system is acceptable to various physical wears, like of you install an industrial system or a biogas system within a very small area around the compound, then you have to take note of that. Because those systems are more likely to some in contact with lots of people including children.

Jennie: Do you train the persons who buy the biogas plant?

Duncan: Definitely. For sustainability, if any product is to work then the end user must, it's just like giving them a manual, but you look at the clientele that install biogas plants then it's very hard for you to just deliver a manual and just say now you can read this and you'll understand everything.
Definitively you have to give them some sort of training like quality use of a training whereby you take a farmer through the various stages of a biogas system, how they work, how they correlate and how to basically do some trouble shooting. Because not all the time you're supposed to keep going back to the farmer, there are some things they can do on their own. It saves on your cost and their cost.

Jennie: Which people in the household do you usually train?

Duncan: The approach now is, before, you know the men are also equal stakeholders contrary to perceptions, because when it comes to the financial aspect of a biogas plant, biogas plants are not very cheap. They're not cheap so at the end of the day the man will have to be directly involved. With the, with the whole process you have to sit down, understand the concept and then do the financial contribution. So due to the fact that the cost of a biogas system is slightly high then the money becomes directly involved and we want to know everything that goes on with the biogas system.

Jennie: Even though the woman is the one working in the kitchen?

Duncan: Even though. You'll find cases, this is one of the few technology where you'll find a input from both genders. The man will probably chart the digester ad the waste to the digester and the woman would cook.

Sara: So you will educate both of them?

Duncan: Of course, it's important.

Sara: Do you give them something like a manual or a poster or something?

Duncan: Now manuals, we have posters we have manuals. If you go to the KENDBIP office you can probably get that, they have lots of them for the national program.

Jennie: Do the rain seasons effect the biogas plant?

Duncan: No, rain no. But the cold season, yeah because you know it's a --- process and it's highly dependent on temperature. So when it's real cold, the fixed dome biogas systems, the pity is that the production will not go down so much. But with some other design like the floating drum, the production then basically goes down.

Sara: Do you organise all the marketing?

Duncan: Yeah, there's no one doing the marketing for me. I market.

Sara: How do you approach new customers?

Duncan: From my own experience, at times I go to field days but on rare occasions or shows --- fairs but or rare occasions because this business is basically refer on. If you do a god job someone will refer you to the next person, yeah the next person will refer, refer, refer you and then you create a huge network spreading all over the country. Depending on the way you handle the clients.

Sara: So you build all over the country?

Duncan: Yes, I get referred all over.

Jennie: Do you have a team of other masons that's marketing for you?

Duncan: Yes.

Jennie: How many do you have?

Duncan: It depends on the work but I can easily be able to get close to 10 masons at --- time.

Jennie: How does your payment look like?

Duncan: During the project the payment was basically coming from the subsidy, so the subsidy will take care of the technical aspect. But now all the payments come from the farmers and the way we do it is that you create percentages. So that by the time you're through with this stage you get paid this much, by the time you're through with the next stage you get paid that much and by the time you do testing and commissioning and handing over the project to the client you get paid that much.

Jennie: Do you get the 100%? Because there's a guarantee within the KENDBIP programme that's one year.

Duncan: Within the KENDBIP programme there was some aspect of retainment. They retain some money, a certain percentage of the digester cost, that's probably 10% of the subsidy, to tale care for wobble problems or follow-ups or what. In case the system fail and someone will not go back in and do their jobs. But I can attest for the fact that I have never had a system that doesn't run. My failure rate is zero percent.

Sara: The masons that work for you, do you often send one or two to build a biogas plant?

Duncan: One. But that depends on the size, but here I think your interest is in the domestic biogas plants, the small systems that are installed in homes?

Sara: Yeah.

Jennie: Approximately, how many biogas plants have you constructed?

Duncan: There are many.

Jennie: Are you still in contact with the farmers?

Duncan: Yes, sometimes someone calls and I ask them, where was that? But they still remain contact because even if the systems do not require intensive maintenance, at a particular point in time they will notice something different with the system and then they're likely to go with that information to you, whether it's a good sign or a bad sign. So we have to keep contact.

Jennie: Does it cost anything to maintain the biogas plant?

Duncan: It depends on the. What I do, what I do is this; if I construct a biogas plant, even within the guarantee set up, if I construct for you a biogas plant and then after I leave your compound I leave a good working biogas plant and then you tamper with the pipes, you tamper with a lot. You do some changes in the design, then if you call me to come in and undertake maintenance then I'll charge you. Just like you go and buy a car and if you're changing the tires, who do you charge for that? But it's rare, people do follow instructions, it's very rare. I haven't had problems with farmers for a long time.

Jennie: Who's responsible during the establishment?

Duncan: I'm in charge when we construct a new biogas plant.

Jennie: What's the challenges when you're constructing a biogas plant?

Duncan: It totally depends with the person you're doing this for. Because there isn't supposed to be challenges. Because in the first place you have to do some prior planning. You'll have to plan the process very well so you know at this particular stage this is what's supposed to happen. So if you don't plan that well it is when problems come about but when you do proper planning of the whole process, of the whole project then you're unlikely to face challenges. I can't say there's many challenges, those people who start biogas plants, start construction the plants knowing very well what they're getting in to.

Jennie: The masons that you have, have you trained them?

Duncan: Seriously. They have a certificate.

Sara: Do you train them both theoretically and practically?

Duncan: Both, some aspects of theory. Although most of the theory lays with me. For me, what I expect from them, because most of them have not gone through formal education, so what I expect from them is a good biogas plant. But then theoretically I have to train them on the way to measure the biogas plant, the way to set up biogas plants in different conditions. I have to train them both theoretically and practically.

Jennie: Do they get any training from KENDBIP?

Duncan: My team, no. But for me it was basically like, what can you call it, like a refresher. Because we were brought the diagram and I was able to interpret it very well so the training was more of a refresher.

Sara: So you have more practical training than KENDBIP?

Duncan: Yes, it's important. Practical and some aspect of theory because there are some things, even if you're a good builder you'll have to adapt that system in different setups. So if you only know this is how I'm supposed to construct and then you go to a place whereby where you are supposed to construct does not really work well and you're supposed to make some changes then that becomes an issue. You have to be smart, you have to be able to adapt the design to different locations and different setups.

Interview 5: John Thuku Macharia

Date: April 7, 2014
Area: Nakuru, Kenya
Organization: KENDBIP
Interpreter: -

Present: Jennie Boérius – Student of Chalmers
Sara Helmrot – Student of Chalmers
John Thuku Macharia – Mason and B.C.E, Jotmac Contractors

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Sara: Regarding the different kinds of biogas plants, what lifespan do they have?
John: I think, of the three past years I've been constructing the Kenbim design, in brick and stone. It has been doing well, it ranges from 4-12m³ as it is domestic. But the most effective design or model, the most used in our rural area is 6m³ up to 10m³. We construct those in 4m³ and 12m³ but 6 and 8 are the most used biogas plants. As you know most of our farmers, the animals they have, range from two to four. And the 12m³ is a bit big, it needs a person to have six, or eight, or ten animals of which most of those people are richer most of them use electricity. But the other range of farmers, the lower class, the ones who would like to install the 4m³, you can see also they are the people who have maybe one animal or two. They're a bit poor, they don't have money, even if they need it they are not able. But with this six to eight are the middle class, they have three to four animals, they have resources, so I think that's, the middle class are the most people, home usually and working.
Sara: What's the lifespan of that digester?
John: It can go up to even 50 years. As you know all the works are masonry. There's not any parts where corrosion can take place, --- can take place. You see sand, stones, bricks they can't rust so it has a long lifespan.
Jennie: For how many years have you been working as a mason?
John: I have been in the field for five years, since the KENDBIP came in.
Sara: Have you always worked with the KENDBIP?
John: Yeah. I'm even a supervisor.
Sara: Do you have other masons who are working for you?
John: Yeah.
Sara: How many?
John: I have six right now.
Sara: How does it work when you're building a biogas plant, do you send all of them or just one?
John: Actually what we does, there are many of my masons that I subcontract. I have a plant here, I have another here, then the most of my recommended masons, who I have trained to the higher grade that they need less supervision, I can subcontract them. I have charged the farmer maybe around 20 000 KES a plant, then the mason goes and tells him, or we agree I am going to pay you 10 000 KES when you complete this digester. There are some I pay on per day basis, depending on the salary in that certain area.
Sara: The masons that you've trained, have they gone through KENDBIP's training?

John: Some, but some are not. They're under my supervision.

Sara: How did you train them?

John: You know we even have the drawings. With me you know, I've undergone KENFAB's (now known as KENDBIP) trainings, the first mason training. The after that we had been picked the best masons, then we are upgraded, we have been trained to be supervisors so now I am a supervisor as well as a mason. I can construct, I can supervise.

Sara: When you train them, do you take them in the field and train them practically or do they read a book?

John: Yes I train them in the field and no no no I don't give them a book. I goes with them to the plants. When I start doing with the masons, you know most of the masons before entering the biogas industry they were already masons building the other structures, houses and other things in the construction industry. But as long as they don't know how to work with biogas they don't know how keen biogas demands. Then during the first few digesters to be built I am always there. I start with them from point A to point Z. When I see the areas where they've already have cached up I leave that to them but if I see the most important areas like the dome, where the gas is stored, I can't leave that person alone. I must be there so that I assure quality.

Sara: Is it usually a part that breaks first?

John: With me, you know before I entered this biogas industry I was a very good constructor in the building industry. So when I came to this industry of biogas I already had the experience in the work of building. Apart from that I didn't know the dimensions and the parameters of the bio digesters. So with me there is no, any time that I've constructed a plant which failed. I know the piping also, I does it by myself. All my digesters I am the one who does the piping, I. I've never left that to any person. I am the one who is responsible in piping.

Jennie: What's most important to think of when you're constructing a biogas plant?

John: The most thing that you have to think is how you're going to do that biogas. With less time so that it won't cost you much. The other thing you have to look at is how best the workmanship can be done so that after completing the digester you have no repetitions, which will cost you much. And the other thing is that you have to meet the satisfaction the farmer needs so that they will also sell you to get more jobs.

Sara: What kind of maintenance is important to make sure the plant works properly?

John: After the work has already been completed I have a warranty of one year after sale service. Whereby I won't charge him or her anything apart from if there's a defect in appliances caused by the farmer. If the defect is from the farmer then he has to buy the thing that might be needed. But installing it I won't charge him or her anything, apart from the agreed amount.

Jennie: Do the rain season affect the biogas plant?

John: In our area, as we are almost closen to the equator. So if you live in Nakuru area, Eldoret area the weather is almost constant, it never changes much. You see like now, we can say now this is our cold weather time. You see but how are you feeling it, is it really cold? So but there are some areas like Jendaula, like Maunakock, like Keringit, like Nuahuru, the higher zone area. During the rainy season there are a bit cold and the change of temperature. But with me, I haven't experienced the changes as most of my work is done within this area. But through the information I get from the other masons or

B.C.E.s they say like in Nyandalua there are some times when the cold weather is a bit cold and the performance of the digester reduces, but not completely but it reduces. As you know the digester, the anaerobic process that produces the gas mostly depends on the --- area in the digester. And the warmer it is the more bacterias increase. And the warmer it, the more bacerias increase. And when the weather is a bit warmer the bacteria multiplies and then the bacteria produces more gas. And during the cold season the bacteria reduces and they're somehow dormant. Sometimes they becomes dormant whereby they need to be activated. There are sometimes where you take the slurry from the outlet area to the inlet area so that they can mix up to revive the bacterias.

Jennie: What main materials are the digesters made of?

John: The construction materials, the one used in building the digesters we have first of all, we have sand, we have barlast that's aggregates, then we have the fired bricks, then we have cement, the best quality because we have different brands of cement some are not very highly effective but we know the best that can be used in biogas. We use the steel bars, either the twisted bars or the round bars. So after completing the digester walls we enforce it so it gets stronger. It may be in the ease of adequates or in some wet areas where water in the ground comes, it makes it strong. Then we uses the waterproofing cement so that the weather cannot easily penetrate from either the outside or from the inside to the outside areas. Then we use the GI pipes, galvanised iron pipes, for the main pipe, the gas pipe from the dome. The steel pipes are more expensive than the plastic ones so many farmers go for the plastic ones, which breaks more easily. The PPR pipe, when joining them we use fire, they're moulded. With IPS we use dias, the sockets with dias, so we screw them like steel pipes. With the PVC we use glue but because of the UV radiations we don't recommend it much because it breaks easily.

Jennie: What is your relationship with KENDBIP now when there's no subsidy?

John: Currently, like now, I have three which are being constructed, even right now I have my masons at the field and they have no subsidy. But the work has already gone down a bit but let alone I think it will pick. At briefing them the importance of the digester being compared to the firewood they had been using and compared also to the LPG gases they had been using. It's only because most of our farmers are not well up. It's not that they can't do without the subsidy the issue here is because they need it but their ability is a bit low.

Sara: Do you reach a different clientele now without the subsidy?

John: no. You know recently we had gone to a training at Nairobi that was sponsored by SNV. My area is Nongoro. Then after I was invited to a training with Africa Tunner Out which is sponsored by SNV and KENFAB (now known as KENDBIP). And we have been trained on how we can do biogas as a business and we are better enlighten. I have started reaching some other people who I was before I was not able to reach because I have been, even skills on how to approach them and how to talk to them and now I think, I'm in a better position now. I am going to do more.

Jennie: How do you still have contact with KENDBIP now?

John: We are still under them even though we are doing at our own. But you see if I'm constructing one plant they're motivating me with 1000 KES, to keep me running.

Sara: So they give you 1000 KES for every plant that you build?

John: Yeah.

Sara: When you've constructed a biogas plant do you give the client any information about how it works?

John: Yes. You see, earlier before we had some brochures. And like with me I have another project at IFAD. I don't know whether you've hears about IFAD, International --- for Agriculture Development. They have a programme here known as smallholder, SDCP, Smallholder Dairy Commercialisation Programme, dealing with dairy farmers. And I am the chairman of this region and we usually have work plans of the activities that will be taken within a certain quarter. And within our working plans we usually have demonstrations on various things. We have a few days where I usually have a stand where people can come and learn about biogas and learn about the slurry use as a fertiliser. I usually, sometimes, I even invite Mr Monickie and some of our masons tom come and teach farmers about the importance of the biogas. And by doing so we usually get some clients.

Sara: So you give them a brochure and you tell them how it works?

John: We give them some brochures and sometimes, you know there are some announcements in the Medias? When we go to the bario places we usually inform them about the biogases, when we go to the wedding ceremonies we also take the advantage because there are so many people there.

Sara: Do you just tell the farmer or do you tell the wife and the other ones?

John: Yeah we inform them all the details belonging to the biogas industry.

Jennie: Who do you tell, the farmer?

John: Not just a single farmer but the household.

Jennie: Who is responsible during the building process?

John: In most households, you know, fathers usually goes to their either business or goes to where they're being employed. Now most people whom we are left with at the household is usually the wife. They're the most responsible people in the biogas when we are constructing the biogas. But the father, or the husband, usually is absent but comes and keeps in touch with what's going on after he comes from, either from the job or from his business.

Interview 6: Stephen Macharia Kimenyi

Date: April 7, 2014
Area: Nakuru, Kenya
Organization: KENDBIP
Interpreter: -

Present: Jennie Boérius – Student of Chalmers
Sara Helmrot – Student of Chalmers
Stephen Macharia Kimenyi – Mason and B.C.E., Makimenyi Green Energy
Laban Kaara Mwaniki – Biogas Technician, KENDBIP

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Jennie: For how long have you been a mason?
Stephen: Three years.
Jennie: Have you always been in the KENDBIP programme?
Stephen: Yes.
Sara: Do you work by yourself or do you work with anyone else?
Laban: He works by himself and he also his team. He has a number of employees actually.
Jennie: How many does he have?
Stephen: 13.
Sara: Do you train your employees?
Stephen: Yes.
Sara: How do you train them?
Stephen: I train them when I'm constructing the biogas. They train.
Jennie: So it's practical training?
Stephen: Yes, exactly, yeah.
Laban: What, it is what we call the on sight training, yeah.
Sara: Have they gone through the KENDBIP training as well?
Stephen: No, no.
Jennie: Did you get any training from the KENDBIP program?
Stephen: Me, yes. The workers, no.
Sara: Was it a good training?
Stephen: Yes.
Sara: What kind of maintenance is important to make sure that the biogas plant is working well?
Stephen: Yes, because I am following them for at least one year.
Jennie: When you're done with the plant, what kind of maintenance is important to keep the digester working?
Stephen: Yes, when I construct that biogas I follow up, how can maintenance need. I train the client.
Jennie: How do you train them?
Stephen: How can mix, clean the digesters, how can use them so I try how can be happy the client because of that biogas.
Sara: Do you train the whole household or just one person?
Stephen: I'm training who use the, mothers, worker for that house.
Sara: When you're constructing a biogas plant, what is the most important thing to have in mind? What do you have to think about when constructing a biogas plant?

Stephen: When I construct that biogas, mostly, because I have the workers, I following. I going through all the continue constructing to help us how can do the better that plant.

Laban: Actually what he saying, during construction he go back for what you can see the supervision. He visits sight frequently to make sure his workers are do or doing exactly what they --- by the programme ---. And he also maintain the design specification of the systems, that is the working within the design measurements, they're following the issue material quality they are mixing, they make sure the material qualities good.

Sara: What is the most critical part in the construction?

Laban: The most critical part of the digester, of the construction is setting out the digester and also the gas storage chamber. If you fail to meet the design specification you may find that at the end of the day the system is failing function properly. Maybe there's insufficient supply of gas when the digester is too large compared to the gas chamber and sometimes you find that, sometimes the system is failing to function completely because in term of design parameters some measurement is not getting together.

Sara: If you go back to a sight, to a biogas plant, if they call you and are saying it's not working, what is usually the problem?

Stephen: When I go back to the sight first of all I look in the feeding because they maybe are underfeeding or overfeeding. I check the cow dung cause when the cow dung have the chemical the bacteria will already be dead. So I check so many part of the quality of the cow dung. If the cow dung is good I look in to leakages cause can be piping, the mason when doing piping badly maybe there is a leakages. So I make sure that if the digester is not working I look at the system from the digester to the user point if is good, if the cow dung is good maybe I can say ti remove that cow dung to check all the digester have some problem, like leakage, maybe finishing is poor, like that. And make sure the digester is working.

Sara: Why would the cow dung have chemicals?

Stephen: Maybe when they're spraying the cow cause of ticks, they spray the house of the cow. Then you collect that cow dung you put it in the, inside the digesters.

Jennie: Do the rain seasons affect the biogas plant?

Stephen: Depending if the digester you're constructing good you can make it.

Sara: How does it affect the biogas plant?

Stephen: The rain season, if the plant will working, it is working but the time of rain season it is going down. Maybe the problems, it is not working well because the time is not warm. When the rain is cold the digester cool down.

Jennie: What main materials are used when you're constructing the digester?

Stephen: I using the material of sand or ---, stone, barlast.

Laban: Those are locally available materials.

Sara: Does it cost anything to maintain the biogas plant?

Stephen: Maintain?

Sara: If you come back and fix something does it cost anything for the client?

Laban: The program has a component of what we call after sale services, ok guarantee time. It's a period of one year. During that time the mason is mandated to make sure the system is functioning very well. It is also during the same, same time the mason conduct the on sight training to the farmers of the biogas system. So after that if a system fails or there are some kind of maintenance problem after a period of one year and a farmer not --- there

during that period, farmer is entitled to part with the cost.

Sara: But if the farmer breaks something, if he cracks a pipe?

Laban: If the farmer cracks a pipe that is his own ---.

Sara: So then he'll pay for the pipe?

Laban: He must pay or the pipe.

Sara: Does he pay for the job to reconstruct the pipe?

Laban: Yeah, because at the end of the day, what the mason does, they give a proper training the farmers to make sure the system is well protected first and also there is no such things occurring. Because if it occur the farmer must face the cost. These people are masons that is their work they do to employ them so if there is some kind of crack in the pipe you call these guys. These guys is inquire some cost to repair that pipe so the farmer is part with that cost actually.

Jennie: What does the payment look like?

Stephen: Depending on the size.

Jennie: Do you get the money from the farmer directly or is it divided?

Stephen: Now you get the, you direct the farmer. By that time the program will promote us with the subsidies, the client. Maybe the farmer will buy the materials, I construct the biogas and then the labours are paid by the program. But now, because no subsidies, the farmer buying the materials, the labour. But it is different labours because it is different size, because they have 4-12m³.

Sara: Do they pay you directly or after you've installed the plant, or when does that happen?

Stephen: When I starting there is a, first of all when I start the constructing they pay half. When I finish that one they pay me the rest.

Jennie: Who is responsible during the building process? When you're constructing a plant, who is responsible?

Stephen: Me.

Interview 7: Charles K. Ngéno

Date: April 8, 2014
Area: Nakuru, Kenya
Organization: KENDBIP
Interpreter: -

Present: Jennie Boérius – Student of Chalmers
Sara Helmrot – Student of Chalmers
Charles K. Ngéno – Farmer, mason and B.C.E., Ngeno Biotec co.
Laban Kaara Mwaniki – Biogas Technician, KENDBIP

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Mason interview

Jennie: For how many years have you've been a mason?
Charles: Two years.
Jennie: How did you get in touch with the KENDBIP programme?
Charles: Mr Monic, he was constructing here, I was a new farmer. So I got it from him. Then after that I asked him to take me as a mason and he agreed and he took me to training at KENDBIP.
Jennie: Do you have masons working for you?
Charles: Yeah.
Jennie: How many masons do you have?
Charles: Right now I have four.
Jennie: Have you trained them?
Charles: Yeah I trained them.
Jennie: How did you train them?
Charles: I was training in sight where I'm working. They accompanied me, practical training.
Sara: Did they go through any KENDBIP training?
Charles: No, I only.
Jennie: Did you give them any theoretical training?
Charles: No.
Jennie: Regarding the different biogas plants, how long is the lifespan?
Charles: In fact I've been working only two years so I don't know the lifespan, but I think it is 20-25 years.
Sara: What kind of digesters do you build?
Charles: Normally in this area we construct 12m³, it is Kenbim type (fixed dome). I have constructed one AKUT of 24m³. But the others, right now I think I have constructed nearly 200.
Jennie: Have you made any in plastic?
Charles: No.
Jennie: Is there a certain part that usually breaks first?
Charles: I don't understand.
Sara: If someone calls you and says my biogas plant is not working, what's usually the problem?
Charles: I try to reach the place and I look which part is not working.
Sara: Is there usually a certain part that breaks first?
Charles: I think it's different. Maybe piping, leakages or blocking. But let's say in one month or two months or five months someone call you once, not

always.

Sara: Why are there blockages?

Charles: Maybe outlet. The farmer not removing the slurry so it can cause blockages.

Jennie: How long was the training that you got from KENDBIP?

Charles: Three weeks, let's say one month.

Jennie: Did you have a test as well?

Charles: Yeah I had a test.

Jennie: When you passed your test, did you get something?

Charles: Yeah I have it, the certificate.

Sara: What's most important to have in mind when you're constructing a biogas plant?

Charles: First of all you go to the sight, sighting. Then when you start it you must be accurate in measurements, you know if you mess that biogas can't work. So you must be keen in measurements and levels.

Sara: When you're building a biogas plant, do your masons build by themselves or are you a team that's building?

Charles: No, like now my masons are they know everything. And right now I'm the one going around to, I'm the supervisor. Training, KENDBIP trained me after we have worked with them for one year so my work was good. We were in Jauru for three weeks for training, supervisor.

Sara: Do they work by themselves?

Charles: No. I'm the one to, I'm marketing. I market my work then when I get one plant two I take them there.

Jennie: What kind of maintenance is important for the biogas plant, to keep it working?

Charles: First of all when you've finished your work, you know we are following, we do follow up after finishing. After finishing we do follow up everything, now and then we go there to see if the farmer is doing well and if it's a problem we just advise them.

Sara: How many times do you go back?

Charles: Even others, you know, we can communicate in calling. So even I can't, sometimes you call another one he told you it is ok so it's no need to go there. But then, you know, when you are finishing to construct we give them our numbers so if there's any problem they can call you.

Sara: Do the rain seasons effect the plant?

Charles: In this area no. But normally, sometimes I can travel far --- a cold area. Sometimes they can call you saying no --- so you advise, it's because of rain, that area is very cold.

Jennie: Does it cost anything to maintain the biogas plant?

Charles: No.

Jennie: How does your payment look like?

Charles: Right now, is very difficult. When you have subsidy, the time of subsidy we were working well but now it seems work is going down. But it depends about, it depends with the plant, we have 4m³, 6m³, 8, 10, 12. The big one is not the same as the smallest in payment.

Sara: Do the farmers just pay one time or do they?

Charles: No, after starting, when you go there you start. After one day, two days they can pay you what we have agreed 22 000 KES they can pay first time 10 000 KES, the other five when you finish, let's say they can give you a little and after sale services they can give you the remaining.

Jennie: How do you keep in touch with the KENDBIP programme now?

Charles: They have an office here in Nakuru so you just communicate when you have something, when you want something, anything.
Sara: Are there any money going from KENDBIP to you or in the other direction?
Charles: Right now, no.
Sara: Who is responsible for the establishment of a biogas plant during the building process?
Charles: I'm the one and when it is ready I can call our PT.
Sara: And they check if everything's ok?
Charles: Yes they check.
Sara: What materials are the biogas plant made of?
Charles: Stones, sand, barlast and cement waterproof, we have R8 and R6 bars and binding wires, we have mesh.

Farmer interview

Jennie: You have a biogas plant yourself, what kind of digester is that?
Charles: Kenbim, fixed dome.
Jennie: What materials is it made of?
Charles: Cement, stone, barlast.
Jennie: How large is it?
Charles: I have two types. First of all when I was starting I. I told you I visit my neighbour I interested to make one so after making I build a $6m^3$. Then I always have visitors coming to see biogas so the gas process ---. I decided to build another one, a bigger one, $12m^3$.
Sara: How much gas do you get per day from the $12m^3$?
Charles: Let's say the whole of the day.
Sara: When you just had the $6m^3$, how much did you get?
Charles: Let's say two to three hours.
Jennie: Do you still use both of them?
Charles: No just the $12m^3$.
Sara: How long have you had the $6m^3$?
Charles: Let's say one year and the other one, one year.
Jennie: Have you experienced any technical problems with the digesters?
Charles: No.
Jennie: What are the main types of feedstock that you use?
Charles: I feed with dung, cow dung.
Sara: How many cows do you have?
Charles: Eight.
Jennie: Before the installation of the biogas plant, did you use the cow dung for anything else?
Charles: Yeah, I have my garden nearby so I transport it there.
Sara: Did you use all of the cow dung that you got from the cows?
Charles: No, just a little. And let's say two days, three days feeding depends on what we have used. Right now my kids are not around, when they close the schools so we feed every day. Bur right now three days, four days.
Jennie: How much do you put into the digester, how many buckets?
Charles: Three buckets after three days.
Jennie: And when your kids are here?
Charles: Every day.
Sara: Before you used the biogas you got cow dung that you didn't use for the garden? No, you used everything?
Charles: Yes I used everything.
Jennie: And today, what do you use the slurry for?

Charles: For planting my gardens.
Jennie: Do you use all of it?
Charles: Not always, let's say in a month.
Sara: What do you do with the slurry that is left, that you don't use?
Charles: Just let it be.
Jennie: Before the biogas plant, what type of energy source did you use?
Charles: Firewood, charcoal, sometimes electricity.
Sara: Do you still use them?
Charles: No. Since that time, but I can use charcoal sometimes.
Jennie: For what?
Charles: For let's say when it's cold and sometimes when, you know, normally we cook Githeri (local dish). When you cook Githeri it takes some times, let's say four hours, three hours, they use charcoal.
Sara: The biogas isn't enough? Or don't you want to use the biogas?
Charles: They don't want to use it. Sometimes when I have visitors, you know, the burner is smaller so we can use charcoal.
Sara: Because the stove is too small?
Charles: Yeah.
Sara: Does biogas require more or less maintenance compared to the other energy sources?
Charles: You know biogas is cheaper. Since the time I constructed, no more, it's not like charcoal you know every, after one week you have to go and buy it. And here now we, the cost of charcoal is let's say 1000 KES so you see it's very expensive. But the biogas we constructed let's say I used nearly 70 000 KES and I forgot till now, so it's slurry work.
Sara: Do you save any time?
Charles: Yeah, it saves time.
Sara: In what way?
Charles: You see when you're using charcoal, the time of lighting all the, it's not like biogas. Biogas you can go and just start using. But charcoal it takes some times to prepare, some times adding.
Sara: Do you see any difference in your garden now that you're using the slurry?
Charles: Yeah it's better.
Sara Why is it better?
Jennie: What happens to the garden when you out the slurry there, compared to when you put the cow dung?
Charles: The slurry is rich, the slurry is working faster. So the plants grow faster.
Sara: Did you use any chemical before?
Charles: Yeah, DEB. When you put it in the ground, sometimes you need, it can change other fertilizers. But the slurry you can't, you can't use. You can use the slutty always.
Sara: Do you use any chemicals?
Charles: No.
Jennie: Throughout the year, do you have enough water to supply the biogas plant?
Charles: Yeah.
Jennie: What is the household's main source of income?
Charles: I have milk, I sell milk and right now I have build a house, renting house.
Sara: Do you make any money from building biogas plants?
Charles: Yeah. Right now, let's say I'm depending on biogas.
Jennie: How was this biogas plant financed?
Charles: It was very good.

Jennie: How did you pay for it, this one?
Charles: I paid, by the time it was 25 000 KES.
Sara: The subsidy?
Charles: The subsidy.
Sara: Did you take any loans?
Charles: No.
Sara: How many people live in this household?
Charles: Right now there are three. But when the close the schools we're less than eight.
Sara: Is the biogas enough?
Charles: Yeah it's enough.
Jennie: Are you able to sell the biogas to someone?
Charles: Right now no, because we don't know how to pack it or we don't have those packages.
Jennie: Is the biogas only for this household?
Charles: It's only this household.
Sara: If something breaks, who will pay for that?
Charles: It's me.
Jennie: What was the main reason for you to invest in a biogas plant?
Charles: To reduce cost.
Sara: What do you use the biogas for?
Charles: Cooking and lightning. But right now I am not using light. I was using lighting but now only cooking.
Sara: Why not lighting?
Charles: I have electricity.
Jennie: Have you noticed anything different in your health, like breathing or in your eyes, when you started using biogas compared to before?
Charles: Yeah. Right now, you know, biogas is clean and charcoal, my wife was suffering breathing but right now, by the time we started using biogas it's gone.
Sara: Have your life changed in any way?
Charles: Yeah, because the best you are using every month, you are using 2000 KES for buying charcoal but right now. So we save a lot and it saves time.
Jennie: What level of education do you have?
Charles: Standard eight, I didn't go form four.
Sara: The one who operate and maintain the biogas plants, is it you, is it your wife, or is it someone else?
Charles: It's my wife.

Interview 8: Peter Wangendo

Date: March 28, 2014
Area: Kikuyu, Kenya
Organization: KENDBIP
Interpreter: -

Present: Jennie Boérius – Student of Chalmers
Sara Helmrot – Student of Chalmers
Daniel Gichuhi – Administration Coordinator, REFCEL
Robert Kiamu - Public Relations, KENAFF
Peter Wangendo – Farmer

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Sara: What kind of digester is used here?
Peter: It's cow dung.
Sara: And it's the brick one?
Peter: Yes it's made of brick and stones.
Jennie: How large is it?
Peter: It's 12m³.
Jennie: For how long has it been in used?
Peter: I think now for 2 years.
Sara: Have you experienced any technical problems?
Peter: Not really.
Jennie: Which are the main types of feedstock?
Peter: Cow dung, only cow dung.
Jennie: How often do you feed the biogas plant?
Peter: 6 buckets of cow dung every other day.
Sara: How many cows do you have?
Peter: I have two.
Sara: Before you installed the plant, before you had biogas, did you use the cow dung for anything?
Peter: Just for planting.
Sara: Did you use all of the cow dung you got from the cows?
Peter: Yes, we used to use it here and another somewhere else. I even use to give some people some.
Jennie: Did you sell it to them or did you give it to them?
Peter: Sometimes I give, sometimes I sell.
Jennie: And the slurry that now have, what do you use that for?
Peter: I use it for the plants.
Jennie: Do you sell and give it to people as well?
Peter: No, I'm not selling it.
Sara: So before you had the biogas plant, what energy sources did you use?
Peter: I used the firewood, charcoal and ordinary gas: LPG.
Sara: Does the biogas require more or less maintenance than the other sources?
Peter: I think less. Less maintenance.
Jennie: And throughout the year, do you have enough water tor the biogas plant?
Peter: Yes, water is no problem at all.
Sara: So what is the household main source of income?

Peter: It comes from the cows.
Jennie: How was the biogas plant financed?
Peter: I took a loan, I think I used about 100000KES ($1250 USD).
Jennie: And the payback-time for that load was?
Peter: I think maybe, I'm not sure when I will get it back.
Jennie: You are still paying back right now?
Peter: Yeah yeah.
Sara: And if something breaks here, who will pay for that?
Peter: Since the time I've got it nothing has broken.
Jennie: Do you know what happens or what to do if something breaks?
Peter: No, or the person who build this thing, I have his contacts. So in case of anything I'll just call him.
Jennie: Are you able to share and sell the biogas to your neighbours?
Peter: No, I just use it me alone.
Sara: Which were the main reasons for investing in the biogas plant?
Peter: To buy the ordinary gas is expensive. Firewood, you can't even get firewood. It is not possible to get the firewood so I think the alternative is biogas.
Jennie: And what is the biogas used for?
Peter: For cooking, only cooking.
Jennie: How many hours a day do you have gas?
Peter: I would say 8-12 hours a day.
Sara: How has the biogas plant affected you daily life?
Peter: Well, it's good because I'm saving money because I'm not buying the cow dung, I have cows so instead of going to buy the biogas I use that money to something else. I also save time.
Jennie: Now you have had your plant for 2 years. Have you noticed anything different about your health?
Peter: No, nothing.
Jennie: How many people are living in this household?
Peter: It's me, my wife, sometimes. I think we are about 4 or 5.
Jennie: Is the produced biogas enough?
Peter: Yes yes. We cook with it, water for washing. It's enough.
Sara: What level of education do you have?
Peter: I've been going to school. Up to 2nd school.
Jennie: Do you still use other energy sources?
Peter: No, I just use biogas.

Interview 9: David Wawerú Kahenya

Date: March 28, 2014
Area: Kikuyu, Kenya
Organization: KENDBIP
Interpreter: -

Present: Jennie Boérius – Student of Chalmers
Sara Helmrot – Student of Chalmers
Daniel Gichuhi – Administration Coordinator, REFCEL
David Wawerú Kahenya – Farmer
Robert Kiamu - Public Relations, KENAFF
Peter Wangendo – Farmer

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Sara: So you have two cows?
David: Yes.
Sara: And how big is the digester?
David: It's 10m³.
Sara: What material is the digester made of?
David: Brick and stone.
Jennie: For how long have you been using the digester?
David: I would say about a year now.
Jennie: Have you experienced any technical problem with the digester?
David: Well, it's not very efficient let me put it that way. Because the gas get finished very quickly, before the food is ready. But making tea and simple things is quite fast. That's my observation.
Jennie: For how long can you use the biogas, approximately during a day?
David: One meal, making one meal it will finish sometimes. But it might get finished before the food is done. It's about an hour. Yeah one hour and then it is gonna be exhausted.
Sara: What types of feedstock is used?
David: Only cow dung.
Jennie: Before the installation of the plant, did you use the cow dung for anything?
David: Yes we took it to the garden, all of it in the garden.
Sara: Do you use the slurry today?
David: Yeah, we use all of it in the garden. For planting whatever we plant.
Jennie: What energy sources did you use before you had the biogas?
David: The standard gas LPG, it is till there in the house. We use the small one in safety in case the biogas get exhausted before the food is ready and then we shift it from the biogas to small cooker.
Sara: And through the year, do you have any problems with the water supply that you need?
David: Water is a problem because here we depend on the Kikuyu water company supply. And sometimes we can go for a week without water. Which is a disaster. Like now, here I've got two almost three rains, yes three rains of supply. And you usually don't get a special time without water.
Jennie: Does the biogas plant require more or less time than the other energy sources?
David: There is nothing to maintain here so it's better than the old energy source.

Jennie: What is your main source of income?

David: That is tricky because I don't go out to work, I'm retired. I used to work but then I was told to go home because of the younger generation, they need some space to do some work. I don't know what they want us to do. Now we are analogue, we don't know what to do. Well like you can somebody there working for me. I'm just expanding my little farm. I'm finish with these houses (pointing at some houses behind us) recently, which I rent out to people. So I want tot supply them with eggs and things like that. That's how I have to survive. These houses for renting it's my project.

Jennie: How did you pay for the biogas plant?

David: It was subsidized by ehhh..

Robert: KENAFF, that is us!

David: Yes, yeah they are the one who subsidized this.

Jennie: All of it or just a part of it?

David: I can't remember how much I paid, how much were we paying?

Peter: I think we used about 100000KES ($1250 USD).

Robert: And then KENAFF subsidized 25000KES ($312,5 USD) on all sizes.

Jennie: So did you take a loan?

David: No, no loan.

Sara: If something breaks here, is it you who pays for it?

David: Yeah, it would be me. And I'm hoping it won't break soon.

Robert: But then there is a guarantee with the masons about the techniques for one year. So as long as it not of within one year. The technician, if it is his fault. But that doesn't mean he takes this (pointing at a lid made of brick) and he breaks it and think that the masons will come. It it's a technical error on the part of the masons on the part of KENAFF, then the mason have to come and get paid free of charge. That is within one year.

Jennie: Are you able to sell the biogas to your neighbours?

David: No no. I wish I could because I would have supplied all these people (pointing at Peter and the houses that are for rent). I wish I could.

Sara: But maybe in the future.

David: Hopefully.

Sara: Which were the main reasons for you to invest in the biogas plant?

David: Because the other gas is becoming out of reach, it is becoming too expensive. I don't know what they want us to do.

Sara: So this is better?

David: This is cheaper, it's clean.

Jennie: What is the biogas used for?

David: We use it for cooking, heating water, whatever.

Sara: How has the biogas plant effected your daily life? Have you noticed any differences?

David: Well in fact I've reduced my bill of 6000KES ($75 USD) to about 3000KES ($37,5 USD), almost by 50%.

Sara: That's a good thing.

David: Because I keep on buying the small cylinder, that one I have to buy once a month. In fact I've saved about 5000KES ($62,5 USD).

Jennie: A year or a month?

David: A month! Because we always go for one more cylinder once a month. Meaning that all the other time we have used this. (Pointing at the biogas plant).

Sara: Have you saved any time?

David: This one is very efficiently. In fact there is much quicker than the standard gas. This one is much faster.
Sara: When you cook?
David: When you cook. Yeah it's much faster in this work, much faster. And it also gets finished very quickly. What I suspected is we don't have a control. Some of the gas is wasted.
Sara: What level of education do you have?
David: I went to school when you were not born.
Jennie: But did you go to university?
David: No I went up to form four. But believe you me I was getting paid better than university people because I was a hard worker. I was a hard worker.
Jennie: How many people live in this household?
David: It's only me and my dear one. All the others have gone. There are on their way, they are on their own. We have one son is here so we are three in the house.
Jennie: And the biogas is not enough?
David: Yeah, it's not enough.
Sara: Therefore you still use the other energy source?
David: In the kitchen it's only biogas and standard gas.
Jennie: Is anything done to the cow dung before you put it in the digester?
David: We make sure we collect it clean from the shed when it comes here (pointing at the digester). When you mix it with the water you don't bring it without a lot of dirt because it's going to make the work much harder. So you remove all the rubbish from there and then you make it thick, you mix it with water and then you release it.
Jennie: So you know by the eye how much cow dung and how much water you are going you use?
David: I was told by the mason that things takes about 20 litres. 6 things of 20 litres.
Robert: 6 buckets.
David: Yeah 6 buckets.
Sara: How often do you refill it with cow dung?
David: We do it every morning because we have to clean the shed every day. So that is fed every day (pointing at the digester).
Jennie: Have you noticed anything different about your health?
David: I don't, no no.

After the interview there was a discussion about why the farmer could only use his biogas for
an hour. The recording started a little late.

David: The man who did the construction of the plant, there was no following up.
Robert: Okay.
David: He should have followed me up so he can get me educated. So I know where I am loosing.
Daniel: Because of you look at this (removing the lid from the outlet where the slurry is and we all look inside), it's like water.
David: Yes it is.
Robert: It should be thick, very thick. Thick, thick, thick. You see if you make it too thick or too thin it won't work. That's what we normally say the issue is one to one.

David: One to one?

Robert: But, depending on the dung, the condition of the dung, it could be so thin from there, so if you add another portion of water it becomes too thin.

David: You are lucky because I'll be coming here in time of two days. So the problem is not even the technical part. It's feeding. This is just to thin.

Peter: I should be like a porridge.

David: Yeah it should be like a porridge that one I was told.

Jennie: Was it the masons' job to tell him that?

Robert: Um yes. He didn't come to show you the feeding, the initial feeding?

David: When we finished the project he showed me how to do it. And that was that.

Robert: What was the name of the mason?

David: Wambugu.

Daniel: If it's Wambugu, I'm sure he told you everything you need to know. I know him, that guy is good.

Robert: You don't even have to call him. (Speaking in Swahili).

Peter: After either 4 or 5 days. (Speaking in Swahili).

Daniel: You should feed when it is thicker than usual, so that the inside becomes thicker.

Robert: So just make it thick. Other for 10m³, between 6-8 hours of gas nonstop. How often do you use it? Continuously?

David: This is always on. But now I know what the problem is.

Robert: So what we have requested him to do, he thickens that (talking about the feed mixture), very thick so that when it becomes uniformed with the one inside here. So when it comes to the digester it's twice as thin as when you put it inside. So if he makes this very thick, he won't be buying any standard gas.

Interview 10: Brenda Nabtutu Wekesa

Date: March 28, 2014
Area: Kikuyu, Kenya
Organization: KENDBIP
Interpreter: -

Present: Jennie Boérius – Student of Chalmers
Sara Helmrot – Student of Chalmers
Daniel Gichuhi – Administration Coordinator, REFCEL
Robert Kiamu - Public Relations, KENAFF
Brenda Nabtutu Wekesa - Farmer

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Sara: How big is your digester?
Brenda: I know it's medium. I think that's 8m³.
Sara: What is it made of?
Brenda: Stone.
Jennie: For how long have you had the plant?
Brenda: Since December.
Jennie: So it's new!
Brenda: Yes it's new.
Jennie: Have you experienced any technical problem so far?
Brenda: No.
Sara: What type of feedstock do you use?
Brenda It's cow dung. We put cow dung here. Just cow dung and water.
Jennie: How often do you do that?
Brenda: Daily, at least 4 buckets of cow dung.
Sara: How many cows do you have?
Brenda: We have 2 cows.
Jennie: Before you had the biogas plant, did you use the cow dung for anything?
Brenda: Yes, for manure.
Sara: Did you use all of it or did you get anything left?
Brenda: We used all of it because we have a lot of plants in different places.
Sara: And do you use all of the slurry that you get from the biogas plant?
Brenda: Yeah, we use here for planting. It's all over.
Jennie: Which energy sources did you use before you had the biogas plant?
Brenda: The other gas for buying (LPG), we bought it. We mix charcoal and then firewood. We used to mix.
Sara: Do the biogas require more maintenance or less than the other energy sources?
Brenda: Biogas requires less. It just requires to fill the cow dung, nothing else.
Jennie: Do you still use any other energy sources?
Brenda: For me, we use this. But we are using it for two houses. But my mom (other house), she mixes uses with firewood. But for me I just use the biogas.
Jennie: So how many people live in your household?
Brenda: We are 3.
Jennie: And in your mom's household?
Brenda: They are 4.
Sara: Throughout the year, do you have any problem whit the water supply for mixing?

Brenda: No, we have enough water.
Sara: What is the main source of income for your household?
Brenda: Mostly salary from my husband.
Jennie: So your husband works? What does he works with?
Brenda: Yeah he works. He works at ILRI, International Livestock Research Institute. It's our main source of income.
Jennie: How did you finance the biogas plant?
Brenda: My husband paid for it. And it was ehh
Robert: Subsidized.
Brenda: Yeah subsidized.
Jennie: Did he take a loan?
Brenda: No he didn't take a loan. No loan.
Sara: Are you able to sell any biogas or do you just use it for your mom and yourself?
Brenda: For now we are just using it. We are waiting until we get 4 cows. That's when it will be enough to sell.
Jennie: Who do you wanna sell it to?
Brenda: My neighbors and the ones I'm renting there houses for. (Pointing at some houses).
Jennie: If something breaks, who will pay for that?
Robert: In case it doesn't work (speaking in Swahili) that's what they are asking.
Brenda: He will pay, my husband will.
Sara: Which were the main reasons for investing in biogas?
Brenda: It's cheap. It is cheap for us. And it is convenient because there is no day that there will be no gas.
Jennie: And what is the biogas used for?
Brenda: Cooking. And the slurry for manure.
Sara: How has the biogas affected your daily life?
Brenda: It has improved because now the expenses that we had for buying charcoal and the other gas is really reduced.
Sara: Do you have to spend more or less time?
Brenda: It's less because the gas is much much more. It's produced by a morning a lot, and it has that pressure so it cooks faster.
Jennie: Have you noticed any differences about your health compared to when you used the other energy sources?
Brenda: Yeah like when you use charcoal it effects eyes and then lungs that start coughing. But this honestly you notice nothing.
Jennie: So you feel better?
Brenda: I feel better!
Jennie: What level of education do you and your husband have?
Brenda: We are both undergraduates, bachelor degree.
Sara: And the produced gas, is it enough for your household?
Brenda: Yeah its enough. That's why we use it for 2 households. So it is more that enough.
Jennie: Is anything done to the cow dung before you put it into the digester?
Brenda: No. We take it from the ground and put it in there. It is fast. We only use it after, when it comes out, the slurry.
Sara: What were your subject when you did your bachelor?
Brenda: Biomedical science in technology.

Interview 11: Felister Mumbi Kimunja

Date: April 3, 2014
Area: Kiambu, Kenya
Organization: KENDBIP
Interpreter: -

Present: Jennie Boérius – Student of Chalmers
Sara Helmrot – Student of Chalmers
Daniel Gichuhi – Administration Coordinator, REFCEL
Felister Mumbi Kimunja – bonde

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Jennie: What kind of digester do you use?
Felister: 8m³, it's made of bricks and stones.
Jennie: For how long have you used the digester?
Felister: We were the first to be constructed. So 4-5 years. Mine is the first, it's the demo for the other farmers. When KENDBIP came I was given the demonstration for farmers to learn about it from my farm.
Jennie: Have you experienced any technical problem with the biogas plant?
Felister: There is a time when we had, but it is due to our management. The way we were taught to feed we had to feed. But in the others, they are okay.
Sara: Did you feed to much water?
Felister: Not much water, but we were feeding a lot. Almost everything we got from the diary.
Sara: What kind of feedstock do you use?
Felister: I use cow dung, just cow dung. It is plenty.
Jennie: How often do you feed the digester?
Felister: Almost every day and about 3 buckets, 20 litres á bucket.
Jennie: Before the installation of the biogas plant, did you use the cow dung for anything else?
Felister: Yes, manure in the farm and compost.
Jennie: Do you use the slurry today?
Felister: I use it in the farm. I do put it in my bananas, even in the drain house.
Sara: Do you get more slurry than you can use? Do you use all of the slurry?
Felister: No, it's plenty. I don't use all of it, but in the remaining I do use to make the compost manure. I just pore all the dry materials and I mix it. I mix it with all the greens that I don't use.
Sara: What do you use the compost for?
Felister: I use it in the farm. When I put it in there it takes about a month, when it is well composed I take it to my farm. I plant it by the maize and where I don't use the slurry.
Jennie: Do you see any difference in your crops now compared to before you used the biogas?
Felister: Yes, it is a great difference. When I'm using the slurry it is very fast, the uptake of the slurry in the plants is very fast. And you see where the slurry is, it is always green. There is always something to harvest. You always have food.
Jennie: Before you had the biogas, what kind of energy sources did you use?

Felister: The firewood, charcoal which was very very expensive. And even the other gas, LPG.

Jennie: Does the biogas require more or less maintenance?

Felister: Yeah, biogas is less and also it is very good because even with the children you are not fearing anything. When you forget to close it is not harmful. So even when the children are there you are not scared. With the LPG, the moment you leave it you might burn the whole farm. So biogas is economical and safe. It is very beneficial. It is very good.

Sara: Throughout the year, do you have enough water to supply the digester?

Felister: I have a lot water. I have many tubs. The water is enough.

Jennie: What is the households' main source of income?

Felister: The major is the diary and also the greenhouse. But you can't compare the diary with the greenhouse. There are a lot of charges is the greenhouse of which even manure, if you are diary well it is a good source of income. With the milk, you sell the milk, you get the gas, you get the manure. I also sell the compost manures.

Sara: How was the biogas plant financed?

Felister: I took the loan from the bank, and the loan is paid by the cow. So I get the loan, I supply the milk. Also the subsidy from KENFAB that was 50000KES. But the loan was not only for the biogas. I have children, I pay school fees with the same loan.

Jennie: How long did it take you to pay back the loan?

Felister: 2 years.

Jennie: If something breaks on the digester, who will pay for that?

Felister: It's me who is to renovate and I call the mason who constructed it. Even if he comes, the duration time for him to repair is finished so I'm the one to pay. But they had given us a 1 year guarantee.

Sara: Do you sell the slurry as well, you your neighbours?

Felister: I don't sell the slurry because now, with the slurry I only see it is good to use in compost. The slurry is to thin and liquidity to be able to sell. The compost is sold in bags. It is easier to carry the bags and therefore easier to sell.

Jennie: Are you able to sell the biogas to your neighbours?

Felister: No. There is distance in the farmers. From my farm to another farm there is a good distance. But possibly even if I can pipe to my houseboy and possibly to a house for my son, when he becomes married. But it is a sorted distance.

Sara: But do you have enough biogas?

Felister: I can say it is enough. I was hearing some other people it was fluent but mine it is time you will go and find. As you use it, it is minimized, but when you close it for a time it will recharge.

Jennie: How many hours a day does the biogas last?

Felister: We normally say we use it in the morning, during lunch time and in the evening. In the morning I put it on at 5 because I wake up at 5 till about 8. By 8 you will see it is minimizing so when you close it for a time, an hour or so, it will recharge itself. So we use it around 9 hours a day.

Sara: What do you use the biogas for?

Felister: Cooking, just cooking.

Jennie: What was the main reason for you to invest in a biogas plant?

Felister: It is very economical, it is very healthy, it is very comfortable. Like now if there is somebody in the house we could have drunk his tea already.

Because it is fast, no waste of time. It is good for us women because without the smoke, no red eyes. You to would become blackheads.

Jennie: So have you noticed a difference in your health?

Felister: Yes very very much. Even when you were staying in that smoke, you cough a lot. You compare somebody coming out from a smoky house and you understand a lot of things. She is coughing, her eyes are crying. In hurry there might be a side effect in the health on anybody.

Sara: How has the biogas plant affected you daily life?

Felister: There are a lot of benefits. You see now to prepare the fire with the firewood it would take time. But biogas is very fast. You wake up and that water is tea. So the time we were wasting on collecting the firewood, the tune we were wasting preparing the fire, we have converted it to money. Everything is money. When you waste an hour you have wasted a lot of money because you could have done another beneficial work and another source of income. So with the money we are now not using, with the time we are wasting, that money have we converted, it's a lot of money.

Jennie: So you save a lot of time?

Felister: Yes, we save a lot of time. Also you are not coughing.

Jennie: What level of education do you have?

Felister: All levels, that is form four.

Sara: Do you still use other energy sources?

Felister: We normally use but it is rare. Like now I was cooking a --- you see now if you take. Now I wasn't possible to be there, I was in the farm, so I just leave it there. Because even if the biogas go down, and you put it in the firewood it will continue. And also, when I've not piped, I will not allow the houseboy to use the other kitchen to boil the water for milking. So you also use that. But not in many hours. It is only when I'm not around.

Sara: When you leave the house you have you close and then you use the firewood?

Felister: Not me, the houseboy. He can't enter the house when I'm not in. You can't leave the house open so that when the time comes for milking you make the water there. When I leave them they just light the fire there, with the firewood, just put the water for milking that's all.

Jennie: How many cows do you have?

Felister: 5 but I also have calves.

Jennie: How many people live in this household?

Felister: There are me, my husband and our 6 children.

Interview 12: David Too

Date: April 8, 2014
Area: Nakuru, Kenya
Organization: KENDBIP
Interpreter: -

Present: Jennie Boérius – Student of Chalmers
Sara Helmrot – Student of Chalmers
David Too – Farmer, KENDBIP
Laban Kaara Mwaniki – Biogas Technician, KENDBIP
Charles K. Ngéno – Farmer, mason and B.C.E., Ngeno Biotec co.

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Sara: What kind of digester do you have?
David: 12m³, Kenbim, fixed dome.
Jennie: For how long have you used the biogas plant?
David: It's now one year.
Sara: Is it just your household that uses the biogas?
David: It's nice. I've used it for cooking, everything.
Sara: Do you use it for cooking?
David: Yeah cooking.
Jennie: Have you experienced any technical problem?
David: No. So far no.
Jennie: What is the main type of feedstock that you put into the digester?
David: Cow dung mixed with water.
Sara: How many cows do you have?
David: Eight.
Sara: Is the cow dung enough?
David: It is more than enough.
Jennie: Before you had the biogas plant did you use the cow dung for anything?
David: Just take it to the farm, manure.
Sara: Did you use all of the cow dung?
David: No.
Sara: What did you do to the cow dung that you didn't use on the farm?
Jennie: Like before, when you took the cow dung to the farm, did you use all of the cow dung?
David: Yes.
Sara: Do you use all of the slurry that you get? The thing that comes out of the biogas plant?
David: Yes.
Sara: What do you use that for?
David: I use it for planting.
Sara: Do you use all of it?
David: I use everything.
Sara: Have you noticed anything different between the cow dung and the slurry?
David: Yeah, there's a big difference. From the biogas is actually more productive when you use it for planting tree, vegetables.
Jennie: What happens, does it grow faster?
David: Fast and healthy.
Sara: Did you use any chemicals before?

David: Before it was fertilizers but --- is when I've used this cow dung.
Sara: So you don't use any chemicals?
David: I don't.
Jennie: What energy source did you use before the biogas?
David: I just used normal gas, LPG.
Sara: Do you still use it?
David: No. Since I used biogas I've never. I've removed even the tank the cylinder from it.
Jennie: So you didn't use firewood or charcoal?
David: I use firewood and charcoal and now I use charcoal for other jobs, for chicken.
Sara: Why do you use charcoal instead of biogas?
David: I've not had the right burner
Sara: So the burner is too small?
David: I think there should be a special burner for small chicken.
Jennie: You don't have that one?
David: I don't have.
Jennie: Throughout the year do you have enough of water to supply the biogas plant?
David: Yes.
Sara: Do the rain season affect the biogas plant?
David: No, it did not.
Jennie: What is your main source of income? How do you make your money?
David: From the chicken and the milk.
Sara: How many people live in your household?
David: Four.
Sara: Is the biogas enough?
David: Yes.
Sara: How many hours of gas do you get per day?
David: You know, most of the time nobody is at home. So it's the weekends.
Jennie: How many hours a day can you use the biogas for if you would need it? Would it be 10 hours or 12 hours?
David: 10 hours.
Jennie: How was the biogas plant financed?
David: Through the subsidy.
Jennie: Did you take a loan as well?
David: No.
Jennie: If something breaks on the digester, who will pay for that?
David: Don't know, because there's no damage yet.
Jennie: Do you know who will pay for it if something breaks?
David: I don't know.
Sara: Do you sell the gas to neighbours?
David: No.
Jennie: What was your main reason for investing in the biogas plant?
David: One because it was, I have the cows, the normal gas was too expensive. Since the project started I also moved --- so I found it was convenient.
Sara: What do you use the biogas for?
David: Cooking.
Jennie: Have you noticed anything different since you installed the biogas plant? Like breathing or eyes?
David: No.

Jennie: Do you know if your wife has noticed anything different?
David: Nothing, she has not complained.
Sara: Have you noticed anything different in your life since you installed the biogas plant, has it changed?
David: I spend a lot to pay the walker since the walker is milking and after that put cow dung in the digester.
Sara: So do you save some money?
David: Yeah.
Jennie: Do you save time?
David: My wife mostly, my wife must know.
Jennie: But you know that you save money?
David: Yeah.
Jennie: What level of education do you have?
David: My level of education is form four and a diploma building industry, building construction.
Sara: How often do you feed the biogas plant?
David: Normally it's twice a week.
Jennie: How much do you feed it?
David: About three barrels, buckets.
Sara: Is that like 20 litres per bucket?
David: Yeah.
Sara: Did you get any education about how the biogas plant works, like when they installed the biogas plant?
David: No. I saw the construction, I know it goes and the construction.
Jennie: Were you able to be there while the mason was building?
David: When they were building I managed to see something.
Jennie: So you sked questions when they were building?
David: Yes, yes, yes.
Sara: Did you get any posters or manuals or something?
David: No.

Interview 13: Mary Wanja

Date: April 8, 2014
Area: Nakuru, Kenya
Organization: KENDBIP
Interpreter: -

Present: Jennie Boérius – Student of Chalmers
Sara Helmrot – Student of Chalmers
Laban Kaara Mwaniki – Biogas technician, KENDBIP
Mary Wanja - Farmer

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Sara: What kind of digester do you have?
Mary: We call it Simgas, it's in plastic and 6m³.
Jennie: For how long have you used it?
Mary: I think I've used it for 2 years.
Jennie: How many hours of gas a day do you get from it?
Mary: Every day like now I use it from 6-9 and then like now you see I'm busy, so I use it at lunchtime and also in the evening. So I thing maybe 6 hours.
Jennie: Is the gas enough?
Mary: Yeah, it's enough for me, but in the evening I use the charcoal because I'm cooking many dishes so I have to.
Sara: So you use the charcoal in the evening?
Mary: Yes, in the evening. But it is not much. You know I have to put water to boiling and for this one I put it for cooking.
Jennie: Before you had the biogas, which energy sources did you use?
Mary: I was using firewood and also charcoal in the evening. You see we have trees so we didn't have any problem with getting firewood. But it took me so long to cook with or dry it. But now when I'm using the biogas it is just to put it on there and start cooking. It doesn't take much of my time.
Sara: How much time do you think you save?
Mary: I think it's around, because in the morning before I had to wake up at 5, so that I light the charcoal, especially then when it is still wet the firewood is wet so lighting it took almost all of my time. Now the way I do I can also time myself. When I wake I just take this put it there I have hot water and then I got to work.
Jennie: Have you noticed any difference with your health?
Mary: Yeah yeah, because there is no longer, when I use to light the other charcoal it made me itch my eyes. But now I'm free.
Sara: And did you see any difference in your repertory?
Mary: Yeah. The smoke was a problem, made me couth. It's over now. Some are allergic.
Sara: How many people live in this household?
Mary: Like now, the kids has gone to school, we are 4.
Jennie: Have you experienced any technical problem with the biogas plant?
Mary: Only when I put in it. The problem I had especially, what do you call it. If you don't have enough cows you have a problem and then like now mine are a bit okay because I have a unit, especially those we do not have is become hard to go collecting from different places, but now we have them in one place so there is no problem.

Jennie: What are the main types of feedstock that you use?
Mary: Only cow dung and water.
Sara; How much do you put in it?
Mary: Like now mine is 6m³ so I put 2 buckets of water and 2 buckets of cow dung everyday. Everyday because now the unit have to clean it everyday, so I pt it everyday.
Jennie: Before you had the biogas plant, did you use the cow dung for anything?
Mary: You know this one has helped me because when it is digestered it is easier to use. Before we could just collect it and put it somewhere and wait for so long. But now it is right here. It is easier to use.
Sara: Before, when you didn't have the biogas, what did you use the cow dung for?
Mary: Just for putting in the farm. Just manure, but it was taking long.
Sara: Did you use everything?
Mary: Yeah, but it was hard. You know now it is collected somewhere and put in the digester and everything is there. But before you know it was all over so it was hard to collect. But now it is easier because it is collected somewhere. I am collecting it from wherever and it is easier.
Jennie: Do you have enough water to supply the biogas plant throughout the year?
Mary: Yes, I don't have a problem.
Sara: What is the households' main source of income?
Mary: I get from the cows, then from the crops, I grow, manure.
Sara: What crops do you grow?
Mary: I grow potatoes, beans, peace, maize and even fruit. Like now I have, I'm planting because now we have the manure so now I even decide to grow, to add the plantation of the fruit.
Jennie: How was the biogas plant financed?
Mary: Like thins one from the Simgas, I pay 5000KES when I can, so it is easier for me. I couldn't pay it all at once. I haven't finished paying it of. I'm still doing it. I'm getting the money to pay so I continue with my farming and getting money to pay them.
Jennie: Did you take a loan?
Mary: No I didn't because I pay a small amount of money when I can. The money is not much so I am able to do it without loans.
Jennie: And if something breaks, who will pay for that?
Mary: It happened. We are till working with them. So if I see any problem I just call, and they come. I don't know who will pay.
Sara: And do you sell the biogas to anyone else?
Mary: I just use it myself. The problem with biogas is that it has no storage, you have to use it. If you don't put more pipes so that you can share it. But now storage is hard.
Sara: Have you notice any difference in your crops?
Mary: A lot, a lot. I don't use a lot of fertilizer. So I use organic.
Sara: So you used chemical before?
Mary: Yes, a lot. But now I can even plant and then.
Jennie: What level of education do you have?
Mary: Form four.
Jennie: Why did you invest in a biogas plant?
Mary: For once we had a problem before to go looking for the firewood, so it was easier for me to get the manure to make the work easier for me and then the problem with the smoke, you see I told you I have problem with it so I

found it easier for me too.

Jennie: Did you get any training about the biogas plant, how it works?

Mary: Yeah, the ones who were planting it they showed us how to do and use it.

Jennie: Did you get any posters or something?

Mary: Yeah, they have it. But now, like myself I'm moved passed that. So what we are doing, we are just working with them. But the people had the posters here.

Sara: What is the biogas used for?

Mary: Only cooking.

Sara: How has the biogas plant affected your daily life?

Mary: How do I put that, I've explained it has helped.

Jennie: Is anything done to the cow dung before you put it into the digester?

Mary: Yeah, I have to clean it. To remove all the grasses.

Sara: How many cows do you have?

Mary: 5 cows.

Interview 14: Grace Gathungu

Date: April 8, 2014
Area: Nakuru, Kenya
Organization: KENDBIP
Interpreter: Laban Kaara Mwaniki – Biogas technician, KENDBIP

Present: Jennie Boérius – Student of Chalmers
Sara Helmrot – Student of Chalmers
Grace Gathungu – Farmer
Laban Kaara Mwaniki – Biogas technician, KENDBIP
Daughter of Grace - Farmer

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Sara: What kind of digester do you have?
Laban: Plastic, just plain straight plastic. Simgas.
Sara: How big is it?
Grace: 8m³.
Jennie: For how long have you used it?
Laban: 1 year.
Sara: How many cows do you have?
Grace: 8.
Jennie: Have you experienced any technical problem?
Grace: Yes.
Laban: It is not efficient of the gas production actually.
Sara: Why is that?
Laban: We told them there is a lot of feeding in the system. They are overfeeding it. Overfeeding means a lot of dung then this is expected. She is calling for the technical person to come here and come up with a resolution she has been reaching them but they have promised they will come actually.
Obervation: The slurry is like water, very liquidity.
Sara: But they haven't come yet?
Laban: They have not yet arrived.
Jennie: And when did you call them?
Laban: One month ago.
Sara: How much gas do you get every day? How many hours of gas?
Grace: Only tea. 30 minutes a day.
Jennie: Before you had the biogas plant, did you use the cow dung for anything else?
Laban: She was using it in farming.
Sara: Did she use all of it?
Laban: She collected it and spread it on the farm.
Sara: Do you use all of the slurry that you get?
Laban: She is using all of it.
Sara: Is she using it for her farm?
Grace: Yes.
Jennie: And before you had the biogas plant, what kind of energy sources did you use?
Laban: Firewood.
Grace: Charcoal.
Jennie: Do you still use them?

Grace: Yeah.
Laban: This one is not efficient.
Jennie: Throughout the year, do you have enough water to supply the biogas plant?
Laban: The water is enough.
Jennie: What is the households' main source of income?
Laban: Farming.
Sara: What do you grow?
Grace: Everything; maize, potatoes, cabbages, carrots
Jennie: How was the biogas plant finance?
Laban: She is on the system, what can I call, through the Simgas company. She never paid direct in full amount, she is paying little amount out after every month.
Sara: Did she get a subsidy?
Laban: No.
Sara: Did she take any loans?
Laban: No, because what she is doing. The Simgas Company installed the system for her but she is paying every month.
Jennie: For how long will she do that?
Laban: 12 month.
Jennie: And if something breaks, who will pay for that? Like now it's broken, who will pay for the repairs?
Laban: It will depend on who has broken. The company had given them a guarantee of a period of one year. After one year it doesn't matter who breaks it, the farmer will face the costs.
Jennie: How many people live in this household?
Grace: Me, only me. One.
Jennie: So the gas is only for you?
Laban: Yes.
Jennie: Is the gas enough?
Grace: No.
Sara: Why did you invest in a biogas plant?
Laban: She was running out of other, like firewood and other sources of energy. She was experience some charges in using them. So to get biogas was an alternative of a source of energy.
Sara: What does she use the biogas for?
Laban: Cooking.
Sara: Has the biogas plant effeced your daily life?
Laban: No.
Jennie: Have you noticed any difference with your health?
Laban: No.
Daughter: In terms of health? Okay, for once it is healthy because it doesn't have smoke. But we can't say it has changed because we still use the other sources.
Sara: Have you been to school?
Grace: No.
Jennie: How often do you feed the digester?
Grace: Morning.
Daughter: Once a day, 4 buckets of dung and 4 of water.
Laban: They say she puts 8 buckets of the substrate which has already been mixed in a ration to 1 to 1.
Jennie: When you got the biogas plant, did you get any training about it and how it

works?
Daughter: Yeah.
Jennie: Only you or everyone?
Laban: Everyone who is a family member.
Sara: What kind of education?
Laban: She was trained on how to mix, how to use and how to use the slurry.
Jennie: Did you get any posters or a manual?
Daughter: No.
Sara: Since they installed the biogas plant, have they come back?
Daughter: Yeah, several times.
Jennie: For how many months have you had the problem with this?
Daughter: It worked well for 2 months, so 10 months of problem.
Sara: Do you use any chemicals?
Laban: Yes, they use it on the fields and also to clean where the cows are.
Jennie: So what do you think the problem is?
Daughter: Well the one for the company said it was leakages.
Observation: Många rostiga skruvar och muttrar samt ståltråd som var i anläggningen. Endast ett lager plast som satt ihop knytet på olika ställe.

Interview 15: Daniel Gichuhi

Date: April 4, 2014
Area: Nairobi, Kenya
Organization: KENDBIP, Renewable Energy for Forest Conservation and Enhanced Livelihoods (REFCE)
Interpreter: -

Present: Jennie Boérius – Student of Chalmers
Sara Helmrot – Student of Chalmers
Daniel Gichuhi – Administration Coordinator, REFCE

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Jennie: You're responsible for a project within KENDBIP, can you tell us a bit more about that?

Daniel: The program specifically covers the Kenbu area and by getting 300 biogas plants and also doing reforestation by getting 500 hectares and also agriculture and food security. We are trying to build the capacity of the farmers around the area so that we can be able to use the slurry they're getting from the biogas to have more food in their homes. At the moment we have 160 plants so we got 140 more to go.

Jennie: Is there a certain reason for choosing that area?

Daniel: Yes. We realised people cutting trees from the forest and that's a resource so creating the water tower is a resource, the rivers are becoming dryer and dryer. So it was more about conservation about you can give people alternatives and ideas so maybe you can save the forest. With that resource we can get more water in the rivers.

Sara: What kind of digesters do you use?

Daniel: We do fixed dome, especially the Kenbim model, but the sizes do vary. Most of our clients they have 8 m^3 but the others have six, some with ten and others with 12. But most of them have 8.

Sara: Are they all made in brick and stone or do you got any in plastic?

Daniel: All of the fixed domes are made of bricks and stones.

Jennie: For how many years ago did this program start?

Daniel: Two years ago and we're entering the third year.

Sara: How come some series are more common than others?

Daniel: It's because of the number of animals they do have. Most people don't have so many cows in the project area. So when they should pick a size usually I advise them not to go for the bigger sizes. Then the place is so cold so the production per plant is usually lower than in hot places, so it's not advisable to go for smaller sizes. So we discourage them to do the smaller sizes and also because of they don't have so many animals we discourage them to go for the bigger sizes. So the middle one is the ideal.

Jennie: Do the farmers get subsidies?

Daniel: Yes, but differently from how KENDBIP does theirs. Cause for them, they give them in cash. After a construction you get a check of 25000 KES. But for us, we buy the materials and we pay for the labour so they just come and construct the biogas at the farm. So we subsidies by giving them the major materials and paying for the professional labour.

Jennie: So the farmer don't pay for anything?

Daniel: They do, the main materials. First we'll give them the bricks, the stones,

sand, barlast, waterproof cement, the cement, the burner and we pay for the professional labour. For them now they pay the pipes and the reinforcement bars. Approximately 15000 KES that the farmer spend and we spend around 85000 KES.

Sara: What's the most common feedstock?

Daniel: So for all of them that we have constructed for are only using cow dung. As you realise you have a provision for anybody who might be interested in connecting their toilets to the digester. But so far nobody has had an interest, but we have an inlet for that so in case someone just want to. You can observe when you go to the field some of our biogas plant have two pipes. It is left there if someone's interested they can always connect bur again there's always the issue of perception. People think like ok if it is human waste definitely I can't eat food cooked by biogas from human waste. We've heard that a lot. I've come across a school where they did a very big biogas and the students rioted that there being cooked for from that biogas.

Jennie: Is the farmer getting some sort of education or training for the biogas plant, how to use it?

Daniel: Yes.

Jennie: How does that work?

Daniel: First the basic training, the most basic training is done by the masons themselves. Usually they tell them after the construction of the biogas they must train the farmers of how to use it, how to troubleshoot basic problems and all that and how to maintain it. Secondly, after the farmer has used the plant for quite some time usually organise them into groups and train them further on biogas use and also, mainly on bio slurry use. And then, now that that faze of training, ok we're planning to have now massive trainings and now those ones are intended for the …. We have all the manuals; manuals on maintenance, manuals on trouble shooting, manuals on bio slurry use so we'll be going door to door training them on all the issues.

Sara: Do you have any posters to give them?

Daniel: Yeah.

Sara: Is that the same that KENDBIP uses?

Daniel: Sometimes we get materials from them, sometimes we develop our own. Sometimes we use theirs, in addition to that we have our own materials.

Sara: And the posters, is it text or picture?

Daniel: Both text and picture.

Jennie: What kind of maintenance is important to make sure the biogas plant works properly?

Daniel: The basic repairmen for a biogas to work well is feeding, they should be able to feed it well. If they're able to feed it well, ok, the other issues are just minor issues. And then you know they're covered by a guarantee so all the … we can address. But when it comes to feeding that's were, ok all the biogas that we had issues with the main problem was feeding.

Jennie: That they were feeding it wrong?

Daniel: That they were feeding it wrong. Either they feed to thin or to hick, or without, or they feed dirty cow dung. They're not removing the grass and all that. So those are the main issues that we have.

Jennie: Is it important for the farmer to clean the inlet?

Daniel: Yes it is. Because when it's left with all dung on the side the dung will dry. So the next time he'll come to fill it, as now he puts the fresh dung, you'll find that even the dry dung will find its way into the digester. With time it

will form scamp at the dorm of the digester so at some point they may need to empty and remove the scamp.

Jennie: How often should they clean it?

Daniel: Usually I advise them to do it daily, after feeding. The dung is still wet and there's an overflow, usually an overflow pipe, so as soon as you feed the digester, ok just with some neutral cause the dung is still wet, it's very easy to clean and then you open the overflow pipe and the inlet is clean. So they should do it daily immediately after feeding.

Sara: KENDBIP have stopped with their subsidy and you're going in the opposite direction by adding more subsidy, why is that?

Daniel: The reason that we went in that direction is because initially, ok, the subsidy is meant to stimulate the sector so that people can put the digester on their own. But now the uptake of that area was very slow and now apart from now the objective of KENDBIP which is to stimulate the biogas sector as we had another objective to conserve the forest. So that's why we had to do something that will probably rush the uptake because as we wait for people to decide whether to take the biogas or not they're still cutting the forest and the water levels are still going down.

Sara: So the area that you focus on didn't get biogas as much as the other areas?

Daniel: Yeah the uptake was quite slow. People are still doing biogas but very slowly so we thought if we wait for them to do it, by the time they decide to do it the forest will be gone.

Sara: Why didn't they invest like the others did?

Daniel: Still biogas technology is still expensive even with a subsidy it's still expensive. So you'll find, even in other areas, it's possible. The KENDBIP have over 10000 plants but theirs distribution is also, they're spaucily distributed. It's really hard to go to one village and get 300 plants within a village, because definitely in villages all those people who can afford still put the biogas. Cause if a farmer has to go and contribute like 80000 KES that's still a lot. But now for that area we needed quicker action so that's why it was not possible to wait. The few who can put up the biogas. But that's why we had to go for a bigger subsidy.

Sara: If the digesters break, what's the most common part to break?

Daniel: The slabs that cover the expansion chamber. In the expansion chamber we have some concrete slabs covering the extension chamber, those ones break first. But now we are changing instead of having slabs now we cast the whole expansion chamber. So those are the ones that usually breaks first. The other thing, maybe piping. Piping is not that common so basically I would say most plants are trouble free.

Jennie: If it breaks, who will pay for that?

Daniel: During the first year they have the guarantee from KENDBIP but for our project we also do it. So long as the project is operational we take up all the cost and if there's any damage we'll take up the cost.

Sara: For how long time is that?

Daniel: It's for the project period, so one more year. After that they have to rely on their one year guarantee.

Sara: What's the lifespan of the plants?

Daniel: The engineers usually say it would be at least 30 years. But now you know, we haven't built for that long so I don't know it will …, so we'll see.

Jennie: Are there any government agencies involved in the financing?

Daniel: Ok first, like the funding for the project is from DANIDA but ROCDTF,

CDTF is Communited Development Trust fund, which is a government fund. That's the first level of involvement. Secondly yeah we work with people from the government ministries in the project so they advise and on sort of things, so that's their type of involvement at the project level.

Jennie: What does the payment for the farmer look like, does he just pay for the pipe and the materials that he's supposed to pay for and then he's done, or does he need to give you a certain amount of money for those things?

Daniel: They just pay the materials and then there's an … why we usually tell them to buy the material. It's because if you ask them in cash it means they have to ackulate the money to the 15000 KES, which is required. But if we give them a list of all the material they need to buy and that time they get 1000 KES they'll go and buy one thing. Then another time he gets another 1000 KES and he goes and buy something else. So that way it's cheaper, ok, they're able to tribute because they don't need the whole amount at a go.

Jennie: Are there any money going between the project and the farmer?

Daniel: No.

Jennie: Who was responsible for the establishment of this project?

Daniel: I was.

Interview 16: Peter Githuka

Date: April 3, 2014
Area: Kiambu, Kenya
Organization: Renewable Energy for Forest Conservation and Enhanced Livelihoods (REFCEL)
Interpreter: -

Present: Jennie Boérius – Student of Chalmers
Sara Helmrot – Student of Chalmers
Daniel Gichuhi – Administration Coordinator, REFCEL
Peter Githuka – Farmer

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Sara: What kind of digester do you use?
Peter: It's 8m³ and it is made of brick and stone.
Jennie: For how long have you used the biogas plant?
Peter: For the last 2 years.
Jennie: Have you experienced any technical problem?
Peter: No, nothing.
Sara: What type of feedstock do you use?
Peter: The dung from the cow. Only from the cow.
Jennie: Before you had the biogas plant, did you use the cow dung for anything?
Peter: Manure.
Sara: Do you use the slurry which is left from the digester?
Peter: Yes, for manure and farming. I use all of it.
Jennie: What energy sources did you use before you had the biogas plant?
Peter: Electricity and I still use it today.
Sara: What do you use the biogas for?
Peter: Cooking, only cooking.
Jennie: Does the biogas plant require more or less maintenance than the other energy sources?
Peter: Less.
Jennie: Throughout the year, do you have enough water to supply the biogas plant?
Peter: Yes.
Sara: What is the households' main source of income?
Peter: We do farming in graining.
Jennie: How was the biogas plant finance?
Peter: We were supported by the subsidized through NEDA with 85000KES.
Jennie: Did you take a loan as well to pay the rest?
Peter: No.
Sara: If something breaks on the digester, who will pay for that?
Peter: I can't tell. I have not reached there. We have no damages.
Jennie: But do you know who will pay id something breaks?
Peter: Yeah, KENDBIP.
Sara: Do you sell the biogas to your neighbours?
Peter: No.
Jennie: What was the main reason for you to invest in a biogas plant?
Peter: I wanted to eliminate in the operation and make the work easier for my wife when cooking and in the future we are planning to use it as a, to light the lamps. Yeah, that's in the future.

Sara: Did you use firewood before?
Peter: Yes, firewood and charcoal.
Sara: Do you still use it?
Peter: Not that much.
Jennie: How has the biogas affected you daily life?
Peter: Somehow it has changed. But it's not completed. There is a fair different change, that is cooking.
Sara: What level of education do you have?
Peter: Form four.
Jennie: For how many hours a day can you use the biogas?
Peter: 5-6 hours.
Jennie: Is that enough for the household?
Peter: It's enough.
Jennie: How many people are living here?
Peter: Me, my wife and the children. So 5.
Sara: Before you used the biogas, was the cow dung a problem for you?
Peter: I used everything for the farms.
Jennie: How many cows do you have?
Peter: 6.
Jennie: Is anything done to the cow dung before you put it into the digester?
Peter: No. Just only mix it with water.
Jennie: How often do you feed the digester?
Peter: We feed it after 3 days, and we feed it around 30-50kg of cow dung.
Sara: How many buckets is that?
Peter: 2-3 buckets.

Interview 17: Moses Ngugi Gichuhi

Date: April 3, 2014
Area: Kiambu, Kenya
Organization: Renewable Energy for Forest Conservation and Enhanced Livelihoods (REFCEL)
Interpreter: -

Present: Jennie Boérius – Student of Chalmers
Sara Helmrot – Student of Chalmers
Daniel Gichuhi – Administration Coordinator, REFCEL
Moses Ngugi Gichuhi – Farmer
Peter Githuka – Farmer

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Jennie: What kind of digester do you have?
Moses: It is made of bricks, I've been using it for 2 months, I think it is 8m³.
Jennie: How many hours a day do you have gas?
Moses: I don't have a measurement. I use it every day. And it is enough. Maybe I would say 5-7 hours maybe.
Sara: Have you experienced any technical problem with the biogas plant?
Moses: No.
Jennie: What are the main types of feedstock that you use?
Moses: I use only cow dung.
Jennie: Before you used the biogas plant, which energy sources did you use?
Moses: Lights now. Before I used charcoal, firewood.
Sara: And the cow dung, before you used it for the biogas plant, did you use it for something else?
Moses: I use for manure, to take it to the garden. I use it like manure. I used everything.
Sara: The slurry, which you get from the digester, what do you use that for?
Moses: I use it for manure.
Sara: Do you get enough of it?
Moses: You use it all of it.
Jennie: What is the households' main source of income?
Moses: I sell milk, I plant my foods I sell it. I'm a businessman.
Jennie: How did you finance the biogas plant?
Moses: I didn't pay. I got subsidy, 85000KES.
Jennie: Did you take a loan as well?
Moses: No.
Jennie: If something breaks, who will pay for that?
Moses: I don't know.
Sara: Do you sell the biogas to your neighbours?
Moses: No, I use alone.
Jennie: What's the main reason for you to get a biogas plant?
Moses: I decided to take biogas because there is a problem to get firewood. It make work easy. It saves time.
Jennie: What is the biogas used for?
Moses: No according to my knowledge you can use it in another way like in lamp like lights. For these time I only have it for cooking.
Sara: How has the biogas plant affected your daily life?

Moses: No difference.
Sara: Do you see a difference before you used the biogas and after?
Moses: Yeah, so many differences. When I'm in a hurry I just come and use it and then I go back to work. I cook faster.
Sara: What level of education do you have?
Moses: Form four.
Jennie: Do you still use other energy sources?
Moses: No, not at this moment. Only biogas and electricity.
Sara: How many cows do you have?
Moses: 2.
Jennie: How many people live in this house hold?
Moses: 4 people.
Sara: How often and how much do you feed the biogas plant?
Moses: Between 2-3 days, 1 bucket.

Interview 18: Simon Gitura Mwangi

Date: April 3, 2014
Area: Kiambu, Kenya
Organization: Renewable Energy for Forest Conservation and Enhanced Livelihoods (REFCEL)
Interpreter: Henry

Present: Jennie Boérius – Student of Chalmers
Sara Helmrot – Student of Chalmers
Daniel Gichuhi – Administration Coordinator, REFCEL
Moses Ngugi Gichuhi – Farmer
Peter Githuka – Farmer
Simon Gitura Mwangi – Farmer
Henry – Responsible for the finances, REFCEL

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Jennie: What kind of digester do you have?
Henry: Kenbim-model, 8m³. I think it's called Fixed Dome.
Jennie: What is it made of?
Henry: It is made of cement, stones.
Sara: How long has the biogas plant been used?
Henry: I think 1.5 years.
Jennie: Has he experienced any technical problems with the biogas plant?
Henry: There were problems, but not technical. Feeding problems, but no technical.
Jennie: What was the problem with the feeding?
Henry: Well the ones had no gas coming, but after some time it came. That was the issue.
Sara: What type of feedstock is used?
Henry: Cow waste.
Jennie: And is that the only feedstock?
Henry: Yes.
Jennie: Before the installation of the biogas plant, what did he use the cow dung for?
Henry: Well initially for the farm, but then it was a dry material. But now he uses the slurry for farming and then everything is growing well, he uses all of it.
Sara: Before the biogas, did he use all of the cow dung?
Henry: No, much of it was drying up. But now the system us effective so he collect all of it and put it in the digester.
Jennie: How often and how much is he feeding the digester?
Henry: Every morning with 2 buckets.
Sara: Before the biogas was used, what kind of energy source did he use?
Henry: He used charcoal and firewood.
Jennie: Throughout the year, is the water supply enough?
Henry: Yeah I can say, because we have --- we have good water supply.
Sara: What is the main source of income for the household?
Henry: Farming and diary farming.
Jennie: How was the biogas plant financed?
Henry: We had a founding from CDTF (Community Development Trust Fund) so we give the farmers the material for about 85000KES but the farmers contributes with pipe materials. The whole construction was a found from

CDTF.

Jennie: If something breaks, who will pay for that?

Henry: KENDBIP has put some money away so they will pay it to the farmers.

Jennie: Is he able to sell the biogas?

Henry: No, it's just for this household, the size is not so much so it can only measure to this house.

Sara: Why did he want a biogas plant?

Henry: To reduce the use of firewood, save money and efficiently. The slurry is also good for the manure. He doesn't waste so much time.

Jennie: What is the biogas used for?

Henry: For energy.

Jennie: What kind of energy?

Henry: Cooking and lightning.

Jennie: So both of them?

Henry: Yeah.

Sara: How many lamps does he have?

Henry: Currently he does not have one that works, but he used to have one.

Jennie: Has he noticed anything different since he got the biogas plant?

Henry: His life has been made better.

Sara: What level of education does he have?

Henry: Umm, non.

Jennie: Did he go to school? Form four?

Henry: No.

Jennie: How many people are living in this household?

Henry: 3.

Jennie: For how many hours a day does the biogas last?

Henry: 2 hours in 3 times, so 6 hours. Breakfast, lunch and dinner.

Jennie: Is the gas enough for the household?

Henry: It's enough.

Sara: Do they still use other energy sources?

Henry: No.

Jennie: How many cows does he have?

Henry: 2.

Interview 19: Graham Benton

Date: April 1, 2014
Area: Githunguri, Kenya
Organization: Takamoto
Interpreter: -

Present: Jennie Boérius – Student of Chalmers
Sara Helmrot – Student of Chalmers
Graham Benton – Director of Market Development

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Jennie: Is there a certain reason for choosing these areas to establish the biogas plants?

Graham: Yes. Do you mean this region of the country or this specific where I put the biogas digester?

Jennie: This region of the country and why Kenya?

Graham: Okay, well Kenya was initially chosen not by me, but it was chosen because of its urban development so it has good infrastructures, it has good roads, it has good power grids referred to its neighbouring countries. So essentially that and also it got a very good atmosphere for entrepreneurship. It got a lot of social enterprises that starting here, it's got a lot of energy I the community to support that, a lot of things around.

The reason I chose, I was the one who chose the region of the country. It was for a couple of reasons. One is the density of farmers and also the amount of cows the people have here. And the amount of people who are running dairy farms. So it's very high density, this is actually one of the biggest farmers we have and you know we can't see neighbours. There is neighbours just around so you get a sense for how close there can actually be. Many people have a quarter of an acre and own 3-4 cows on that quarter of an acre so it's very denst. There is a lot of good infrastructure around, there is a good road access there is a lot of derive infrastructure, crops and things. Therefore it's organized but there is a lot of easy access. But if I want to I could go to a medium of 400 diary farmers and preset my information where as in other parts of the country that would never, I would have to organize that meeting and it would be very hard to bring people together.

So that together with the fact that people like KENAFF or KENDBIP whoever be for and a lot of other NGO's have come here before and done education about biogas, it's a huge amount. Of the probably 200 farmers I've talked to in the last year, maybe one or two have been like "Hey, what's biogas?!" Most of them know what it is, then again majority have cooked on it or seen it being cooked on and then very few, very few who have never seen it or eating out of or whatever so yeah so those factors are probably the leading class of why we chose this central area.

Sara: What kind of digesters do you use?

Graham: We stared out using the Floating Drum, that you can see behind us, this black one sort of thing. We are going to check it out. We use it because it's, well centrally for a couple of reasons. One was that it's very durable, it's very simple so it's very little that can break whenever on it, and the organization that manufactures the container was very willing to work with

us, so they sent their engineers to our house and we worked on the design together and then we, they gave us two of them, we tested them and we went from there. We have moved away from them for a couple of reasons. One is because they are fairly small it's a 3m³ with about 2m³ gas storage so it's really not too big. And most of our farmers are finding that they need a lot more gas capacity then that. Which is above what we expected, which is good. They are also very expensive, they are about almost 70000KES per unit. So of those factors it came into that we wanted to find an alternative. Because even if we can get that cost down to half our business variable goes way up. As our business.

Jennie: How many biogas plant do you have?

Graham: We have 107 installed right now. Of those 107 106 of them re working. Of these Floating Drum style we have another type which is manufactured by a company called SimGas, have you ever talked to them? You should goggle them, they are very easy and they have a big website, yeah you can look them up, SimGas. And then we are trying this new one from Q-energy. But yeah, in fact even, we used to do the mason-ones, the big stone like KENAFF does, but those are very expensive as you probably know. That's their main problem, per m³, they are very expensive. And also when you fail, you fail totally, there is no in-between. So if they develop a crack on top, you have to replace the digester essentially. And then it costs another 100000KES. And the farmers, very few farmers, can afford that. Anybody who can afford 100000KES is in top of the economic pyramid or upper-middle. So the goal of Takamoto is to bring digesters to the lower and make it accessible for everybody. And so to have 107 digesters installed in an are with radius of 10km is fairly good, and no other company has been able to do that. Talking to other companies they are saying "We installed 60 this year". In four month I installed over a hundred so yeah, it's pretty good.

Sara: So the farmers that chose biogas, how much do they earn?

Graham: It's a range, and it I hard to tell because a lot of them have, they don't have accenting practises. Everything is cash in hand, for instance José would cut bananas, take them to the market and sell them and get cash for that. And then there is no way to really know. As soon as you sell.

Sara. Because we told you KENAFF, and they said that they don't reach their goad=

Graham: The bottom? Yeah so our farmers will earn as little as 15000KES/month. So 15000KES. I've farmers who are not our target of market, who could easily afford a big system but they are just interested in ours because it is innovative, it's new, it's the thing to have and so they are just curious and so. These guys could probably afford a masonry digester but they want to be able to have something new, be the first in the area, so they (pointing at the farmer) were actually the first in this area. So yeah it's actually interesting.

Jennie: And regarding the different kind of digesters in the plants, what lifespan do they have?

Graham: Well the manufactures says 15-20 years, before critical failure. We have noticed that different kinds fail for different reasons, the SimGas-model, we had almost 50% fail rate after 6 months so it would just develop a crack and then it's done. We had to replace a peace of elder, give it or do something to it. We never had anything else fail because of natural like old age of course, but yeah manufactures say 15-20 years.

Jennie: Is there a certain part that usually breaks first or is it just a crack?

Graham: Of the whole system, front to back: digesters, stove, the peace that I would say fail the most would be the piping first, and then the stove and then the digester. Digesters are fairly robust. The only thing is you know old age gonna kill them, sunlight is going to decade them or just get worn out, stress plastic or whatever. The piping can fail because they users are very abusive, it's kind of hard to say that but they handle the things very hard and they don't, there is no word in Swahili for maintenance so people don't maintain their things because it is just not involved in their culture.

Sara: How ling do the stoves last?

Graham: We have yet to have any fail for just normal wearing tear and we've had stoves on the ground for three years. We replace bummers when somebody pour something into the stove or something, breaks a nub or whatever. So those sort of things happens now and then, but it is not to common. I would say, yea I guess we never had a stove fail because of normal variance but they are also, everything is very young, everything is under three years so.

Jennie: How long does the digestion take?

Graham: It is always happening, things are always being decaled by bacteria. There is three stages in the digestion process when you put cow dung into a digester. There is an aerobic and an anaerobic. But then there are three types of bacteria that grow to make the biogas. The first is the aerobic bacteria die off and stop giving of their acids because their bi-products of digesting are acid. Another bacteria takes root. And that bacteria makes sugar, glycols, type of thing as their bi-product. The third type of bacteria, a pathogenic bacteria, will start to, their population will start to come up and those guys give of biogas. That whole process starts to happen immediately upon putting things into the digester. The aerobic bacteria, the first type, that give out the acid, dies as soon there is no air. They need oxygen to survive. So it is very easy to kill those guys off. The second type are necessarily fort he pathogenic bacteria to start. I've had digesters start on fresh cow dung within a day and I've had digesters start three weeks later. So, it really depends a lot on different factors one is quality of what you putting in. If it is just cow dung, like this one right here, it is fairly dry cow dung, we've got a whole bunch of kick-starts because we are gonna empty the old digester and put it in the new one so it's gonna, it should start almost immediately, immediate it should kick-off! Yeah but it doesn't take long. We estimate between 3-5 days, so you put it in and then after 3 days we should see some gas, no matter how little. Even the same day it's gonna start given out gas, but it is just not ---, it's not gonna be flammable, it is going to be carbon dioxide. Which is bi-product if that second bacteria, that gives of the glycols it also gives of carbon dioxide. So it is just non-flammable gas. If you had a digester that's full of gas that is non-flammable it's because that 3ed bacteria is not there. So you have to introduce it.

Jennie: What is the most common feedstock?

Graham: Be sure of cow dung. That's the only thing all of our farmers use, but again I chose this area because of it's diary farming. It's so reliable for that. Cow ding is actually required because it got that pathogenic bacteria. Pigs don't have it, chicken don't have it, which are the other two feedstock. The third bacteria, pathogenic bacteria, come naturally in the cow digester track so it comes out through its dung. It's suggested every digester stated with cow dung although you can by the culture, you can buy that liquid that is that bacteria and then you can pour it into the digester and certainly kick-start it.

But that is fairly expensive, because you have to get it somewhere else. Most of the time we will just say well alright we will put in a ton of cow dung and then add whatever feedstock you can. Like I said there is cow, that is most common for us, it's the only one. Pig is also a big one, pig dung is actually better than cow dung per kg. One kg cow dung will produce about 75% of what a kg of pig dung will produce. And then again a kg of chicken dung is better than pig. It even produces more, the problem with chicken dung is that it comes out of these little pellets and they dries up very quickly, so you have to soak it for a while and then a wider of chicken farmers will put down soy dust which is bad for the digester, because it is just dead fibers it is not of any use. So then you have to have some sort of clean collection system for the chicken waste, so it is a little tricky but it can be done, it can be done for sure.

Jennie: Are the cow dung an environmental issue?

Graham: It is not very known or well cared about here. But there are a couple of NGO:s that are working, that I've met, that are working to trying to get rid of Kenyans cows because a cow produces a lot of greenhouse gases, methane is a greenhouse gas and It goes up and it raises greenhouse effect. A cow will have cow dung and fart and it will do all these things and make a lot of maternities life. So they are trying to promote biogas because it's a way of collection that and then burning it which breaks it of and it goes apart. And then it doesn't become a greenhouse gas. But farmers don't really care about it. Nobody really cares.

Sara: But do they use all of the cow dung that they have before?

Graham: Yeah. This guy (Francis) will. He has four acres of land, which is a lot. He will take it and put it on his bananas, on his nil-grass just for feed for the, or his little farmyard which is corn, potatoes, or whatever he grows. So yeah he uses it as recourse out the farm. It is unrealized as a resource. A lot of times it's just dried and actually, that get rid of a lot of nutrients. So far as I understand, I'm not great soil-scientists so I'm not 100% sure, but for one thing that gets utilized is enzymes and a lot of living things that are in it which is good for soil and to compost. So it's sort of underutilized in that scene. It could be utilized much better. But that's part of the digesters that they will process it. They will kill all the seeds of the fungus all the everything, they'll burn it. And then as the flung that comes out can be spread or mixed into the soil, as you can see a bunch staff around.

Jennie: Do you know if anything is done to the feedstock to gain the best biogas?

Graham: It's mostly just as it is. The way it's added into the digester it's mixed with water in a 50/50 ratio. So if you take the cow dung you just pit it in a bucket with equal parts of cow dung and water and then you just mix it up and we mix it much more liquored into the consistence of a yoghurt, a light yoghurt and then it's poured into the digester. And that's the only reason that's happens is so that it can flow through the system of the digester. These digesters has forcer pipes, as a bottle-neck. And corners and stuff on the inside so if it's to thick or viscous it gonna push like a plug through. It is not actually going to get all of the stuff through. It is not actually going to get all of the stuff through. As it does when it is watery.

Jennie: Is the demand of feedstock larger than the supply?

Graham: No. So one criteria we have when we install the digester is that the farmer has at least 2 cows. And 2 cows will produce about 40kg of dung in a day. Some big cows, one will produce that. So 40kg isn't too much to ask. It's 2

buckets. Most people can get that from one cow but we say 2 cows for a couple of reasons. So if you have one cow we won't install for you. In that way we sort of have a safe card.

Jennie: What kind of maintenance is important to make sure the biogas plant works properly?

Graham: On the farmers side there is not a lot. It is really just add, that they keep adding the cow dung and water mixture on a daily bases. Some farmers will add it daily, some farmers will add it two-daily even tri-daily, like every three days. But it always has to equal the same ratio. So if you add it everyday it's 40kg of dung. If you add it every 2 day its 80kg of dung, if you add it every 3 day its 120kg of dung. So that's for farmers.

For us we, since we have a meter on the system. We will regulate, we can monitor pressure and production. And we will come on monthly bases, at least, to check so there is no leakages and to make sure there is no plugs in the pipes, or anything like that. I've installed digesters and completely forgotten about them for 6 months and then I just say "Oh crap we forgot about this one", so ten we will go back and visit and then everything is working fine. So of you built a system in such a way, so it is self-maintaining is that the pipes were sloped so no water can get trapped in it. And we just build a robust system, that really takes little maintenance.

Sara: But you come back every month?

Graham: Yeah just to check the system. So it will take five minutes for someone like Tedline to come and just look at the system and see how it is doing. See that everything is okay. He just checks the meter, checks the pipes and turns the stove on, lights it and see how it looks. And then just notes anything that is unusual ware tare. Nubs and stoves are often broken. Not that they don't work, it's just that they automatically sticker doesn't work. Because they don't push and turn it. They don't use it properly. So those things is sort of going fairly very easily. So it won't take them very long to maintain. Then he either fixes it himself if he can on site. Which is most things he can repair, he just goes with a whole toolset and repair-kits. If he needs a truck like if he needs to add a lot of kick-start because the digester is not working for example or if there is any PPR-welding pipes well in any pipes he doesn't carry that machine a lot of times although I've got him one from China so he should be able to do it. So if anything he makes a little repair-ordering to the operations team. And the operations team goes and takes the tool machines, the trucks or whatever is necessarily to fix it and that usually take 3 days.

Sara: So you have a solid team that builds all the digesters?

Graham: Yeah, this is it! We have two technicians: David and Monguru who do the installation and these are all helpers: Alager, Simon, John, George and the Paul is usually in the office. He is our RND, so he does all the discovery of problems so that's our system right now.

Jennie: Which technical problems are common?

Graham: I think with, in system in general, it wouldn't really be cracks. The most common, crack happens because that specific digester design series was bad. So there is something they've replacing and trying to fix it. The most common problem that happens in biogas in Kenya is, as far as I can tell or as far as my knowledge goes is piping. People don't take the time with it to do it well. One most coming problem would be that the gas is moister when it comes out, it is very humid. As you can imagine and so it comes into the

pipe and then condenses in the cold pipe, that's in the ground. And then the water drips down and settles in the low parts of the pipes so if the pipes got a local minimum it's gonna make a little pool in all those tracts in the pipe. And then overtime it's gonna fill these tracts up. And then the gas is just not going to get to the home or it's gonna go "wo-wo-woo-woooo", it's gonna pause. That is probably the most common problem and clients, before we were just not recognizing this as a problem. Because it happens very slowly so a lot of times I'll go to a client's house and it will be really badly pausing and it will just take three seconds and I will just open the water trunk and all the water comes out and I close it and it's fine. Before when it was doing the biogas system, a lot of clients would call me to their houses' and say "It doesn't work, can you come in?" Because we used to do sort of repairs and come out and it would cost like 1000KES, we do our repair or whatever. And a lot of times there is just water in the pipe. You just blow it through or whatever , trying to get he water out, and then it's fine again.

Either that, that is probably the most common problem, water condensing in the pipes, causing blockers. The other problem is probably people hitting the pipes, either digging or whatever they re doing. They will hit the pipe with the shovel and it will crack and then, the guy/farmhand who is doing the digging doesn't want to tell the farmer so he covers that up. That happened with one of our clients. That was actually a fairly common repair that we will have to do when we are out and about doing repairs. Being paid to do that so.

Jennie: Do the rain season affect the biogas plant?

Graham: For the one above ground it does a little because it cools the digesters and temperature is a big factor in the production of the bacteria so it will go down by anywhere from 5-20% of the production depending on the type of digester, how protected it is in the rain/sun and all those things. So it does effect.

Sara: How were the biogas plant finances?

Graham: The way we do it is we buy the digesters. As a company we will buy a digester and then install it by the clients' house, then the client buys the biogas that the digester produce. And use it as a utility. So it is different than most biogas companies, where the client buys the system.

Right now it's just through the company. We have grants for personal loans, personal money and all these things. We'll help buy these digesters. Things like CSR, from other companies, they wanted to take all their money and then do something good for the people of Africa. So they well sponsored biogas digesters, we put their log on it and a sticker or whatever and install it and take pictures and tell a story or something like that. So yeah, mostly it's the company who buys it ad then installs it for the client. The client pays a small upfront cost of about 10% of the cost of the digester or 10000KES, and then just uses the gas on daily bases to pay it back. Right now our system have about a three year pay-back period, and we need to get that down, Because if it's to high then we can't loan from banks, we can't go to those big funders.

Sara: So that's why you come back and check if they are alright?

Graham: Yeah, so part of the contract with the client is that they don't own the digester, we own it. And we need it to work to make money. So of it's not working we are not making our money.

Jennie: So the clients are just paying for the gas and the 10% of the digester?

Graham: Yes. Then if it all stops working, we need to come and fix it. So we trying to do that if a client call, we are tying to be there within that day if they call before noon or the next day by noon. So within 24 hours we're there.

Jennie: How much do they pay for the gas?

Graham: It's 55KES/m^3. Which is a m^3 will cook on one burner for about 2 hours. So if they were spending, if a client is using $1m^3$/day, it's what we want, that's perfect.

Sara: And it's that cost less then like firewood or charcoal?

Graham: Eym yes. So when we did our initial business-plan , business-model, we did all these tests with charcoal, firewood, LPG, kerosene and biogas. We cooked the same meal, actually David was in the office and he cooked the same meal like 20 times on all these different fuels. And we saw how much we spent on charcoal, how much charcoal we burned or wood or whatever and what that ended up costing us cooking in the end. And so, LPG is more expensive but more efficient than biogas. Biogas is less efficient but much cheaper that LPG. It is much more efficient and cheaper than charcoal and firewood. Kerosene is like a whole other, it's so expensive. So don't even consider it. It's not even a competitor. Nobody is using it as a primary source of cooking, because it is so expensive.

It should be cleaner, easier to use, more efficient and more cost effective. Because if it is more efficient, even it it's the same price as charcoal or firewood it's gonna be cheaper because it's , you use less of it to do the same. And it is more efficient and it is cheaper. So you can't really, it's much more economical adaptable. But at the same time we are still facing the fact that clients aren't using all their biogas. We'll have three biogas for them because it won't be metered yet. And they still won't use it. It is a culture thing, they don't actually use all the biogas, they still wanna cook on the firewood, they still wanna cook on charcoal they still wanna cook on these traditional fuels, we don't know why. It's just a traditional thing, culture, habit. Things like that. So it's just a little tricky.

Jennie: Does it cost anything to maintain the biogas plant?

Graham: It does for us but not for the client. Right now our cost of maintenance system is about 1000KES7month/system. So a 100000KES/month. That needs to come down tremendously. We want it to get to about 300KES/month/system. Right now it's so high simply because the meter-technology is not up to snuff. So a lot of the meters, although it's getting much better, even as we speak they are working on it. So even in the last month we've made tremendous progress and reduces our costs there, but the problems gonna occur when a client pays ad the meters falling of network. And then the payment doesn't go through, the meter doesn't get it so then we have to come there and physically switch meter on and off to get it to come back. So now they automatically get back on the network and things like that so our cost has come down tremendously. So our goal is to get it to about 300KES/month/system. And that would be fine and that is literally just coming and then every five system spending a couple 100KES to replace that piece or something. We expect to have to do this a little while for repairs.

Sara: But, you grow all the time and is the economical factor the reason for not growing anymore?

Graham: Of repairs?

Sara: Yes.

Graham: No, because of id we can get it down to 300KES even that 1000KES that was before we started renovating the piping system and stuff. If we can get it to 300KES then the amount of what we should be making is about 2000KES from every client, so we can still make a pretty god profit of each digester. If we can make $20 USD out of each digester each month then we hit our target for pay-back period for each digester.

Sara: And how long is that?

Graham: We are trying to get it all under 3 years. Right now it's a little bit higher. It's around 4 years. That is simply because these repair-costs are high, digester coast are fairly high. But all that is gonna come down with scale. If we had enough money to order a thousands meters, that cost per meter would get halved, from $100USD to 50. But to order a thousand it's 50000USD so it's like whaaaaat., that's expensive so. We can't really do that right now. Digesters, we are trying this new types they are much more costive effective so and much simpler. Like this Floating Drum, it's 600-700 USD and this one (pointing at the one in plastic) it's 300USD. So if we can get the cost, that we can make that cost work for us then we are fine. We are fine so. But yeah I mean as the more digesters we have in the ground the less that thin margin actually matter to make it a viable business. If we have a 100 digesters it's 2000USD/month, if we have 10000 digesters and make 20 USD out of each digester we will make much more money. Actually the more digesters we have in the ground, the more viable we become.

Jennie: Are there any government agencies involved in any way in the establishment?

Graham: There is couple, there is KENAFF which you've talked to they are actually runned with a governmental organization so they kind of have government oversight so there is a lot of connection there. But the other ones probably KEBS, KEBS is Kenya Bureau of Standards but they have, they do standards on different pieces. So if you can get a KEBS certified digester, then you can get/ should be able to get tax-remission or get waved on a lot of the taxes. So we are working with them to get these digesters inspected by them. Also then it goes into certain taxes and stuff if they can carry away taxes on biogas related products for instance any stove that comes into the counting from chine will double in costs due to taxes, just taxes. So if we can do that then we can offer the same products to half the price, a little bit less because of transport. Probably those three organisations are the largest and most involved: KENAFF, KEBS and I don't know what branch or who is really rate. It could be actually KEBS, I'm not sure I don't deal with it. It is mostly Kyle and the other people in the office.

Jennie: Who was responsible for the establishment of Takamoto Biogas?

Graham: Kyle was the founder. He founded it in March 2011. Kyle Schutter. He was already here doing it by himself until October when me and Laura, his sister Laura Schutter, came over and stared to help him out. And then from there we hired Paul and all these other people.

Jennie: Does he have the current responsibility?

Graham: M.D. He is the Manager Director. Yes I guess he sort of is filling the shoes of Technical Director as well just because although we are hiring out for those positions somebody demonstrate, you know technology side of the company, so we can see how we can do with that like with applications and hire people now.

Sara: And what is your position?

Graham: I'm the Director of Market Development. My bill job is to go and find new markets and develop them for biogas for Takamoto. In our business model and sort of work with anybody who can help do that sales and sort of start up different regions. So going to, you know when we go to Uganda I'll go to Uganda and work with other companies or whoever I need to establish ourselves there and then once it's up and running I would get it to a point higher to the people I need to run it to get them to run it and then I move to the next place. So I'll be in every location. Maybe a year or so, two years get it going and then you move to the next place. That also means that like I would be in charge of moving around in the country so when we start to move out of Githunguri, I would go into new regions and start of talk to them and see what their opinions on biog are. Because there are a lot of different cultures, a lot of different tribes in Kenya. There is a lot of different temperature, landscapes so all these factors needs to be considered. Cell-phone coverage is huge. If there is no cell-phone coverage we can't operate because we have a meter that operates on cell-phone in our network. So that's really my job. What I am currently is that-ish but we are not really developing in any new areas now. I'm running all the operations so that is from managing to sells team, managing client selection and sell-process to installation projects. Tedline, who you met is the customer service. So I work with him to make sure all the problems that clients are having or met and that we have an erecter response time to that. So we solve these ones. So all that plus some business development stuff. I am working in Nairobi with the call to developing different things. So it is fairly multiday-tasks. That's the nature of a start-up.

Jennie: During your time here at Takamoto Biogas, what has been the main challenges for the company?

Graham: For the company I think I probably just say technology, unusually. It's something new, nobody has ever done it before in the world. Sort of metering gas has never been done as far as we can tell, we tried with research but we haven't found anybody yet. Trying to work with people who are able to do that is very tricky and getting it done in Kenya is actually fairly difficult. Because a lot of the skulls that are needed are fairly rare here. Kenyan like people to develop GS connection to GSM and certain boards and all these things. It is actually not very easy. I would say that.

The other major problem that we have is plant selection, at this point I would say. Like I say most of our clients are spending below what we want then to spend, by a couple of thousands of KES. So if we can get our clients selection and out post sales selling type of thing, post sale sales up and consumption, where if people can just use more biogas then we would be on. Of we can prove that and we can get the technology working there is no limit of what we can do. Where we can go and what we can do. We can franchise and then be around the world a year.

Sara: When you measure the gas do you need to have electricity?

Graham: Yes, so we have a little solar panel, running into a battery it's a charging battery and the meter pulls of the battery so it's a stain alone power generation system. Right now it's using a way more power than it needs to, it should use less that a cell-phone, which need a very small solar panel to run and very small battery. But right now we it's using like five times that, just because there is fascinating efficiently with in the technology. The cermets boards, half of them are hand made and then glued together and

then little holes throes in them. So you can imagine how in-efficient that is. Again when we go to scale with it we can order a thousands units that inefficiently can come way down. We've developed with the communicative burke alarm, we've developed a meter that uses a fraction of the energy, it's way more efficient it has a much higher up time which means it's own the network. It find's that work much easier it stays in the network much easier it's much more efficient. It's all together with the circlet board, the GSM need marginal, it's all fixed on one circlet board, which is ideal. As soon as that happens it's very easy to go.

Sara: How come you did this thing when you sell the gas instead of doing as KENAFF who sells the whole digester?

Graham: If you talk to KENAFF the biggest problem is cost. When I started out we did the stone-mason- system like I said. I survey I probably 500 people just through, talking to them on the phone, talking to them face to face, getting their phone number . We talked to about 500 people and we asked them if ---. Because we having about 1 % or 2% rage. So out of 100 people you get 1 or 2 people who will buy. We asked them why are you not buying and everyone of them is saying it is too expensive. So it is risky. So we wanted to bring down the economical payment and increasing of the access. If you can do that you will have a much more bigger market. Also you are helping the much more in-need group of people. The people who were buying it before had never seen a hard day. Living in these houses, very wealthy, work for the UN whoever can afford whatever they want really. They don't need the biogas. It is not like it's gonna make a big difference in their life. Where if we can bring biogas to people who have to carry firewood for 4 hours a day and spend half of a day or an entire day a week harvesting firewood. And then carry it 20km on their back, it's gonna make a pretty big difference if they haven't need to do that on their weekly bases.

Jennie: How do you promote this biogas company?

Graham: It's all word to moth. We did one marketing event we had over 300 people come to it and there were 300 people come through and sign a little thing saying "I was here" and taking all your information. After that there is no need to spend any more money on marketing. It's just one client tells another client they say/call the office or the shop pr whatever. We have 2 sells representatives right now who go around and talk to clients and work with them and a more face to face bases. So if a client is interested the sells rep can go there and talk to them. When they pay for the biogas I'll go there and inspect their sight and also that stuff. So they'll do promotion, but it's you know they have very few material it's all word to mouth.

Sara: Do you have any instructions for the farmers who use the biogas? How you should maintain and how you should..

Graham: Yeah when we install a system David will actually spend usually about an hour with the client, well 30 minutes to an hour, answering all their questions. Just going through the whole system pointing out what different pieces are and then talking to them about what different rations of the cow dung/water they should do, how they should do, how they should fill it and mix it and really what it should work. Even how they fill is important but how it should work because if they can identify problems as it states to happen before it actually becomes a big problem it saves a lot of time and money. If they find out where when the gas stops working then it won't be ---. So we do quite a bit of training and then even the sells guys, when the

gas comes, the sells guys spend another hour or so with the client cooking with them, showing them how to use it efficiently and trying to reduce their costs so they increase their uses. We just need to show them that you can cook anything on biogas, because people won't believe it. They are like "No this has to be cooked on charcoal because it's how my mother did it". Okay but you can still do it on biogas to half the price and third the time and you don't stand over a stone fire to do it. So we do a lot of that stuff to.

Jennie: And the team, do they get training or education?

Graham: Yeah we trained them all, they have very different backgrounds, high school or not high school educated. But we put them all through 3 months probation so they have a 3 month training time after they are hired and after 3 months if we think they can either do the job that's fine, if the can't we usually start looking for a new person. So far that's only happened twice. And we say sorry. But it's usually the person saying this isn't a good fit for me, it's too instable or they don't like working in the field or whatever. So yeah, it's not usually a problem.

Sara: So much of your time you spend in the filed? Like the whole company?

Graham: I would say 2/3's of the company by volume is in the field most of the time, so I have these two guy, myself, shaft keepers, the sells reps, Tedline, they are all in the field, almost all of the time. As in the field I mean easterly in Kiambu. We have an apartment here so these guys stay in the apartment and that's fine. The other half, Paul is usually in the office, Laura does communications in the office, Kyle us usually in the office the meter guys who are working on the meters are usually in the office, we have a woman called Jane who assists us who is an office assistance and works in the office. So yeah about 2/3 of the company is field based.

Jennie: And this team is the one who constructs all the biogas plants?

Graham: Yes. All the basic. Well actually that's note quite true. Mombugo was joining us for probably 80 or 90 digesters. And same with David. O the installations team used to be me, Paul, Kyle, Tedline and we use to do installation. And then one other guy. We did that to learn a lot because I can't tell these guys what to do until I know how I feel as a manager. For that we du 5 or 6 digesters and then we started, I hired David ad then we sold another 10 maybe and then Mambogo and Bordo started to go in an earnest. And so Mambogo manages this team of guys and then I just sort of facility that and make decisions and stuff. So yeah they have been with us most of the time.

Interview 20: George Waithaka

Date: April 1, 2014
Area: Githunguri, Kenya
Organization: Takamoto
Interpreter: -

Present: Jennie Boérius – Student of Chalmers
Sara Helmrot – Student of Chalmers
George Waithaka – Mason, Takamoto

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Sara: Regarding the different kind of digesters, what lifespan do they have?
George: It depends. The ones we have the cantinas (floating drum, plastic) they can stay to 10 to 15 years, yeah something like that.
Sara: And the new one, the Simgas?
George: Sandra (from the company that's selling Simgas) was saying, she hopes that maybe it goes to 20 years. But I'm not quite sure about this one cause it's a new one and it's the first one in fact.
Jennie: With the pants you have, is there usually a part that breaks first?
George: Not really, no.
Sara: Is it different every time?
George: Yeah.
Sara: What usually breaks, if you go back to a sight and you have to repair something?
George: Mostly the pipes. But not these big pipes, the smaller pipes, the BPR pipes. Between the digester and house and sometimes the digester itself.
Jennie: What is most important to keep in mind when you're constructing a biogas plant?
George: My opinion the services, what ever it will do for you
Sara: What kind of maintenance is important to keep the digester working?
George: Mostly you have to do a lot of feeding on the digester because if you don't feed it won't work efficiently. So you have to feed it, like daily.
Jennie: Do the rain seasons effect the biogas plant?
George: Not much. But when it's a bit cold cause they still need some warmth from the sun. So when it's a bit cold they don't perform that much like on the sunny seasons.
Sara: If you got a technical problem, how do you solve that?
George: Repairs.
Sara: Mostly repair, not changing?
George: No, we haven't done any changing. Mostly we do repairs.
Jennie: Does it cost anything to maintain the biogas plant?
George: No we don't charge for that.
Jennie: So you'll pay for it, like if something needs to be changed?
George: Unless the repair we're supposed to do you're the one who caused the damage, we charge for that. But the normal damage we don't charge for that.
Jennie: Who is responsible during building or constructing a biogas plant?
George: The company, Takamoto.
Sara: Have you constructed the ones in brick?
George: No.

Sara: How do you think the new one, the Simgas, will work?
George: We have one in the main office and I've been there, I've seen it work so I hope for the best. I hope it will work out too.
Sara: So do you think this one will work better than the floating drum?
George: Yeah, because this is much bigger.
Jennie: How many hours of gas will the Simgas (4/6m^3) produce per day?
George: Four to five hours, maybe six hours.
Sara: How many hours of gas do the floating drum produce per day?
George: Three to four hours of cooking.
Sara: When you install a biogas plant, do you explain to the client how it works and how it should be maintained?
George: Sometimes we even do it prior to the installation and then after we're done constructing we still explain that.
Sara: Do you explain for all the people in the household?
George: Yes, because of safety precautions so everyone has to get the idea of this things. Not one or two people, everyone.
Sara: Do you leave like a paper that explains how it works?
George: Yeah we do.

Interview 21: Francis Mburu Kamitha

Date: April 1, 2014
Area: Githunguri, Kenya
Organization: Takamoto
Interpreter: -

Present: Jennie Boérius – Student of Chalmers
Sara Helmrot – Student of Chalmers
Francis Mburu Kamitha – Farmer
José Kamitha, with the same kind of digester - Farmer

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Sara: What kind of digesters do you use?
Francis: The old one is a floating drum and the new one a Simgas.
Sara: We'll be asking you about your old one.
Jennie: Do you know how big it is?
Francis: 3,5m³.
Sara: Are you connected to a network, do you share your biogas with anyone else?
Francis: It's only my house who's using the biogas.
Jennie: For how long have you used the floating drum?
Francis: Since this September.
Jennie: Have you experience any technical problems?
Francis: The network, it cuts off all the time so most of the time it does not work.
Jennie: Did you solve the problem?
Francis: I always call them. I especially call Teddy, Teddy knows all the problems with the meter, with the network.
Jennie: What types of feedstock do you use? What do you put into the digester?
Francis: Water and cow dung. About one bucket, 20 litres. One bucket of water and one bucket of cow dung.
Jennie: How often do you do that?
Francis: Every day.
Jennie: How many cows do you have?
Francis: 15 cows.
Jennie: Do you use all of the cow dung?
Francis: I use everything on my fields. Sometimes Takamoto come and get some. *(*To their digesters at their office*)*.
Sara: Before you started using the biogas, what did you use the cow dung for?
Francis: For manure. For planting my bananas, coffee… It's for farming.
Jennie: Do you use all the slurry that comes out from the digester?
Francis: Yes, nothing gets wasted.
Sara: Before you got biogas, which energy source did you use?
Francis: Gas, firewood and electricity.
Sara: The gas, is that LPG?
Francis: Yes.
Jennie: Throughout the year, do you have enough water to supply the digester?
Francis: It's enough.
Jennie: What's the household's main source of income? How do you make your money?
Francis: From bananas, the milk and some from the pension.

Sara: How many people live in this household?
Francis: Four people.
Jennie: What was the main reason for you to buy this biogas?
Francis: In the near future there'll be no firewood. The government is telling us to preserve the forests. At the same time you can't rely on electricity so we find it a better alternative.
Jennie: Do you find it cheaper?
Francis: Yes:
Sara: What do you use the biogas for?
Francis: For cooking and boiling water for cleaning.
Jennie: How has the biogas effected your daily life?
Francis: It is better. It's easier than collecting firewood. It's easing our burden.
Sara: Do you save time?
Francis: Yes we save a lot of time.
Jennie: Have you noticed anything different with your health since installing the biogas plant?
Francis: No.
Sara: Is the biogas enough for the household?
Francis: Well it is not enough. There's only one burner that can be used at the same time, we've got two. That's why we're installing the new digester, the Simgas.
Jennie: Do you still use other energy sources?
Francis: Sure, yes. What I'm not using is LPG gas. I'm using firewood and electricity.
Sara: What level of education do you have? Have you been to school?
Francis: I've been to school, up to form four.
Jennie: Before you put the cow dung into the digester, do you do anything to it?
Francis: We mix it with water till it becomes liquid form, then we put it in the digester. Every morning.
Sara: Have you had any kind of problems with the biogas plant?
Francis: No technical problem, just too little biogas. We have worked with cow dung all our lives so we know it.

Interview 22: Jane Nungari Ngonga

Date: April 2, 2014
Area: Githunguri, Kenya
Organization: Takamoto
Interpreter: -

Present: J³ennie Boérius – Student of Chalmers
Sara Helmrot – Student of Chalmers
Jane Nungari Ngonga – Farmer, Takamoto
Laura..... - ....., Takamoto
…….. - ……., Takamoto

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Sara: What kind of digester do you have?
Laura: Floating drum.
Sara: How big is it?
…….: 3m³.
Jennie: For how long have you used it?
Jane: One year and three months.
Sara: Have you experienced any technical problems?
Jane: Not really, it has got no problem.
Jennie: How much do you feed it?
Jane: I always feed it with two buckets of dung and two buckets of water. That's what I was instructed to do.
Jennie: What are the main types of feedstock?
Jane: I just use cow dung.
Jennie: Before you used the biogas, what kind of energy source did you use?
Jane: I was using the LPG.
Sara: Does the biogas require more or less maintenance than the LPG?
Jane: Biogas is good, because I have two stove plates. I can cook tea on one and Ugali (a Kenyan dish) on one. It doesn't take so long. The LPG was finished before the end of the month. I can cook very quickly with biogas, even within one hour! It's faster than the LPG.
Sara: What do you use the slurry for?
Jane: I plant with it, everything. I put even inside my bananas, you can see now how many children they have now, I have so many bananas now.
Sara: So it's better?
Jane: Yeah.
Sara: Did you use the cow dung before?
Jane: Yes I was using before but since I started getting from the biogas, it is very nice.
Jennie: Throughout the year, do you have enough of water to supply the digester?
Jane: Yes.
Sara: What is the household's main source of income, what do you make your money from?
Jane: I always make money from the cow, sometimes I get money from my son's salaries.
Sara: Why did you want the biogas plant?
Jane: Because it's good for me. I cook faster, it gives me manure, so many things I get from the biogas.

Sara: Do you save any time, compared to before you had the biogas?

Jane: Yes, because at the time I was carrying heavy manure and now I'm carrying that one with a bucket. I go and plant it without getting very tired. Before when I was sweeping the house of the cow I was carrying with my back but now I'm carrying with two buckets.

Jennie: Have you noticed anything different with your health compared to when you was using your old energy source?

Jane: When I was using the firewood we cough, we get cry in our eyes because of smoke but now we are like good people.

Sara: Have you been to school?

Jane: Yes.

Sara: How many years?

Jane: I finished form four.

Jennie: Is the produced biogas enough for your household?

Jane: Yes for me it's enough. But I want my sons to have as well.

Sara: When you're cooking are you still using other energy sources?

Jane: When I have many visitors. When I have like just five visitors I just use the biogas. When I have more visitors I cook with a bigger pot so I cook over firewood (because the stove is too small). You have to cook certain meals over firewood, it's supposed to cook over firewood.

Jennie: How many cows do you have?

Jane: Two.

Interview 23: Moses Ogeto Gekara

Date: April 7, 2014
Area: Nakuru, Kenya
Organization: SimGas Limited (Company)
Interpreter: -

Present: Jennie Boérius – Student of Chalmers
Sara Helmrot – Student of Chalmers
Moses Ogeto Gekara – General Manager, SimGas Kenya LTO

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Sara: Can you tell us a bit about yourself and what you're working with?
Moses: Ok, my name is Moses Ogeto Gekara, I'm working for SimGas Limited. SimGas Limited is a biogas providing company, head office in in Nairobi but we are partner with a few individuals, a few people, ---. So we're operating in Tentahia country of Kenya. In Tanzania we have, our --- is in Tanzania but we have moved into regions in Tanzania so we have offices in Arusa, Mochi, Tanga, Bcha and Mogorowi in Tanzania. In Kenya we have offices in Eldoret, Karatina and Nairobi.
Sara: Are you bigger in Kenya than in Tanzania?
Moses: I am in charge if SimGas Kenya and SimGas Tanzania stational manager, there for I have moved from after three weeks I was in Tanzania. So I spend one week n Tanzania and the other three weeks in Kenya.
Jennie: Is it possible for a mason to come directly to you to buy a biogas plant and install it?
Moses: They don't do that. What they do is that they come to us and, they request we need this for our customer so can you be able to sell it to me or you sell it to the customer. They buy it from us we go, we do an installation for them because this is a unique product. We install them. I have employed 36 people who are university graduates, who are doing for me the installations.
Sara: How many different kinds of digesters do you have?
Moses: Ours are cylindrical, its start from 3m³ up to, the biggest one we've installed is 14m³.
Jennie: And that's the only sort of digester you have, but in different sizes?
Moses: Yeah. We used to have the GesiShamba, the one for this one is for GesiShamba. We have another one for Kitchen West but we have stopped that one because of product quality. It used to be called Gesafi, but at the moment we don't, we have stopped, we have ended that program up to around December because of raw market, the market's not adopting very much and some quality, technical quality.
Sara: The other one that you install, the GesiShamba, how much does that cost?
Moses: The cheapest, 6m³, it goes for 70 000 KES.
Sara: What size is the most common?
Moses: The most common is 6m³ which goes for 70 000 KES.
Jennie: How many of those have you installed?
Moses: In total we have installed 113 units in Kenya. --- and my partner has installed 28 but the 6m³ I have around 86 units.
Sara: For how long have you been installing that one?
Moses: The circle time for the 6m³ is two and a half days. So the company started --- April, it was going incorporated in Kenya on the 4'Th February last year.

So we've been in operation for about one year and two months. But the research development started four years ago in Netherlands.

Sara: do you have the digester underground?

Moses: Yes it is under ground?

Sara: Do you fill with soil above it?

Moses: Yes.

Jennie: Have you noticed any technical problems with it?

Moses: The first patch, we have four series. Series zero was for testing and development. Series one was for installation. So we have moved from technical to what, so we have now the best quality in the market. The problem was if it's to exposed to the sunlight, it is plastic you know plastic, it cracks. So that's why, now, we have come with a new series, series five, it is being produced in Dari Salam in Tanzania. The series two was contaminated, was mixed with a metal, when they were doing --- injection there was mixture of metal. When you mix a metal with a plastic it just crack at a certain angle. So when we have moved the factory from Portugal, we have brought the machines to Dai Salam, we are doing it there. All technicians, all engineers have moved from Netherlands, from Portugal they're setting up the plant in Dari Salam. Everything is plastic except for the burner.

Sara: Why do you want to buy GesiShamba?

Moses: The reason why we're doing that is it's scalable. It's the plastic, ok, our technology is like this we're using recycled plastic, we're using --- plastic. Constructing, our digesters is less costly, you don't buy barlast, you don't buy bricks, you don't buy cement, you don't buy sand, nothing. It's just a trench, we come with the digester, we fix its parts. It comes in parts, parts, parts. So at the end of the day once we're through with the meating (he means measuring) we unscrew, everything is plastic so it's easier to --- of them. If you want to relocate, you uninstall the digester here today, this customer wants to relocate from here to another town, we can come and assist him to relocate. So it's reusable.

Sara: How much does it cost to install the biogas plant?

Moses: We don't charge so much in installing because all the price we have it's inclusive. When you buy the biogas plant you get the piping, the installation it's inclusive. Inclusive we have delivering, installation, piping, two-burner-stove, user training, after sale services, two year warranty.

Sara: What does after sale services the?

Moses: After sale service, once we've installed a digester, the customer may not feed the digester for two days and he or she feels that she has less gas. So we go there, we check, why is this low gas production. So you can find he or she fed the digester with contaminated cow dung which is intoxicated, which the medicine they're given the cows are some medicine. So you have to go there and retrain the customer.

Sara: Are you able to go to all the farmers in the country?

Moses: Yeah. I have employed quality officers. You have to visit five units per day.

Sara: If I'm calling you and is saying my biogas plant isn't working, how long will it take until you come?

Moses: It's supposed to be 24 hours, from the time receiving the call. It does not exceed 24 hours.

Jennie: So let's say I will buy a biogas plant from you, how long time will it take for me to get the biogas?

Moses: Maximum is fourteen days. So for example you buy today, you send the sales agreement, everything is run, prepare work is done, somebody tomorrow is at your place, he or a she will show you where the pit is to be done, everything is done from there. Then it does not take beyond fourteen days for an installation to be done.

Sara: Do you train the farmers?

Moses: We train three people. The farmer, the woman of the house, the one who is going to use in the kitchen. The person who bought the digester is going o be the husband and another person, a daughter or a son. There's a lady from the Netherlands who comes to train the farmer on the bio slurry, the --- of the bio slurry. She comes all the way from the Netherlands for that.

Jennie: How long is the training?

Moses: The training can be one week, it depends, it can be one week or three days.

Sara: Do they get any posters or manuals or something or is it just mouth to mouth?

Moses: No you are given a poster, there's a poster. How it works. We have manuals, we have mixing manuals, how much you have to mix for this plant, you mix this, you wear this, you have the manual for the chiko, the burner, we have the manuals.

Sara: Do you have pictures or text?

Moses: The poster is pictures with text.

Jennie: Is anything done to the feedstock before you put it in the digester?

Moses: The cow dung, the customer has to prepare enough cow dung, that's the challenge, now we are assisting them.

Jennie: Are the farmers doing anything to the cow dung before they put it into the digester?

Moses: So once we've installed the digester we leave the customer to continue feeding for fourteen days before we're there for commissioning. So they're given a specific amount of cow dung and a given specific amount of water they have to put into the digester.

Jennie: Is it equal amounts?

Moses: Yes it's equal.

Jennie: What kind of maintenance is important to make sure the biogas plant is working properly?

Moses: The maintenance we normally gives the customer is for the chiko, cleaning, how is they securing the chiko, this way not that way, so there's a way that we normally gives them. Then the digester, it has to be fed, that's the main one. The second is, we normally we normally encourage them to plant some plants around the digester for soil compactivity. To keep the soil from moving away from the digester. Then another thing is we normally recommends them to put a fence around the digester.

Jennie: Does it cost anything to maintain the biogas plant?

Moses: No.

Sara: Do they have to clean it?

Moses: Cleaning, it cleans itself, there's nothing. Like this one, once you put here there's nothing else, you clean here, it cleans itself.

Sara: Do you connect the GesiShamba to toilets as well?

Moses: We have not started for the toilet but we have done one in Dari Salam, I've done one in Dorct that is for research so we are waiting for the results to come out. But we have not started this, the SimGas, on toilets.

Sara: Do you think you will go through with the toilets?

Moses: By the next three months I will put one.
Sara: Do the clients usually want to put in a toilet?
Moses: Yeah the clients wants so much, the toilet so much. I have about 30 school who wants this for their toilets.
Jennie: Are there any farmers who want the toilets?

Moses: Yeah there are farmers, I think about 14 farmers here in Kenya.
Sara: Do you do a lot for schools and like hospitals?
Moses: I'm moving towards that direction because once we're producing toilets in our certain development is a 94% free pathogens, it's not 100%.The partner I was doing it with I said as indicated that it has to be 100% free of pathogens. So I am trying to get that element of now to admit the 6% remaining. So once I get the 6% then I'm through. The pathogens I want them to be free to be undered by human waste. The pathogens are the, their --- comes from the digester. We want it to be very free so that you can be able to undered by human beings.
Sara: What's the most common feedstock, the thing that you put into the digester?
Moses: The most common thing I'm doing is pig manure, cow dung, siso which is waste from plants, the kitchen waste the leftovers after cooking in the kitchen after they've finished eating, the leftovers, then banana stems.
Jennie: Is any feedstock better than the other ones?
Moses: For example if you put banana it's the best.
Sara: So it's better than cow dung?
Moses: Yeah.
Sara: And if you mix cow dung and banana?
Moses: Number one, perfect. If you have cabbages, they're chopped, they go there. Because they're biogradeable, those are biogradeable things.
Jennie: What does the payment look like?
Moses: SimGas has partnered so many micro finances. If you're not able to pay cash then I can take you to one of our partners who can give you a loan.
Sara: Do they have to pay everything at once?
Moses: No. The partners they give us the money, they would --- with you as a customer. You'll be paying the loan up to 18 months, it depends with your suitability. You can either pay 18 months, 36 months or the way you're comfortable with.
Sara: If I want to pay by cash, do I pay at once or how do I pay?
Moses: No you pay twice. You can pay even three times, some are four times. You can pay 60% down payment, pay for an installation. After an installation and the commissioning you start paying now the remaining amount in four times.
Sara: You have the digester, do you also have all the pipes, do you buy all the materials?
Moses: What we do is price includes everything. The only thing we does not include is pit preparation, the where the digester is coming to live.
Jennie: Who was responsible for the establishment of the company?
Moses: SimGas was started by two brothers, Sane Kastro and My Kastro, in the Netherlands. They came to Tanzania, they partnered with Ser Africa who were the makers of SimTank. Then they came to Kenya, I partnered with them, so I'm one of the directors of SimGas. So we partnered with them said that they can launch, they can be able to access the Kenyan market. Then now we were welcomed by KENFAB, KENDBIP, said that they can

do, they can give us access to the market for us to do certain development and can be able to put biogas systems. After putting biogas systems in 2012 July we did the testing for about three to four months then they said now the digesters are good, you can come and install. So the owner of SimGas, was started in Netherlands by two brothers.

Sara: Are there any government agencies involved in SimGas?

Moses: Don't think there's any government agencies, no.

Jennie: How many partners do you have?

Moses: We have SNV, we have. Ok one, there's SNV, there's now the KENDBIP, we have HIVOS, then there's other partners we have entered partnership with. We have about twelve of them.