Baseline Study of Renewable Energy Technologies in Ghana

Conducted as part of activities of the China-Ghana South-South Cooperation on RE Technology Transfer

Accra, Ghana

1

BACKGROUND

Project Title	China-Ghana Renewable Energy Technology Transfer (RETT) Project
Sector	Renewable Energy, South-South Cooperation
Location	Ghana, China
Executing Agency	United Nations Development Program (Ghana and China)
Implementing Partners	1) Ghana Energy Commission under Ministry of Power 2) China ACCA 21 under Ministry of Science and Technology
Project Duration	4 Years
Project Budget	2,720,000.00 USD
Source of Funding	DANIDA

2

OBJECTIVES OF THE STUDY

As part of activities for the first year of project implementation, the project conducted a review of renewable energy facilities under some projects

- **Obtain relevant information to estimate the state of development in the RE sector which will serve as a useful baseline for the project.**
- **To interact with project implementers to understand some of the issues underlined in developing and operating such projects.**

3

METHODOLOGY

- Identification and extraction of Renewable Energy projects through desk study and research.
- Field trips involving semi-structured interviews with the project implementers.

RE Technologies accessed

- Biomass fired Cogeneration plants
- Solar irrigation
- Solar Water Purification
- Solar Still
- Solar mini-grid
- Gasifier plant
- Biogas plants
- Poldaw windpump
- Solar battery charging
- Grid connected solar plant
- Solar vaccine refrigerators
- Landfill and sewerage treatment site
- Solar cooker prototypes
- Solar dyers

5

KEY FINDINGS

Biomass Fired Co-generation Plants

Benso Oil Palm Plantation

Twifo Oil Palm Plantation

Ghana Oil Palm Development Company

6

KEY FINDINGS

Biomass Fired Co-generation Plants

Ghana Oil Plam Development Company

2.5MW steam turbine alternator and one of the 2 biogas reactors

- GOPDC is now owned by a Belgium company (Societe d'Investissement pour l'Agriculture Tropicale)
- 4MW CHP generation capacity (from 1.5MW and 2.5MW alternator)
- Currently generates 2.5MW for plant and Kwae community
- 2 X 1000m3 Biogas reactors generates 18,000m3 of biogas per day for the refinery facility
- The 4.5 million euros biogas plant was completed in September, 2014
- This has displaced the about 615,000 litres of diesel that was used initially per year
- GOPDC is willing to sell 1.5MW excess power provided there is a good proposal for off-take

7

KEY FINDINGS

Biomass Fired Co-generation Plants

Benso Oil Palm Plantation

500kW Steam Turbine at Benso Oil Palm

- BOPP is subsidiary of Wilmar Africa Ltd.
- BOPP operates a biomass-fired cogeneration plant
- 13.6 ton/hr boiler generates steam for running a steam turbine alternator
- Generates 500kW for operating the plant
- Currently making plans to increase generation capacity to 1MW
- Treatment of the POME is yet to be explored
- POME is applied as fertilizer to the palm plantation

8

KEY FINDINGS

Biomass Fired Co-generation Plants

Twifo Oil Palm Plantation

Construction of a new boiler underway

- 80% shares owned by GoG, 20% - Private
- TOPP operates a biomass-fired cogeneration plant
- 15 ton/hr boiler to generate steam for alternator
- A 1500kVA/1200kW turbine is used to generate power for the plant
- Just about 50% of the of the alternator's generating capacity is utilised. Hence generates about 465kW for the plant
- Construction of a new boiler (25 ton/hr) sized to match the turbine was under way at the time of visit
- Treatment of POME is yet to be explored. POME is pumped to the field and applied as fertilizer

9

KEY FINDINGS

Biomass Fired Co-generation Plants

- All the palm oil mills are sufficient in fuel and in power
- Palm fruit fibre and kernel are used as fuel for the CHP plant
- The main challenge of the palm oil mills is the inadequate palm fruit for processing and power generation

BOPP	500kW	1MW(future plan)
GOPDC	2.5MW	4MW
TOPP	465kW	1.2MW(soon)

10

Solar and Wind Power

- Solar Water Purification
- Grid connected solar plant
- Poldaw windpumps for Irrigation
- Solar vaccine refrigerator
- Solar battery charging
- Solar Irrigation System

11

KEY FINDINGS

Solar Water Stills

Vodafone Foundation

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World of Difference Programme

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CEESD

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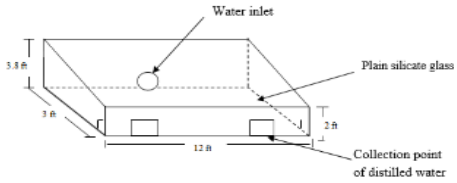
2 Water Stills for Anafo Bisii Primary Schools

12

Solar Water Stills at Anafo Bisii Primary School



- To solve the case of dental fluorosis endemic in the District by purifying the fluoride-contaminated underground water.
- Commissioned in December, 2006.
- Two solar water stills were constructed
- Cost of GH¢ 380
- Provide over 25litres of water daily to 120 pupils in the Anafo Biisi Primary School.
- Bore hole was sunk about 200m
- No maintenance
- The glass covering the concrete water collection trough had been had been shattered.

13

KEY FINDINGS

Solar Water Purification System – Nabogu Water Works

Panels on the roof powering water filtration system

- United States African Development Foundation (USADF) sponsored project implemented by NewEnergy under the "Power Africa Off-Grid Energy Programme"
- Project cost - US$125, 000
- Provides clean water to 1000 inhabitants who rely on a tributary of the White Volta for their water needs
- Purification technology -Advanced Multi-Stage Filtration and Reverse Osmosis
- 5kW roof mounted solar panel powering 2 DC pumps and purification equipment
- The facility supplies 120, 000 litres of water daily
- Purified water is sold at 10 pesewas for 25 litres
- Water from the White Volta tributary is also pumped into a tank for drip irrigation of a 30 acre farm land

14

KEY FINDINGS

Solar irrigation

Solar Irrigation System at Tamalugu

- UNDP sponsored project implemented by NewEnergy
- 30kW DC pump with advanced communication and monitoring capabilities
- Pump is powered with a 15kW PV module
- PV array can be sized to match the pump to increase the pumping capacity
- Pumps 166,000 litres of water per hour from a tributary of the white volta
- Furrow irrigation – 28 acres, Drip irrigation – 3 acres
- Irrigation tariff – GHC100/acre for the whole season

15 15kW solar PV and 30kW pump for irrigation

KEY FINDINGS

Solar Irrigation System at Datoyili

- UNDP sponsored project implemented by NewEnergy
- 2.3kW PV array powers a DC pump
- Irrigation tariff – GHC5/acre for a day
- Water from a nearby stream is pumped into a polytank for drip irrigation
- Drip irrigation capacity – 30 acres

16 Datayoli Solar Irrigation Setup

Central Gonja Community Water Pumping

Central Gonja solar community water pump station

17

- Provide potable water for the Central Gonja Community at Buipe
- Benefited under the GIZ-ENDEV project
- 3 kW PV (250W X 12) powering PS 2 – 1800W Lorentz pumps installed by Pumptech
- 2 systems installed in the community
- Borehole - water source
- 2,690 m3 of water pumped at the time of visit
- The facility is managed by a pump attendant with overarching supervision from Pumptech
- Reservoir available to store water during raining season

Sisili-Kulpawn Irrigation Project - IWAD

Centre pivot irrigation – turning parched lands into viable lands for agriculture at Yagaba

18

- 800 hectares of land leased over 50 years for the project at Yagaba in the Upper East region
- 4 centre pivot irrigation systems installed each covering an area of 65 hectares
- Water pumped from the Sisili-Kulpawn river to a 18000 m^3 reservoir for irrigation

Sisili-Kulpawn Irrigation Project - IWAD

Future pump for drip irrigation and centre pump system pump house

- 80 W solar future pump is used to lift water from a borehole into an overhead tank for drip irrigation
- **A 4 acre land allotted for the installation of solar PV**
- **Explore net-metering to reduce the running cost of the irrigations systems with power from the grid**
- **Support from USAID**

19

KEY FINDINGS

Wechiau Solar Battery Charging Centre

Ministry of Mines and Energy

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off-grid electrification programme

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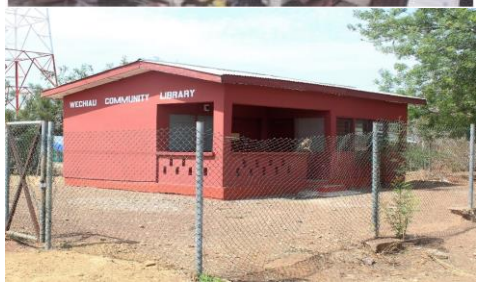
Solar Battery Charging Centre

20

Wechiau Solar Battery



- Installed in 1998.
- Ten battery charging lines.
- Forty-one households provided with 12V, 100Ah deep cycle lead acid batteries along with other PV Solar Home Systems (PV/SHS) on a credit basis.
- With the extension of the grid, the solar battery charging centre became redundant as the community abandoned their PV/SHS for the relatively cheaper grid electricity.
- The centre had been turned into a community library at the time of visit.
- According to a former assembly man of Gwollu the whereabouts of the panels and other components of the centre were unknown. It was speculated that they had all been stolen.

21

KEY FINDINGS

Volta River Authority's Grid-connected Solar Plant at Navrongo

- **2.5MW**
- **Commissioned on 9th of May, 2013.**
- **3,622 Polycrystalline modules**
- **11.79 acres**

- **Constructed China Wind Power**
- **cost of USD 8,082,025.**
- **Solely financed by VRA.**

- **Components include32 combiner boxes, 5 three-phase inverters, metering devices, anti-islanding devices, etc.**

22

Volta River Authority's Grid-connected Solar Plant at Navrongo

- The plant is designed to work autonomously. Generation shuts down automatically at night and in instances where plant output does not meet the minimum to feed into the grid.
- During the day the plant runs on power from its generation, however at night the plants relies on the grid to power relays and other protective devices.
- 59-2amps deep cycle batteries to provide power to relays and metering devices in the substation during total blackouts.

23

Volta River Authority's Grid-connected Solar Plant at Navrongo

- Generation varies daily depending on weather conditions. The annual average peak generation is 10,000 kWh/day and peak generation occurs between 9:00 AM and 2:00 PM.
- Average solar radiation at Navrongo is 6.5 kWh/day.
- Exploring the technical feasibility of deploying a Concentrated Solar Power (CSP) plant at Bongo. In view of this the plant is also monitoring and collating data on weather patterns daily
- Maintenance practices include washing the panels twice a year, monitoring fuses in the combiner boxes and daily visual inspection.
- 6 workers who were trained by the developers of the plant to manage and operate the facility.

24

KEY FINDINGS

Pediatorkope Microgrid Plant

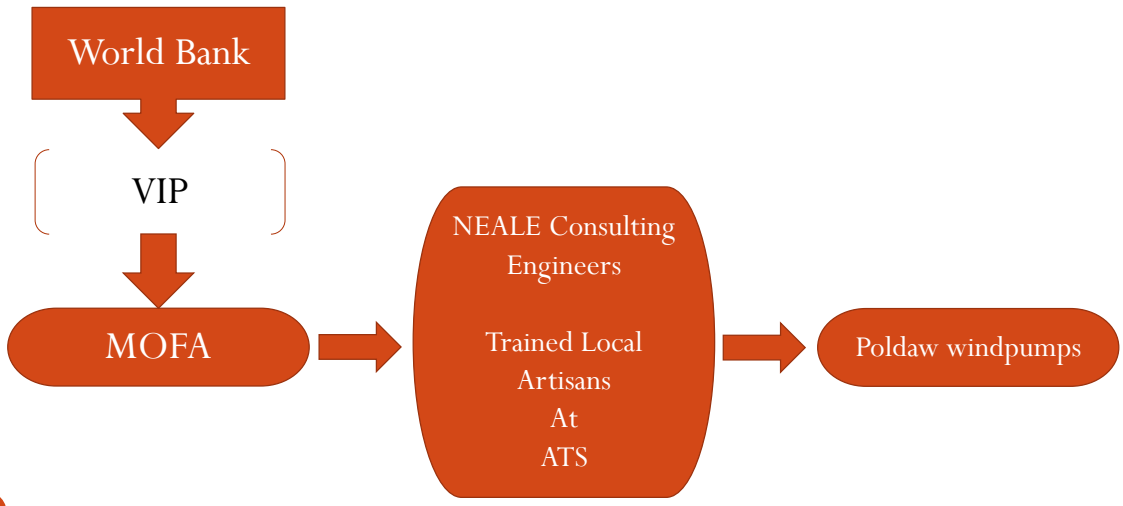
Solar PV Panels mounted on high structures and distribution lines

- Solar/Wind Hybrid AC Microgrid
- This USD 800,000 facility was constructed by a Spanish company, TTA under GEDAP
- The project is funded by MOEP, World Bank and ECA
- Hybrid system of 39 kW solar, 11 kW wind with a 30 kVA diesel back-up generator
- Load limiting prepaid meters (0.5 kW, 1 kW and 1.5 kW) installed for metering
- Similar installations at Kudorkope, Atigagome and Aglakope.

25

KEY FINDINGS

Poldaw Windpumps



26

Poldaw Windpump at Gwollu

Poldaw windpump and storage tank provided for irrigation

- The windpump was designed to pump water from a borehole into a nearby concrete water reservoir to provide water for dry season irrigation.
- The Poldaw windpump has a turbine diameter of 3.5m and can pump a rated maximum of 21,000 litres of water daily.
- Underground pipes connected the reservoir to nearby farms to provide water for irrigation.
- The pump was non-operational at the time of visit.
- Operated for 6 months, following its installation. During this period, it proved to be very helpful as it provided the inhabitants with water in a period of severe draught.

27

Poldaw Windpump at Tampezua

Poldaw windpump at Tampezua

- Two concrete reservoirs to store and provide water for irrigation and domestic use.
- The turbine has a diameter of 3.5m and can pump a rate maximum of 21,000 litres of water daily.
- Underground pipes connected reservoirs to nearby farms.
- The facility was operational for a year following its installation in 2004 by AESD of MOFA.
- The non-operational state was attributed to the broken pumping rod. It was reported that the pumping rod was retrieved for welding but this proved futile as the system did not work after repairs.
- No member of the community was trained to maintain the facility.

28

KEY FINDINGS

B-Bovid Farms

- Located at Prestia in the Western region
- Company consist of a palm oil mill, palm kernel oil mill and organic fertilizer processing factory.
- Yet to explore energy generation from POME and organic waste
- Windpump for pumping water for irrigation and also for the livestock.
- Noisy operation of windpump – Faulty bearing
- High sense of responsibility – regular maintenance

29

KEY FINDINGS

Solar Vaccine Fridges

European Union

Microprojects Programme

GoG → Community-Based Health Planning and Service (CHPS) initiative

30

Solar Vaccine Fridges

Ducie and Ga CHPS

- A 12V/50W Waeco solar vaccine fridge was provided to store vaccines for immunization of babies.
- The solar fridge is powered by a 100W solar system provided to power fridge
- The presence of the vaccine fridge has made it convenient for the health centre to immunize infants against killer diseases.
- Without this facility mothers would have to travel miles to provide such essential needs for their children.




31

Solar-Biomass Dryer

Solar biomass hybrid dryer

- Built by Pens Food Bank in collaboration with the Agricultural Engineering Department of KNUST in July 2015
- The total cost of the facility is USD 18,000
- The project was funded by Pens Food Bank Ent. (20%) and a UK based organization (80%)
- The project was implemented by The Energy Centre (KNUST)
- Dries 5mt of produce per batch (2 batches/day) for 8 hours
- The biomass furnace uses 30 kilos of corn husk for drying harvests per batch during the major season
- The drying tariff of the solar biomass dryer is ₵4
- Major challenge is the high cost of maintenance as the perspex glass is scarce and expensive

32

Sekyedumase Solar Dryer

- Project funded by GIZ and built in the Sekyedumase market in the Ashanti region in 2004
- Managed and operated by the Nyame ne Boafo Farmers and Buyers Association
- The dryer has a drying capacity of 135kg of harvest per batch
- The perspex glass were shuttered after a heavy rainfall in 2014 rendering the facility inoperable
- Major challenge is funds to revive the project

33

Biogas and Landfill

34

KEY FINDINGS
Landfill and sewerage treatment

Dompoase Landfill Site

Landfill Sited at Dompoase

- 100-acre landfill project with modern waste management facilities
- Project funded by the World Bank
- The landfill site is managed by the Kumasi Metropolitan Assembly (KMA)
- J Stanley-Owusu (JSO) operates the engineered landfill and sewerage treatment plant under a contract with the KMA
- The site is designed for a period of 15 years with three phases and has been used for 11years
- Nine ponds at the site for treatment of sewage waste after which it is channeled into a nearby river body
- The tapped gas was being flared after testing on site at the time of visit
- KMA plans to use the landfill gas for power generation for Guinness Ghana Ltd. in Kumasi
- The site will be used for a recreational site when the landfill is exhausted.

35

Key Findings:
Biogas Plants

Ntiamoah Hotel

- $10m^3$ biogas facility with effluent storage
- Constructed in 2007 by Beta Construction Engineers Limited
- The gas produced is used for cooking in the kitchen on a biogas stove
- The spent sludge is pumped from the effluent storage for watering the hotel garden
- No gasholder. Excess biogas is released to the atmosphere to prevent excessive pressure build up.

36

Key Findings:
Biogas Plants

Ntiamoah Hotel

Mfatsipim SHS Biogas

- 16-seater 200m^3 fixed dome biogas toilet facility with effluent filtration system
- constructed 2011 by Beta Construction Engineers Limited
- Funded by the Mfantsipim Old Boys Association
- Gas lamps in the toilet facility is powered with biogas
- Filtered effluent is pumped to an overhead tank for flashing toilets on campus
- The school has a 3500kVA biogas generator. Inability to use the biogas generator because of the lack of gas storage
- Major challenge is the lack of funds for maintenance

37

Key Findings:
Biogas Plants

Ntiamoah Hotel

Mfatsipim SHS Biogas

CRIG Biogas, Bole

- 50m^3 and is capable of generating 12m^3 of biogas daily.
- Shea butter processing effluent used as feedstock for the digester
- Biogas used as fuel in roasting shea kernels
- Biogas is also used to power the shea kernel grinding mill
- Major challenge is the pungent smell of the biogas due to the absence of a H2S scrapper.

38

Key Findings:

Biogas Plants

Ntiamoah Hotel

Mfatsipim SHS Biogas

CRIG Biogas, Bole

Ejura Slaughter House

- The 50m^3 twin bio-digester slaughterhouse biogas plant was built to treat the slaughter waste and to produce biogas for singeing cattle in 2000
- Project funded by GTZ and implemented by TEC
- The facility has been inoperative since 2005
- Explosion of the gasholder rendered the facility useless
- The digesters filled with sand and rubbish as the area gets flooded when it rains

39

Key Findings:

Biogas Plants

Ntiamoah Hotel

Mfatsipim SHS Biogas

CRIG Biogas, Bole

Ejura Slaughter House

Tamale SOS Biogas

- 70m^3 biogas plant with effluent filtration system
- Constructed by Beta Construction Engineers Limited
- Constructed in 2009 with funding from a German Organisation
- The biogas was used for cooking. Feacal sludge and left over foods channelled to digesters as feedstock
- The plant broke down in 2012 due to blockages in the channels
- Effluent filtration pumps damaged due to flooding of the area

40

Key Findings:

Biogas Plants

Ntiamoah Hotel

Mfatsipim SHS Biogas

CRIG Biogas, Bole

Ejura Slaughter House

Tamale SOS Biogas

Cocoa Board Warehouse

- 200m^3 fixed dome biogas digester constructed by Biogas Technologies West Africa Limited in 2014
- Facility has never been operational after its construction
- Residents had no clue of the existence of such facility on their premises
- The facility has been turned into a waste treatment facility

41

Key Findings:

Biogas Plants

Mfatsipim SHS Biogas

CRIG Biogas, Bole

Ejura Slaughter House

Tamale SOS Biogas

Cocoa Board Warehouse

Koforidua General Hospital

- Facility was constructed by Biogas Technologies West Africa Limited
- The hospital has no data about the facility
- The biogas was never used due to the pungent smell of the gas

42

Safi Sana Biogas Plant

- Digester capacity - 2500 m3
- 100 kW biogas generator to generate electricity.
- Faecal matter, slaughter waste and organic waste from the market is sourced for feeding
- The treated plant effluent used as bio fertiliser for growing seedlings
- PPA with ECG for offtake of electricity generated

43

HPW Fresh and Dry Ltd's Biogas Plant, Adeiso

- 2 x 450m^3 concrete biogas digesters and 3 x 100 m^3 gas holding balloons installed in 2011
- shredded fruit processing waste mixed with sliced substandard fruits used as feedstock
- Averagely, about 500 m^3 of gas is produced daily from the plant
- The biogas is used to fuel a 200 kW_{heat} boiler providing heat for drying fruits
- The company was planning on expanding their biogas facility with a third digester

44

Initiatives by Educational Institutions

45

The Energy Centre, KNUST

- Smart Energy Management System
- Solar Water Pump and Solar Thermal System – Photovoltaic Training Centre
- Solar PV Testing Laboratory
- Biogas Testing Laboratory
- Wind Tunnel at the Aerospace Lab
- Wind Turbine Prototype

46

Key Findings: Initiatives by Educational Institutions

The Energy Centre, KNUST

- **Smart Energy Management System**


Part of the 44kW solar PV installed at KNUST

- SEMS switches between the grid and the batteries for uninterrupted power supply
- Project sponsored by GIZ with support from the Federal Government of North Rhine Westphalia (NRW).
- The 44kWp Solar PV System is grid tied through a net meter
- Battery storage with capacity of 54kWh, enough to last for 12 hours.
- A 17kVA Jatropha oil generator is available for charging batteries
- The College has a 4acre field where it cultivates Jatropha to power the generator

47

Key Findings: Initiatives by Educational Institutions

The Energy Centre, KNUST

- **Solar Water Pump and Solar Thermal System – Photovoltaic Training Centre**


Solar PV for DC water pump, TEC-KNUST

- Demonstration facility to create awareness on the benefits of RE
- Sponsored by the Federal Government of North Rhine Westphalia (NRW) and GIZ.
- The facility cost is about €24,000
- The centre was completed in May, 2015
- A DC submersible pump powered by a 750Wp panel pumps water to the Petroleum Engineering block

48

Key Findings: Initiatives by Educational Institutions

The Energy Centre, KNUST

- **Biogas Laboratory**

- Located at the College of Health Sciences, KNUST
- Run by TEC and the Chemical Engineering Department
- Sponsored by the Federal Government of North Rhine Westphalia (NRW) and GIZ
- Lab for testing the methane potential, biodegradable content of feedstock and the methane gas produced by a digester

49

Key Findings: Initiatives by Educational Institutions

The Energy Centre, KNUST

- **Wind Turbine Prototype**

100 W Wind Generator

- **Wind Turbine Blade Prototype**

Wind turbine prototype

50

Key Findings: Initiatives by Educational Institutions
Technology Consultancy Centre, KNUST

- **The Cookstove Testing and Expertise Lab (C-lab)**

- **Institutional Rocket Cookstoves**

- **Ferro Cement Charcoal Gasifier**

51

Key Findings: Initiatives by Educational Institutions
Technology Consultancy Centre, KNUST

- **The Cookstove Testing and Expertise Lab (C-lab)**

Some equipment installed at the C-lab, TCC-KNUST

- Project sponsored by UNDP and USAID
- The project cost US$150,000
- The Lab was commissioned on 31st March, 2015
- The lab is purely commercial and revenue raised is used to run the lab
- The lab designs cookstove prototypes and transfers the knowledge acquired to the industry
- Used for testing the efficiency, performance, emissions levels and heat content of locally-produced and imported cookstoves
- Low patronage of facility the industry is unaware of its existence
- The relatively high testing charges also accounts for its low patronage

52

Key Findings: Initiatives by Educational Institutions
Technology Consultancy Centre, KNUST

- **Ferro Cement Charcoal Gasifier**

10 kW Ferro Cement Gasifier

- Technology invented by TCC with sponsorship from the Netherlands Development Organization (SNV)
- It cost GH₵40,000 to construct the Ferro Cement Charcoal Gasifier.
- The gasifier provides syngas for a modified Mercedes engine coupled to a 10kW alternator to generate electricity
- Operated and maintained by the Rural Energy and Enterprise Development Unit under TCC
- Serves as a demonstration facility for students.

53

Key Findings: Initiatives by Educational Institutions
Technology Consultancy Centre, KNUST

- **Institutional Rocket Cookstoves**

TCC Rocket stove cookstove

- Technology invented by TCC with sponsorship from the Netherlands Development Organization (SNV)
- Constructed mainly from bricks
- The rocket cookstove cost GH₵12,000 to construct
- These stoves have been replicated for a number second cycle intuitions including Kumasi Senior High Technical School, Yaa Asantewaa Girls' Senior High School, Kumasi Secondary Technical School, St. Augustine's College among others
- Cleaner, higher performance and more efficient compared to the traditional tripod
- Reduces fuel cost by 80%.

54

Key Findings: Initiatives by Educational Institutions

Kumasi Institute of Tropical Agriculture (KITA), Biogas Facility

Institutional Biogas Facility

KITA Biogas facility

- First facility under the institutional biogas project sponsored by SNV
- Implemented by the Centre for Energy, Environment and Sustainable Development (CEESD)
- The biogas facility cost ₵70, 000
- Constructed in May 2015.
- 9-seater toilet, 40m^3 fixed dome digester with a gas holder and effluent storage
- 15 kVA biogas generator is used to generate power for lighting on campus
- The major challenge is the low pressure of the biogas

55

Key Findings: Initiatives by Educational Institutions

Kumasi Institute of Tropical Agriculture (KITA), Biogas Facility

Morrison Cookstoves for Pito Brewing

Morrison cookstove

- Built by KITA and sponsored by SNV
- Cost of constructing a Morrison cookstove is ₵200
- The Morrison cookstove is built from clay
- These stoves have been replicated a number of communities including Ayigya, Asafo, Yeji, Ejisu etc for cooking, parboiling shea nut and for pito brewing

56

Key Findings: Initiatives by Educational Institutions

Koforidua Polytechnic

Solar Water Heater Prototypes	Solar Cookers	Briquetting Machine	10m3 biogas plant	Mixed-mode solar dryer
				

- The school started a BTech in Renewable Energy in 2013
- Provides training on RE production and utilization
- Major challenge is the lack of funds to support RE projects

57

Conclusion

Observations on RE Technologies

- Small Market size, difficulty in replacing faulty components
- Lack of sustainable programmes, low awareness
- Poor maintenance culture, lead to eventual failure

58

Conclusion

Factors that affect the sustainability of a project

- Adequate technical know-how for maintenance
  - Case studies of well-maintained projects – Oil Mills Facility, Ejisu Solar hybrid dyer, Solar irrigation systems managed by NewEnergy, Nabogu Water Works, etc.
  - Case studies of poorly maintained projects – Ejura Slaughter house biogas facility
- Good business model to generate funds for maintenance
  - Case studies of Projects with replicable business models - , Ejisu Solar hybrid dyer, Solar irrigation systems managed by NewEnergy, Nabogu Water Works, etc.Case studies of Projects with no replicable business model – Mfantsipim Biogas facility
- Clearly defined ownership structure
  - Most privately owned facilities are properly maintained due to the sense of reasonability
- Clearly structured decommissioning plan to reclaim equipment
  - Usable equipment could be reclaimed from failed projects to be used elsewhere
  - Case study is the Wechiaw Solar Charging centre where all the solar PV and other equipment were stolen from the community

59

60

Asekye Solar Charging Centre

Mr. Manu – self sufficient in energy and power from renewable energy for his home and business.

61

THANK YOU

62