Japan International Cooperation Agency

SURVEY TO ESTABLISH THE STATUS OF UNIDO ENERGY KIOSKS/COMMUNITY POWER CENTERS

FINAL REPORT

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ABBREVIATIONS AND ACRONYMS

JICA	Japan International Cooperation Agency
UNIDO	United Nations Industrial Development Organization
REA	Rural Electrification Authority
GK	Government of Kenya
MoE	Ministry of Energy, Kenya
JKUAT	Jomo Kenyatta University of Agriculture and Technology
UN	United Nations
Rencon	Rencon Associates Ltd
MDGs	Millenium Development Goals
PV	Photovoltaic technology
HPTC	High Performance Temperature Controlled biogas system
UNEP	United Nations Environment Programme
ICT	Information Communication Technology
KIRDI	Kenya Industrial Research and Development Institute
CPC	Community Power Centre / Energy Kiosk
DBSC	District Business Solution Centre
PCC	Power Control Centre
MSEs	Micro and Small Enterprises
RE	Renewable Energy
SVO	Straight Vegetable Oil
WTG	Wind Turbine Generator
SHP	Small Hydro Power
RE	Renewable Energy
LED	Light Emitting Diode
V	Volts
W	Watts
kW	kilowatt
CBO	Community Based Organization
GOJ	Government of Japan
WTG	Wind Turbine Generator

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EXECUTIVE SUMMARY

Introduction

Japan International Cooperation Agency (JICA) is cooperating with the Government of Kenya through Rural Electrification Authority (REA) and Jomo Kenyatta University of Agriculture and Technology (JKUAT) in electrification of Kenya's rural off-grid communities through the installation and management of appropriate renewable energy technology systems. One of the expected outputs under this cooperation is the establishment of rural electrification model using renewable energy in Kenya.

United Nations Industrial Development Organization (UNIDO) Kenya has implemented several Community Power Centres (CPCs) in off-grid areas over the last five years. The CPCs are aimed at providing social and communal services that are intended to spark the provision of income generating activities, contributing to rural employment creation on a small scale with potential for development into innovative and appropriate models for deployment of renewable energy systems for off-grid areas.

JICA would like to utilize UNIDO's experience. However, the CPCs implemented under the UNIDO model have not been evaluated to determine their technical and business performance. An evaluation of the CPCs would play a significant role in clarifying the extent to which renewable energy based on the CPCs concept can contribute to the efforts to establish a rural electrification model using renewable energy in Kenya.

Objective of the assignment

The overall objective of the survey was to establish the status of the CPCs established by UNIDO and determine their technical and business performance to assist the Rural Electrification Authority (REA)/Ministry of Energy (MoE) in the development, financing and implementation of rural renewable energy business model.

The specific objectives were:

- To determine the technologies employed, current operation status including ratings, operating capacities and related aspects;
- To establish the operation and maintenance practices, costs, status and related aspects;
- To determine the nature, form, magnitudes and status of income generating activities spurred by the CPCs;
- To determine the costs and benefits of the CPCs;
- To establish project ownership, management and institutional capacities, organization structures, challenges and related management aspects;
- To establish lessons learnt and make recommendations for consideration in the development, financing and implementation of rural renewable energy business model.

Methodology

The survey was undertaken through a review of the UNIDO CPC programme and projects documents followed by a field survey to gather technical and business performance data. Field data and information was gathered through physical inspections and face-to-face

interviews with CPC managers and committee members. The survey interviews were guided by an interview schedule. The gathered data and information was analysed and this report prepared.

A total of 14 CPCs were visited. Three of the CPCs are under implementation and one is being redeveloped. This report essentially covers the CPCs that were completed and commissioned.

Survey Results

The Community Power Centres were designed as a community-managed, decentralized electrical energy service centres powered by renewable energy technologies. They would utilise a single source of Renewable Energy (RE) system or a combination of sources (Hybrid) to produce electricity from locally available RE resources like water, organic wastes, plant oil, solar, wind etc. The electricity generated would then be used in productive activities that add value to the community's lives, produce and economic activities. The community would use power to run small agro-processing industries that add value to their agricultural produce e.g. milling, processing, preserving etc. They would also use energy to meet household energy needs say lighting by using rechargeable LED lamps instead of the kerosene lamps widely used. The electricity would also spur the development of community-owned business support services such as ICT services.

The main objective of the CPC programme is therefore to provide energy in the non-electrified rural areas with the aim of stimulating economic growth in rural areas through the development of Micro and Small Enterprises (MSEs). The CPC programme specifically aimed at creating businesses undertaking mobile phones battery charging, internet and ICT services, community recreation with a Television, DVD and Satellite broadcast connections. The envisaged light industrial activities MSEs would include Flour milling, Metal welding, Carpentry workshops, Hair cutting, Poultry incubators, Juice extraction, Briquettes making and Soap making.

A generic business model was adopted. UNIDO would mostly finance initial costs by donating the equipment and offering technical assistant including design, installation, testing and commissioning and capacity building. UNIDO would then handover the CPCs to the communities who would own and manage the systems. Stakeholders in various CPCs would be involved in the implementation and contribute in cash or in kind towards the realization of the CPCs.

To ensure sustainability, CPCs were to generate adequate revenue for operation and maintenance from the services the CPC would be offering to the community and also from light industrial businesses powered by the CPCs. UNIDO would provide some production equipment to kick-start the business activities.

All the CPCs were designed to use locally available renewable energy sources namely Hydro power, Wind Power, Solar energy, Biogas and Straight Vegetable Oil (SVO). All the RE resources above are available in Kenya in varying quantities at different locations. The harnessing technologies selected were wind turbine generators, hydro turbine generators, solar photovoltaic (PV), High Performance Temperature Controlled (HPTC) Biogas digesters with biogas electric generators and SVO electric generators.

The systems were technically well designed, installed and commissioned and were configured to operate either as stand-alone systems or in hybrid operation modes. Besides installing the power systems, UNIDO also provided some equipment to kick-start some of the business activities such as mobile charging stations, ICT equipment, Welding machines, wood working machines, etc.

An assessment of the operation and maintenance status shows that most CPC power systems are in poor state of operation and maintenance. A summary of the power systems, technologies employed, installed capacities and their operation and maintenance status is provided in the Table below.

	CPC Name	**Power System Type and capacities**	**Completion Date**	**Operating and Maintenance Status**
1	Olosho Oibor CPC Ngong	14 kW PV/Wind/ SVO Generator System	November, 2009	PV and Wind system operational. SVO generator, the main power source not used.
2	Makandune CPC, Meru	8 kW SVO Generator	October, 2008	Not operating due to mechanical problems and in poor state of maintenance.
3	Mutunguru CPC, Meru	36 kW Small Hydro system	July, 2009	Generator functional but system not in use due to lack of distribution system.
4	Somorio hydro power CPC, Litein	1.5 kW Small Hydro system	October, 2007	Operational and in good maintenance condition. Capacity augmentation works in progress.
5	Uhuru CPC, Siaya	9.8 kW PV/ SVO Generator Systems	May, 2009	PV system operational. SVO generator, the main power source not used. System in poor maintenance condition.
6	Bungoma Municipal CPC	HPTC Biogas digester with 9 kW biogas generator	April, 2008	Not operational and poor maintenance state
7	Changara CPC, Busia county	9.8 kW PV/ SVO generator systems	May, 2009	PV system operational. SVO generator, the main power source failed and in poor maintenance condition.
8	Homabay Municipal CPC	HPTC Biogas digester with 9 kW biogas generator	November, 2008	Not operational due to incomplete installations
9	Wema CPC, Bamburi, Mombasa	HPTC Biogas digester with 9 kW biogas generator Biogas stoves	September, 2007	Not operational. System failed and dismantled.

10	Nyongara, Dagoretti CPC	HPTC Biogas digester with biogas generator Biogas stoves	March, 2010	Operational and in good state of maintenance
11	Kamahuha CPC, Muranga.	HPTC Biogas digester with 10 kW biogas generator and stoves	March, 2008	Not operational and in poor maintenance condition
12	Rembo CPC, Likoni, Mombasa.	Proposed grid-connect PV	Not yet	Under Development – Buildings completed, some equipment on site
13	Sagana CPC, Kirinyaga.	Proposed PV/ SVO generator systems	Not yet	Under Development – Buildings completed and some equipment installed but not commissioned.
14	Salabani CPC, Marigat.	Proposed Solar PV / Biomass System	Not yet	Under development – Civil works in progress

This state of affairs has been caused by a combination of technical and management challenges. Equipment failure, lack of adequate technical training for operation, maintenance and repair, lack of operation and maintenance manuals, lack of spares and local technical support for equipment contributed greatly to the poor state of the systems.

Solar PV, Wind Turbines, hydro Turbine and biogas electric generators have performed well but the HPTC biogas technology has done poorly mainly because it requires high quality feedstock (ideally animal wastes) and maintenance of nearly constant digester temperature for it to work well.

The SVO generators were only run on diesel fuel because no mechanisms were established for the supply of SVO fuel. Even then, the SVO generators have performed poorly due to technical breakdowns that have been difficult to fix.

The systems were technically well designed, installed and commissioned by UNIDO selected contractors and consultants. However, the selection of equipment appears not to have been based on a well-defined quality and performance based technical specification. The source of most of the equipment installed in the CPCs is China. Germany supplied the main biogas equipment.

No CPC put in place any credible technical performance monitoring and evaluation system. Therefore no quantitative data was available for technical performance evaluation.

As far as financial management is concerned, only once CPC, Uhuru in Siaya provided 18 months income and expenditure data. Other CPCs never bothered to keep any useful financial records. No financial analysis could therefore be carried out. The analysis of the Uhuru CPC, the CPCs is not sustainable as a business.

Institutional analysis shows that CPC ownership is clear except in situations where a Kenya Government institution is involved – Changara, Siaya and Nyongara where the ownerships are not yet clear. Most CPCs are owned by community members as community based organizations, self-help groups or Savings and Credit Cooperative Societies. They are managed by committees elected by members. The main management challenge to the CPCs is raising working capital. With suitable training, the management committees should easily manage the CPCs.

The CPC business model was assessed and it was found that CPC program business model was based on general assumptions with no credible supporting data or information. The model was implemented without any business plan. The model assumed that by putting up the CPCs and donating them to the communities, the services and business using the CPC would generate adequate revenue for its sustenance. The prices for various services were fixed arbitrarily. The business volume was assumed. It was also assumed that the communities through the management committees would properly manage the CPCs as profitable businesses. The infrastructure for the supply of biogas and SVO fuel was assumed. These assumptions were erroneous rendering the model unworkable.

The CPCs surveyed did not create any sustainable jobs and only mobile phones charging and Hair cutting and ICT and entertainment services using satellite TV are supported in the 3 CPCs. The envisaged light industrial productive activities never took off. The CPCs have therefor contributed little in terms of social and economic development of the targeted communities.

National power grid has been extended to all the CPCs even though most of them were established when there was no grid power connection nearby. Most CPC customers are shifting to the grid power due to inadequacy of the power supply from the CPCs.

The overall conclusion is that the status and performance of the CPCs established by UNIDO is poor both from the technical and business perspectives. The UNIDO CPC program model needs a total overhaul for it to be used as a business model for the development, financing and implementation of rural renewable energy businesses.

Recommendations

The results of this survey show that of the 11 CPCs established by UNIDO and its partners between 2007 and 2010, only two have operated very well from a technical point of view and none has performed well from a business perspective. A combination of CPC design model, technology and management issues have contributed to this state of affairs.

It is recommended that:

i) The choice of RE resource and harnessing technology should be based on detailed technical assessments. The availability and adequacy of the RE resource and the

supporting infrastructure and logistics should be based on credible data and information.

ii) The RE harnessing technologies should be chosen on the basis of technology maturity, level of commercialization and proven performance. New technologies should be chosen with a lot of care and be accompanied by extended technical support for operation and maintenance and the establishment of an after sales support system for provision of spares and major repairs.
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iii) To ensure that good quality equipment and systems are procured, a detailed well-defined quality and performance based technical specification should be the basis of equipment and supplier selection. Equipment with a good performance history from reputable manufacturers should be selected.

iv) Adequate technical capacity development for operation and maintenance management should be included in program designs and be carried out. Technically qualified people should be identified and adequate training provided to them. The training should include preparation and provision of system operation and maintenance manuals.

v) The importance of performance monitoring and evaluation should be emphasized and that suitable systems should be put in place for data and information gathering for evaluation purposes.

vi) A RE business model should be based on credible data, information and assumptions supported by a good business plan. The business plan should contain as a minimum the marketing plan, the management plan and the financing plan.

vii) The management committees of the CPCs have good people organization and management skills but they should be provided with adequate CPCs business management training.

viii) It is evident that the government rural electrification policy of extending grid power to markets and public facilities is being implemented speedily. Off-grid RE systems and business should be designed bearing this in mind. Provisions should be made for grid integration once national power grid is extended to the facility. It is unlikely that off-grid RE businesses can compete on price with grid power.

ix) The UNIDO CPC model has failed to work. JICA should therefore use the lessons learnt from it to develop new and innovative business models for off-grid rural electrification using renewable energy.

1. INTRODUCTION

1.1 Background Information

Japan has been providing development assistance to Africa for decades. In 2008, during the Tokyo International Conference on African Development (TICAD) IV, the Government of Japan (GOJ) vowed to double its aid to Africa by 2012. In the same year, the GOJ announced its policy support for renewable energy promotion through its 'Cool Earth Partnership', to address the effects of climate change through modernization of industries by, way of technology-transfer, to render them more energy-efficient and more environment-friendly.

In 2009, Japan International Cooperation Agency (JICA) conducted a survey for Renewable Energy (RE) Promotion Program in Africa, focusing on Kenya and Uganda. The overall objective of the survey was to clarify the barriers and means for rural electrification using renewable energy sources.

According to the survey report entitled 'Preparatory survey for Renewable Energy Promotion Program in Africa – Business Promotion and Financing Mechanisms' rural electrification needs are high. The survey identified four key challenges that need to be addressed, namely:

i) correct application of technology,

ii) appropriate model for promoting rural electrification,

iii) correct operation and maintenance

iv) human resource development

In November 2009, a Letter of Understanding (LOU) was signed between the following three parties: JICA, United Nations Industrial Development Organization (UNIDO) and the Government of Kenya (GOK), including the Rural Electrification Authority (REA) and Jomo Kenyatta University of Agriculture and Technology (JKUAT) for the intention to reinforce the cooperation in rural electrification using renewable energy sources. Based on this LOU, the GOK requested the Government of Japan (GOJ) for technical assistance to establish a rural electrification model using renewable energy. Consequently, Record of Discussion (R/D) between the two parties was signed in November 2011 marking the commencement of the Technical Cooperation Project for Establishment of Rural Electrification Model using Renewable Energy in Kenya.

JICA is committed to utilizing renewable energy technologies in isolated African communities to promote rural electrification, growth-led development, poverty alleviation and other targets stipulated in the UN Millennium Development Goals (MDGs), in a way that advances Japan's efforts in climate change.

In furtherance of this commitment, JICA is cooperating with the Government of Kenya through Rural Electrification Authority (REA) and Jomo Kenyatta University of Agriculture and Technology (JKUAT) in electrification of Kenya's rural off-grid communities through the installation and management of appropriate renewable energy technology systems. JICA would like to utilize UNIDO's experience of community power centers.

One of the expected outputs under the above cooperation is the establishment of rural electrification model using renewable energy in Kenya.

Over the last five years UNIDO has established several Community Power Centers (CPCs) aimed at providing social and communal services that are intended to spark the provision of income generating activities, contributing to rural employment creation on a small scale with potential for development into innovative and appropriate models for deployment of renewable energy systems for off-grid areas.

It is believed that the energy kiosks have had a significant impact on the lives of the affected communities that benefited from the electricity services provided resulting in better standards of living, employment creation and poverty reduction.

However, the CPCs implemented under the UNIDO model have not been evaluated to determine their technical and business performance and challenges encountered in their utilization. An evaluation of the CPCs would play a significant role in clarifying the extent to which renewable energy based on the CPCs concept can contribute to the efforts to establish a model that can address the challenge of utilization of renewable energy for productive purposes in rural communities.

Rencon Associates Ltd (Rencon) was contracted to undertake a performance audit survey to establish the status of UNIDO assisted CPCs.

The survey was undertaken in 14 CPCs in the months of August and early September 2012. Three of them are under implementation.

This is the Draft Final Report.

1.2 Survey Objectives

The overall objective of the survey was to evaluate the status of the CPCs established by UNIDO and determine their technical and business performance to assist the Rural Electrification Authority (REA)/Ministry of Energy (MoE) in the development, financing and implementation of rural renewable energy business model.

The specific objectives were:

- To determine the technologies employed at each site, current operation status including ratings, operating capacities, capital costs and related aspects
- To establish the operation and maintenance practices, costs, status and related aspects
- To determine the nature, form, magnitudes and status of income generating activities and related business aspects
- To determine the costs and benefits of the energy kiosks
- To establish project ownership, management and institutional capacities, organization structures, challenges and related management aspects
- To establish lessons learnt and make recommendations for consideration in the development, financing and implementation of rural renewable energy business model.

1.3 Structure of the Report

This Chapter provides the background information and survey objectives.

The methodology employed is described in Chapter 2. In Chapter 3, a review of the CPC Programme is presented. The results are provided in Chapter 4 and conclusions in chapter 5. A discussion of the results and recommendations are provided in Chapter 6.

2. SURVEY METHODOLOGY

The survey involved four key activities or tasks listed hereunder:-

Task 1 Desk review of the JICA and CPC programmes documents

Task 2 Field survey

Task 3 Data analysis and Interpretation

Task 4 Preparation of reports

The methodology employed for undertaking each of the above tasks is described hereunder.

Task 1 Desk review of the JICA and CPC Programmes Documents

A desk review of the energy JICA and UNIDO programmes documents was carried out.

JICA provided the following document:-

- Preparatory Survey for Renewable Energy Promotion Program in Africa – Business Promotions and Financial Mechanism. Final Report, November 2009. Nippon Koei Co. Ltd.

The review of the JICA document was aimed at creating a better understanding of the JICA RE programme background which has been described in Chapter 1.

UNIDO provided the following documents for review:

i) The UNIDO Community Power Centre Program
ii) Feasibility Study for Dagoretti Slaughter House Project
iii) Olosho-Oibor (Ngong Energy) Project Proposal
iv) Siaya District Business Solutions Centre (DBSC) - CPC Project Report,, 31 March 2009
v) Summary of Bungoma (Changara) and Siaya DBSC -CPC Projects, 31 March 2009.

The review of the CPC programmes documents was aimed at creating an understanding of the genesis and evolution of the programme, its design objectives and implementation plans including choice of technologies, procurement, management, operations and maintenance and sustainability.

The review of the 'UNIDO Community Power Centre Programme' document provided the genesis and evolution of the programme, its design objectives and implementation plans including choice of technologies, procurement, management, operations and maintenance and sustainability. This is presented in Chapter 3.

Results of the review of a CPC specific document have been incorporated into the CPC specific detailed report in Chapter 4.

Task 2 Field survey

The aim of the field survey was to gather relevant data and information about the CPCs. The data and information obtained covered the technical and business aspects of the CPCs.

Data and information was gathered from the following community power centres:

i) Olosho Oibor CPC Ngong
ii) Makandune CPC, Meru
iii) Mutunguru CPC, Meru
iv) Somorio (Kaptein and Cheptabach) CPC, Litein
v) Salabani CPC, Marigat, Baringo
vi) Uhuru CPC, Siaya
vii) Bungoma Municipal CPC
viii) Changara CPC, Busia county
ix) Homabay Municipal CPC
x) Wema CPC, Mombasa
xi) Rembo Likoni CPC, Mombasa
xii) Sagana CPC, Kirinyaga
xiii) Kamahuha CPC, Muranga
xiv) Nyongara Dagoretti CPC in Nairobi

At each CPC, face-to-face interviews were held with the chairmen and/or members of the CPC management committees and/or CPC managers and/or operating personnel. The people interviewed are provided under the detailed report on each CPC.

A physical inspection of the CPC systems and equipment was carried at each site.

The interview and physical inspections relating to the technical aspects of the survey aimed to capture the system technical details and the operation and maintenance performance data and included:

- Energy sources and harnessing technologies (solar, wind etc.)
- Design and operating capacities
- Distance from the grid
- Country sources of the equipment
- Availability of technical capacity for servicing and repair of the systems
- Operating status of the power system and operating procedures
- Maintenance status of the power system
- Inventory management and control
- Technical capability of personnel for operation and maintenance
- Performance monitoring, evaluation and reporting systems availability and adequacy

- Appropriateness of the technical design, procurement and construction plans
- The project costs including initial costs, operations and maintenance (O&M) costs, income and expenditure and other associated costs and financial management systems

The interview relating to the business aspects of the field survey aimed at capturing data on the types and nature of businesses (productive uses), customer profiles, business operating systems in place, and organisational setup and management systems. The data sought included:

- Form and nature of business or productive use supported by energy kiosks power supply
- Business ownership structure
- Energy kiosk organization structure
- Composition of the management committee
- Evolution and current status of the business operation
- Customer profiles i.e. household, individual etc.
- Management and operating staff profiles
- Income and expenditure patterns
- Data acquisition (financial), utilization and record keeping
- Management challenges and opportunities
- Community capacity building activities and plans.

A structured interview schedule designed to generate the above data and information was used to guide the interview. This is attached as Annex 1 to this report.

TASK 3 Data Analysis and Interpretation

The data and information collected was analysed to establish:

- Technology types and power system configurations (single technology or hybrid)
- Power system status of operation and maintenance
- Business types and description including management and organization structures and capacities
- Financial performance of the CPC business.
- Challenges and opportunities

The results were discussed with UNIDO's Renewable Energy Expert, Mr. Felix Kiptum.

The interpretation of the results through discussion was undertaken to provide meaning to the findings that led to the recommendations presented.

No significant quantitative data was gathered during the survey, so the data analysis and interpretation was mostly qualitative.

Task 4 Reporting

Four reports are the key deliverables of the assignment. Two reports have been prepared and submitted. This is the third report.

3 REVIEW OF THE UNIDO CPC PROGRMME

UNIDO is the specialized agency of the United Nations that promotes industrial development for poverty reduction, inclusive globalization and environmental sustainability. Its mandate is to promote and accelerate sustainable industrial development in developing countries and economies in transition, and work towards improving living conditions in the world's poorest countries by drawing on its combined global resources and expertise.

In recent years, UNIDO has assumed an enhanced role in the global development agenda by focusing its activities on poverty reduction, inclusive globalization and environmental sustainability. UNIDO focuses on three main thematic areas:

- Poverty Reduction through Productive Activities
- Trade Capacity-Building
- Energy and Environment

Five years ago, UNIDO, in partnership with the Government of Kenya through the Ministries of Energy, Industrialization, Environment and others identified the need to harness and enhance the use of off-the-grid renewable energy technologies to produce power that would be used in productive applications that generate income and contribute significantly to alleviation of poverty.

This resulted in the design and commencement of Community Power Centres Program under the project 'climate change adaptation by using renewable energy power systems for productive uses.

3.1 CPC Objectives

The CPC programme has been designed and developed by UNIDO and focuses on provision of energy in the non-electrified rural areas with the aim of stimulating economic performance of rural areas by development of Micro and Small Enterprises (MSEs). This is because energy is a prerequisite for sustainable industrial development.

The Community Power Centres were designed as a community-managed, decentralized electrical energy service centres powered by renewable energy technologies. They would utilise a single source of Renewable Energy (RE) system or a combination of sources (Hybrid) to produce electricity from locally available RE resources like water, organic wastes, plant oil, solar and wind etc. The electricity generated would then be used in productive activities that add value to the community's lives, produce and economic activities.

The community would use power to run small agro-processing industries that add value to their agricultural produce e.g. milling, processing, preserving etc. They would also use energy to meet household energy needs say lighting by using rechargeable LED lamps instead of the kerosene lamps widely used. The electricity would also spur the development of community-owned business support services such as ICT services.

The main objective of the CPC programme is therefore to provide energy in the non-electrified rural areas with the aim of stimulating economic growth in rural areas through the

development of Micro and Small Enterprises (MSEs). The specific objectives derived from this broad objective are:

i) Create a model of off-the-grid sustainable energy generation system using locally available renewable energy sources.
ii) Stimulate the creation of small-scale industries through the provision of affordable and clean energy.
iii) Provide social benefits by replacement of air-polluting kerosene based lighting with clean, low energy and bright LED lamps
iv) Building capacity of local communities in running renewable energy-powered, self-sustainable business support centers and small enterprises thus creating employment and income generation.

3.2 CPC Technical Design

3.2.1 Choice of RE Resources and harnessing technologies

CPCs are designed to use locally available energy resources and the programme focused on five RE energy resources, namely:

- Hydro power
- Biomass
- Solar energy
- Wind energy
- Biofuels

The above RE resources are available in Kenya in varying quantities at many locations in the country.

The RE harnessing technologies selected for the CPC programme were:

i) Water turbine generators for small hydro power (SHP) electricity generation
ii) Wind Turbine Generators (WTG) for electricity generation from wind
iii) Solar Photovoltaic (PV) for electricity generation from solar energy
iv) High Performance Temperature Controlled (HPTC) Biogas Digester for biogas production
v) Biogas Electric Generators for electricity generation using biogas fuel
vi) Straight Vegetable Oil (SVO) electric Generators for electricity generation biodiesel or vegetable oil

A CPC comprises a power source which could be one or a combination (hybrid) of the above technologies, the power control centre (PCC) which is a system that incorporates battery storage banks, inverters, control units, electric meters etc. and the loads.

A Solar PV system utilizes sunlight to generate electricity. It comprises PV panels, batteries, charge controllers, installation fittings and accessories. PV panels generate Direct Current (DC) and Inverters are incorporated to provide Alternating Current (AC) power. Solar PV technology is proven and highly reliable technology. A well designed, installed and

maintained system should operate for very long time. Maintenance is minimal and the main replacement item is the battery. Even then, good deep cycle batteries can last for over 5 years.

Wind Turbine Generators convert the kinetic energy of moving air into electricity. They are available in small and large capacities from few hundred watts to megawatts. For off-grid operation, wind turbines are generally installed with batteries to stabilize power supply. Consequently Inverters are incorporated to provide Alternating Current (AC) power. WTG technology is a proven and highly reliable technology. Maintenance is minimal and the main replacement item, like in PV, is the battery. Even then, good deep cycle batteries can last for over 5 years. A well designed, installed and maintained system should operate for very long time.

Small hydro power generators are old, proven and highly reliable with minimal operation and maintenance costs.

Biogas generators are standard internal combustion engines modified to use biogas to run a generator.

The SVO generators are standard diesel engines modified for fired using vegetable oil. Generally, they are initially diesel fired and vegetable oil, only filtered rather than refined or blended, is used to run it after attaining the operating temperature. Vegetable oil must be used up completely before it is turned off hence it must be run on diesel to start and also before its shut down.

The main shorting coming of using SVO or biogas instead of diesel is that the power output is reduced. With special conversion kits, diesel engines can readily use vegetable oil with no adverse effect on the engine or its performance.

Maintenance of the SVO and Biogas generators is required every 1000 running hours and specialized knowledge is essential.

The HPTC biogas digester has high productivity (above 10 times more) compared to traditional biogas technology that uses animal dung. It however requires precise temperature control which makes it more expensive to construct and maintain. Solar water heating systems are normally incorporated into the designs.

Generally, the choice of the RE resources took into account available local energy resources and were good. The harnessing technologies are all proven and quite reliable if well managed and maintained.

3.2.2 CPC Configurations, Capacities and Loads

The CPC configurations and capacities and loads are based on the RE resource available and anticipated loads.

Configurations

Four CPC system configurations and capacities were chosen:

i) PV – SVO Hybrid Power System

In this configuration, a PV system with battery storage works in tandem with the SVO generator. The SVO generator runs the higher power light industrial loads and boosts PV batteries when it is operating. The PV system has adequate capacity to run the common utility loads such as mobile phone charging, lanterns charging etc.

To provide AC power from a PV system, an Inverter / Charger is incorporated into the system. The charging function is used to boost the batteries when the SVO generator is running.

ii) Stand-Alone SVO Power System

In this configuration, the SVO generator backed up with battery storage is the only power source. The SVO generator runs the higher power light industrial loads and charges the backup batteries.

The system incorporates an Inverter / Charger to provide AC power from the backup battery when the SVO generator is not running and charge the batteries when the SVO generator is operating. The backup battery is meant to operate the low power common utility loads such mobile phone charging, lanterns charging etc. when the SVO generator is off.

iii) Stand Alone Biogas Power System

In this configuration, a Biogas Electric generator is the only power source. The Biogas generator runs all the loads.

The biogas is produced by the biogas digester system which is the source of the fuel.

The biogas can also be used directly for cooking, heating and lighting applications.

iv) Stand-alone small hydropower system

In this configuration, a small hydro power generator is the only power source for the CPC.

Capacities

Even though system capacities at a different CPC are slightly different and depend on harnessing technologies, configurations and loads, UNIDO appears to have settled on following capacities as standard:

- PV generator of around 2000 Watts peak (Wpk)
- 2 kW inverter/chargers
- SVO Generators of around 10 kVA
- Biogas generator of around 10 kVA

There are no standard WTG, SHP and Biogas Digester capacities. Only one WTG of 3kW has been installed under the program. Similarly only two SHP CPCs have been built, one

36kW and the other 1.5kW. The biogas digester capacities vary between 20 m³/day and 60 m³/day.

Specific capacities are provided under the report for each CPC in Chapter 4.

Loads

The power produced was to be used for lighting and productive uses.

Lighting was intended for nearby households and a typical system was expected to provide lighting to about 400 households.

Productive activities would depend on community needs and would include one or all of the following:

- Mobile phones charging stations
- LED lamps and car battery charging facility.
- An ICT Centre with computer printing, photocopying, internet and ICT training facilities.
- A community recreation center with a Television, DVD, satellite connection, etc.
- An industrial center with light industrial activities. The envisaged industrial activities included:

  - Flour milling
  - Metal welding
  - Carpentry workshops
  - Barbers and Hair Salons
  - Poultry incubators,
  - Juice extraction
  - Briquettes making
  - Soap making

The capacity, configuration and load are site specific and are based on local community needs at each CPC. Details are included in the report for each CPC.

3.3 Ownership and Management

According to the design, the beneficiary communities or entities would own and manage the operation and maintenance of the CPCs. Communities were encouraged to organize themselves as either community based organizations (CBO), welfare associations or savings and credit societies (Saccos) and seek Government registration.

UNIDO was to build adequate capacities for effective management and operation of CPCs as profitable business ventures.

Consequently, UNIDO would hand over the CPC after installation, testing and commissioning.

3.4 CPC Business Model

3.4.1 Financing

Stakeholders in various CPCs were involved in the implementation and contributed in cash or in kind towards the realization of the CPCs. In most cases, beneficiaries only contributed land required for the CPC and some labour. Some beneficiaries contributed cash mainly for purchase of local accessories and fittings.

In general UNIDO would secure financing internally or from other partners such as UNEP and aid agencies to finance the project.

To ensure sustainability, CPCs were to generate revenue for operation and maintenance. The CPCs were designed to generate revenue from the services the CPC would be offering to the community and also from productive uses made of the energy generated.

According to the business model, a typical CPC would serve 400 households. These households would be encouraged to buy 1000 rechargeable LED lamps. These lamps would be recharged once a week.

It was also projected that the community would have 200 mobile phones that would be recharged twice a week and about 50 car batteries would be recharged once a week.

The CPC would also generate income from productive activities.

The projected income of a typical CPC from all sources would be as provided in Table 3.1.

Table 3.1: Projected income from a typical CPC

	Activity	**Monthly Income**
1	LED Lamps charging	80,000.00
2	Mobile phones charging	16,000.00
3	Car batteries charging	10,000.00
4	Internet and Computer services	10,000.00
5	TV/Video Entertainment	8,000.00
6	Barber (Hair cutting)	2,000.00
7	Rent and electricity sales	5,000.00
8	Soap making	12,000.00
9	Maize milling	3,000.00
10	Juice making	4,000.00
Projected Monthly income		150,000.00
Projected Annual Income		**1,800,000.00**

The projected expenditure of a typical CPC from all sources was as provided in Table 3.2.

Table 3.2: Projected expenditure from a typical CPC

	Description	**Monthly Cost (KShs)**
1	Maintenance of Equipment	15,000.00
2	Salaries of 2 caretakers	10,000.00
3	Consumables	5000.00
4	Contingencies	5000.00
Projected Monthly Expenditure		35,000.00
Projected Annual Expenditure		**420,000.00**

The initial costs of the CPCs were projected to vary between KShs 500,000.00 to 10,000,000 depending on the capacity of the CPC and technologies employed.

Based on the above income and expenditure, the net annual income would be KShs 1,380,000.

Assuming the initial CPC cost is the minimum estimated amount of KShs 500,000.00, then the payback period would be only 4 months and the Return on Investment (ROI) would be 278%.

Assuming the initial CPC cost is the maximum estimated amount of KShs 10,000,000.00, then the payback period would be 7 years and 3 months and the Return On Investment (ROI) would be 13.9%.

Based on the projected costs, incomes and expenditures the CPCs would be financially self-sustaining.

Where data and information was availed, financial analysis is provided in Chapter 4.

3.5 Project Implementation plan

The Consultant was not provided with the project implementation plan.

It is however clear that UNIDO played the lead role in all cases and provided the requisite technical assistance for systems engineering, procurement, construction and commissioning of the CPC systems.

4 SURVEY RESULTS

4.1 Olosho Oibor CPC

4.1.1 Introduction

Olosho Oibor is a community centre located in Kedong Valley in Kajiado County, about 12 km from Ngong Town. It is 35 km from Nairobi City.

The community centre has a Dispensary, a Primary School, a Church, a Safe House for Girls and households in the surrounding areas. The community has a population of an estimated 8000 people.

The community centre is 6 km away from the nearest national power grid.

The idea of the establishment of the Olosho Oibor CPC was initiated by the Principal of the Primary School, Mr. Paul Sekuda, who approached UNIDO for assistance.

UNIDO took up the idea and developed it into an energy centre under its CPC program.

Figure 4.1.1: Olosho – Oibor CPC

The community's main aim was to generate power to supply the communal facilities mainly the Dispensary and Primary School buildings which also have staff houses. UNIDO involvement broadened the scope of services to include productive uses in addition to supplying nearby households.

The Olosho Oibor CPC was designed to generate electricity for the following applications within the community:

- Lighting and operating appliances at the Dispensary and school buildings including staff houses

- Lighting and operating appliances in private households
- Charging of mobile phones and rechargeable LED lamps
- Powering social entertainment centre equipped with Satellite TV and Video players
- Youth operated Barber shop or Hair Clipping
- Powering an ICT centre that would provide internet access and ICT services such as photocopying, printing, computer use training, etc.
- Powering metal workshop equipment mainly Welding machine and Grinder.
- Women operated soap making business

The persons listed in Table 4.1.1 were interviewed during the performance audit survey:

Table 4.1.1: CPC personnel interviewed during the survey

	Name	**Designation/Role**
1	Simon Parkesian	CPC Manager and CBO Secretary

During the visit, the Consultant briefly met the Chairman Mr. Paul Sekuda.

4.1.2 Power System Status

i) Renewable energy sources and harnessing technologies

The energy sources for Oloscho-Oibor CPC are Solar, wind, a biofuel - Straight Vegetable Oil and automotive Diesel.

The harnessing technologies employed are a wind turbine generators (WTG), photovoltaic technology (PV) and Duo-fuel straight vegetable oil (SVO)/Diesel electric generator.

ii) System configuration, capacities and Loads

The system is configured to operate as illustrated in Figure 4.1.2.

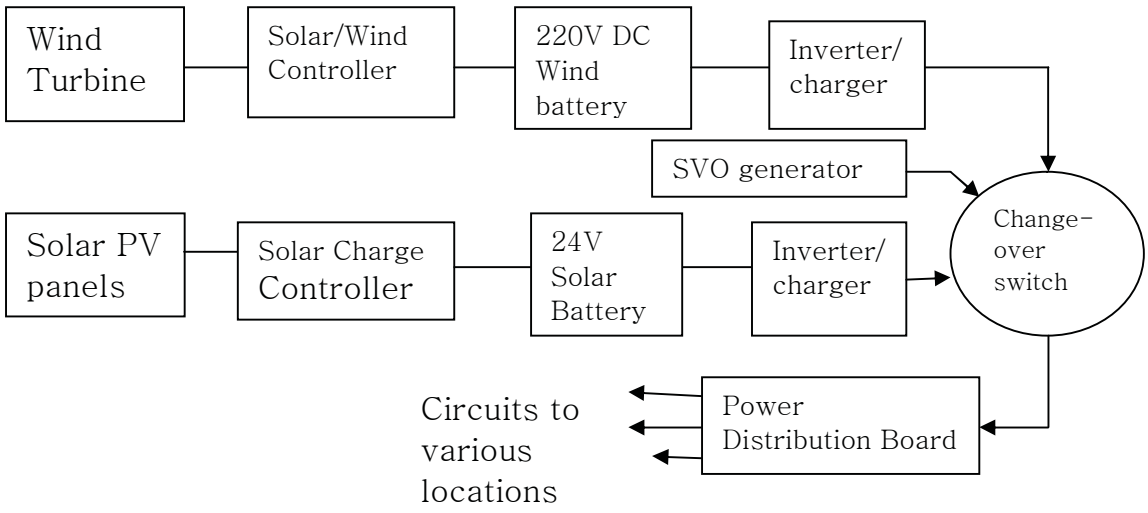

Figure 4.1.2: Power system configuration

The SVO/Diesel Generator is operated to run workshop welding and grinding machines and also boost the batteries when it is operating.

The installed total system peak capacity is 14kW broken down as under:

PV system = 2 kW
Wind = 3 kW
SVO = 9 kW

iii) Suppliers and equipment source countries

The power system was supplied and installed by Glitter City Illumination Company of Schenzhen, China using equipment from various manufacturers. The equipment and manufacturers are provided in Table 4.1.2.

Table 4.1.2. Equipment suppliers and source Countries

	Equipment/Component Description	***Supplier***	***Manufacturer***	***Source Country***
1	160W PV Panels,14 No.	Shenzen Glitter Illumination Co	Not indicated	China
2	Wind/Solar Controller-3kW Wind, 2kW Solar PV; 220VDC	Shenzen Glitter Illumination Co	Not indicated	China
2	Solar Charge Controller, 40A	Shenzen Glitter Illumination Co	Xantrex Corp	USA

3	Wind Turbine	Shenzen Glitter Illumination Co	Not indicated	China
4	Inverter / charger type 1- 2000W	Shenzen Glitter Illumination Co	Not indicated	China
5	Inverter/Charger type 2	Shenzen Glitter Illumination Co	Outback Power Systems	USA
6	Sealed Lead Acid Batteries type 1 – 100AH, 12V	Shenzen Glitter Illumination Co	GuangDong Zhicheng Champion	China
7	18 Sealed Lead Acid Batteries type 2, 200A, 12V	Shenzen Glitter Illumination Co	Sunnyway battery co.	China
8	2 Solar Charge Controllers, 40A	Shenzen Glitter Illumination Co	Xantrex	USA
9	9 kW Duo-Fuel (SVO/Diesel) Generator	Riemag Industries, Germany	Fully Green Power Co Ltd	China

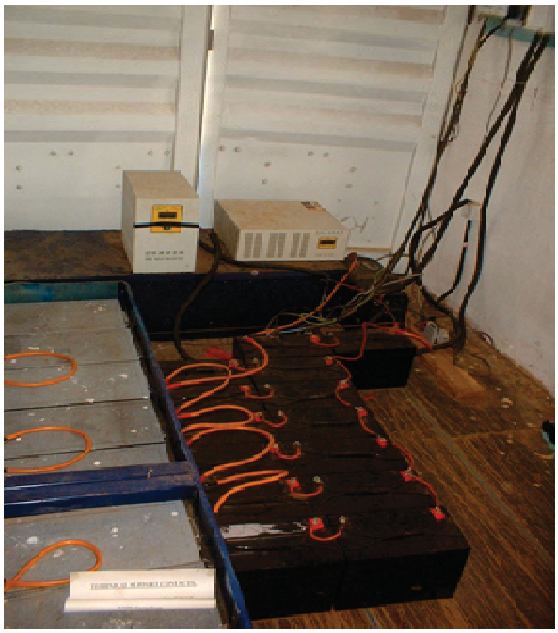

Figure 4.1.3: Olosho CPC system components: Power System controls – Inverter, Solar/Wind Controller , storage batteries and the Wind Turbine

Figure 4.1.4: CPC System Components: The Duo-Fuel Generator with Rencon's John Kyalo taking down the details

The system installed loads are provided in Table 4.1.3.

Table 4.1.3: Olosho CPC Installed Load

	Load Description
1	Mobile phones and LED lanterns charging bay and lighting
2	ICT Centre: 4 No. Dell desktop computers c/w keyboard, LCD screens; 1 Canon Photocopier; 1 HP Scanner; 1 HP Printer all c/w accessories and lighting
3	Social Hall: 21'' LG TV, DVD/CD Players
4	Workshop: Welding Machine and metal Grinder (12kVA)
5	Dispensary: 1 Desktop PC and lighting including staff houses, medical refrigerator 2 Nurses Houses: Lighting and TV
6	Primary School: 4 desktop computers c/w accessories, 1 Scanner and Printer and lighting 5 Staff Houses: TV and lighting
7	Safe House for Girls: Lighting
8	2 Private Houses: TV and lighting
9	Shop: Lighting

Based on the above, the estimated power demand after diversity is 10kW. The power system is therefore adequate to meet the demand.

4.1.3 Operation and Maintenance status

i) Operation situation

The installation of the CPC was carried out in year 2009. The system was commissioned in November 2009.

According to the CPC manager, the system operated fairly well between 2009 and 2011. During that period, the system adequately catered for the connected loads. After sometime, the Solar/Wind Controller failed and equivalent replacement could not be obtained easily. Indeed, the system was initially operated in a hybrid mode with a single solar and wind controller, one inverter and one 220V DC battery bank.

To get the system to work again, some modifications were made:

- The solar PV system was separated from the wind system and two new solar charge controllers and a new 24V Inverter, 2kW Outback Inverter/Charger and a 700AH, 24V battery introduced for the solar system only. This solar system is currently working.

- The wind system remained with the initial 200AH, 220V DC battery bank, the wind/Solar Controller and the initial 2kW Inverter/Charger. According to the CPC manager, the wind system is operating poorly. It was observed that 2 new, 100 AH, 12V batteries wired in parallel (equivalent to 1 battery of 200AH) were added to the system to boost the voltage from the initial nominal 216VDC obtained from 18 batteries to 228 VDC. This indicates that the wind system is operating poorly since this addition is unnecessary. It is also not advisable to mix differently rated batteries in a system in this manner.
- A 3-way change over switch was introduced so that only one system could be used at a time. With the current configuration, only one power source can be used at a time, wind, solar or the SVO generator.
- The SVO/Diesel generator, which was intended for heavy loads such as welding and battery boost charging, is hardly used. The main reason for not using it is lack of funds for fuel purchase. A vegetable oil fuel supply mechanism has not yet been established.

The system is currently operating poorly and can hardly support the connected load even though the installed capacity would be adequate if the wind and SVO generator systems were operating. The system frequently shuts down especially when the weather is cloudy mainly because of lack of bright sunshine which is critical to PV systems operation.

As far as operations are concerned, there are no established day to day operation procedures. The system is left in operation all the time and there is no control of usage. Only the Hair cutting shop and the charging stations operate for 8 hours, 5 days a week during the day. The other customers use it as they deem fit and at any time.

ii) Maintenance Situation

The inspection of the system, as is evident from above pictures, shows that it is in poor maintenance situation:

- The cables are hanging loosely everywhere
- Batteries are covered with dust and terminals are not clean

- The solar PV panels are dusty
- The SVO generator is covered with dust.

In general very little maintenance activities are undertaken to keep the system in good working condition

It is expected that such CPCs would keep an inventory of consumables and spares for maintaining and servicing such systems, even though the systems are low maintenance. No such inventory exists.

iv) Technical capacities for operation and maintenance

Well designed and operated RE systems require little attention to keep them in good operating condition. There is therefore a need to build appropriate technical capacities for operation and maintenance for such systems.

According to the CPC manager, CPC personnel were not provided with any training to operate and maintain the systems. They were shown only know how to turn the systems on and off. Whenever the system has a problem, the CPC manager looks for ordinary Electricians for help. The CPC contacts UNIDO for assistance if the problem is beyond the Electrician's capability.

It is expected that user operation and user manuals would be provided to the CPC. No such manuals were provided.

In general, no significant technical capacity for proper operation, servicing and maintenance exists at the CPC.

v) Performance monitoring, evaluation and reporting

It would be expected that the CPC, being a centre generating and selling energy and related services would set up a monitoring system that would involve data capture, evaluation and reporting on the system operation. One would expect to see a record of energy generated, energy sold, record on servicing, repair and maintenance operations, monthly reports and even annual reports.

For this CPC no performance monitoring and evaluation system was established. UNIDO used to request some information but this is not provided any more.

vi) Technical design, equipment procurement and construction plans

The Consultant did not gain access to the technical designs, procurement and construction plans used. UNIDO played the lead role in all cases and took charge of the technical designs, equipment procurement and construction planning of the CPC. The community played minimal role in the planning and from the brief description provided by UNIDO, the implementation plans were adequate.

In this CPC, UNIDO used external consultants and contractors for the design, supply, construction and commissioning. That the systems were procured, installed and operated well for the last two and half years points to good planning by UNIDO.

4.1.4 Business Status

The CPC was set up to provide electricity for productive use and also for sale to neighbouring households.

The establishment of the Olosho Oibor CPC was accompanied with the establishment of business activities which are provided in Table 4.1.4. Their status is also provided.

Table 4.1.4: Business activities at the CPC and current Status

	Business Activity	**Current Status**
1	Charging station	Operating
2	Electricity sales	Operating
3	Barber or Hair Clipping	Operating
4	ICT services	Not operating
5	Metal workshop.	Not operating
6	Entertainment from Satellite TV and Video players	Occasionally operating
7	Soap manufacture	Not operating

The nature and performance of each of the above business activities is briefly described hereunder

i) Charging station

This business started at the same time as the CPC and is run by the CPC management. This was made possible by UNIDO which provided a section of a Container in which the charging station is housed. UNIDO also provided some LED rechargeable lamps, some for free to the residents. About 200 LED lamps were acquired by the community which created a client base for the charging station.

The charging station is simply a bank of power sockets that are connected to the power supply. It is used to charge mobile phones, rechargeable LED solar lanterns and car batteries. Mobile phones and LED lamps have own power adaptors so one needs only plug them into the socket. Car batteries need a conventional mains Charger which UNIDO provided.

This business has been in operation for the two and half years the CPC has been in operation and it is still functional.

Customers pay KShs 20 per phone, KShs 60 per car battery and KShs 30 per LED lamp.

Between 15 and 20 mobile phones are charged per day.

The LED lamps charging business is small as few lamps are charged at the station per month. Car battery charging business is small averaging 12 batteries per month

This business is run by the CPC itself. The CPC Secretary runs the business.

ii) Hair Cutting

A hair cutting business just needs a premises with power sockets that are connected to the power supply, a chair and hair clippers and of course the barber.

Figure 4.1.5: The Barber Shop and Charging Station

Just like the charging station, the business started at the same time as the CPC. UNIDO provided a section of a container and installed power socket.

This business has been in operation for the two and half years the CPC has been in operation and it is still functional.

The station has about 10 adult customers on average per month. When schools are open, there is much more business from school children. The CPC charges KShs 30 per child and KShs 50 per adult for Hair clipping.

This business is run by the CPC itself. The CPC has engaged a Barber who is paid according to the number of customers attended to. The Barber gets KShs 10 for every child and KShs 20 for every adult customer.

iii) Electricity sales to neighboring premises and a Shop.

The CPC sells electricity to the Dispensary, School, the Church and Households and a Shop housed within the CPC Container. All these were connected immediately after the CPC was established.

This is straight forward business and the customers pay fixed amounts ranging between KShs 200 and KShs 700 per month. The CPC has a total of 12 electricity customers paying a total of KShs 4,600 per month.

A safe house for Girls is set to be connected soon.

iv) ICT services

This business started immediately the CPC was operational.

UNIDO facilitated the business by donating 4 computers, a Photocopier; a Scanner and a Printer. UNIDO also engaged the ICT Trainer. Furthermore the ICT centre was housed in the UNIDO provided Container which houses the power system hence space was immediately available.

Figure 4.1.6: ICT Centre and TV in the Social Hall

Other than for photocopying, which is also occasional and mainly for the School and internal use the ICT business is no longer functional mainly because there is no Trainer. The CPC used to bring and pay the Trainer but currently the business cannot support the training. The system is also performing poorly..

v) Metal Workshop

There is a small metal workshop with a Welding machine and Grinder. This workshop can only operate from the SVO generator which requires either Diesel or Vegetable Oil. Diesel is

very expensive and vegetable oil is unavailable as no supply mechanism exists. This business is therefore closed.

vi) Entertainment from Satellite TV and Video players

This is a free service which is available occasionally. However, the CPC charges KShs 10 per person for Video shows and KShs 20 per person for major football matches like English Premier League.

vii) Soap Making

It was intended that women members would use CPC to make soaps and sell within and without the community. The equipment was provided by UNIDO and women trained to make soap.

This business started and operated briefly and fizzled out as members lost interest. According to the CPC manager, some members started making soap at home and selling locally creating direct competition which contributed to the early demise of the soap making at the CPC.

Soap making does not need the electricity much.

4.1.5 Financial Analysis

The CPC project was fully financed by UNIDO with the support of the Australian Government at a total cost of US$ 97250 (KShs 7.78 million). The community contributed the land the CPC occupies and some labour.

The CPC has not employed any accounting personnel and no formal financial records are kept and no financial information was provided by the CPC manager.

UNIDO donated the CPC equipment so the CPC does not have to pay it back and UNIDO does not expect any monetary returns from CPC investment. The CPC should at least generate adequate revenue to meet its recurrent expenses (i.e. salaries, routine maintenance, consumables etc.) and occasional equipment repair and replacement costs.

In the absence of financial information relating to the CPC operations, it was not possible to undertake any meaningful financial analysis..

4.1.6 Institutional Analysis

i) Ownership

The Olosho-Oibor community has a population of about 1000.

The CPC is however owned by a community based organization called Ewangen CBO which has 125 members. To become a member, one must be a resident of the area and must pay a one-off admission fee of KShs 300.

The members gain from CBO activities like marketing of beads made and planned acquisition of Bee Hives.

ii) Organization structure

The CBO has a Board of Directors of 12 people elected by the members. The board has three key officials, the Chairman, secretary and Treasurer designs the board is organized. Currently, the Chairman is Mr. Paul Sekuda, the Secretary is Mr. Simon Parkesian who is also the CPC manager and the Treasurer is Daniel Kinaiya, The board has 5 ladies.

The committee prepares the CBO plans and strategies and oversees their implementation. The manager is responsible for the day to day operation of the CPC. He has two staff members the office Secretary and the Guard.

iii) Management Challenges

The management of the CPC is facing three challenges.

The first major challenge is raising funds to hire and maintain qualified personnel to operate the CPC. The current CPC Manager and the two staff members get much less pay than what UNIDO was paying them.

The second major challenge is lack of properly trained and skilled technician to operate and maintain the system. The operation and maintenance training provided by UNIDO contractors and consultants was rudimentary and inadequate.

The last major challenge is in business management. UNIDO provided some training which the CPC Manager and Secretary attended but feels it was inadequate to enable him run the CPC as a business.

Currently there are no ongoing plans for capacity build up for the community to address above management challenges.

4.2 Changara CPC

4.2.1 Introduction

Changara is a market centre located 6 km from Malakisi and about 36km from Bungoma town. It is near the Kenya-Uganda border.

The market centre has a good number of shops offering various services including restaurants, general merchandise shops, Barber Shops etc.

The market centre is currently on grid power but the CPC was established when the nearest national power grid was about 8km away.

The idea of the establishment of the Changara CPC was initiated by UNIDO in collaboration with the Bungoma District Business Solution Centre (DBSC), an initiative of the Ministry of Trade that was being implemented in selected districts in the country, referred to as millennium districts which have substantial support from the UNDP.

Figure 4.2.1: Changara CPC

UNIDO mobilised the community to organize itself into CBO to facilitate the implementation and management of the CPC. This resulted in the establishment of the Changara Multipurpose CBO.

The Changara CPC was designed to generate electricity for the following applications within the community:

- Lighting and operating appliances in the shops at the market

- Charging of mobile phones and rechargeable LED lamps
- Powering social entertainment centre equipped with Satellite TV and Video players
- Barber shop or Hair Clipping
- Powering an ICT centre that would provide internet access and ICT services such as photocopying, printing, computer use training, etc.
- Powering metal and wood workshop equipment
- Micro grid for sale of electricity to the market buildings for various applications
- Soap making business
- Poultry Incubator

The persons listed in table 4.2.1 were interviewed during the performance audit survey:

Table 4.2.1: CPC personnel interviewed during the survey

	Name	**Designation/Role**
1	Julius Wamalwa	Chairman
2	Livingstone Otwane	CPC Manager and Secretary
3	Beatrice Opagala	Treasurer

4.2.2 Power System Status

iv) Renewable energy sources and harnessing technologies

The energy sources for Changara CPC are Solar and biofuel i.e. Straight Vegetable Oil and automotive Diesel.

The harnessing technologies employed are photovoltaic technology (PV) and Duo-fuel straight vegetable oil (SVO)/Diesel electric generator.

v) System configuration, capacities and Loads

The system is configured to operate as illustrated in Figure 4.2.2.

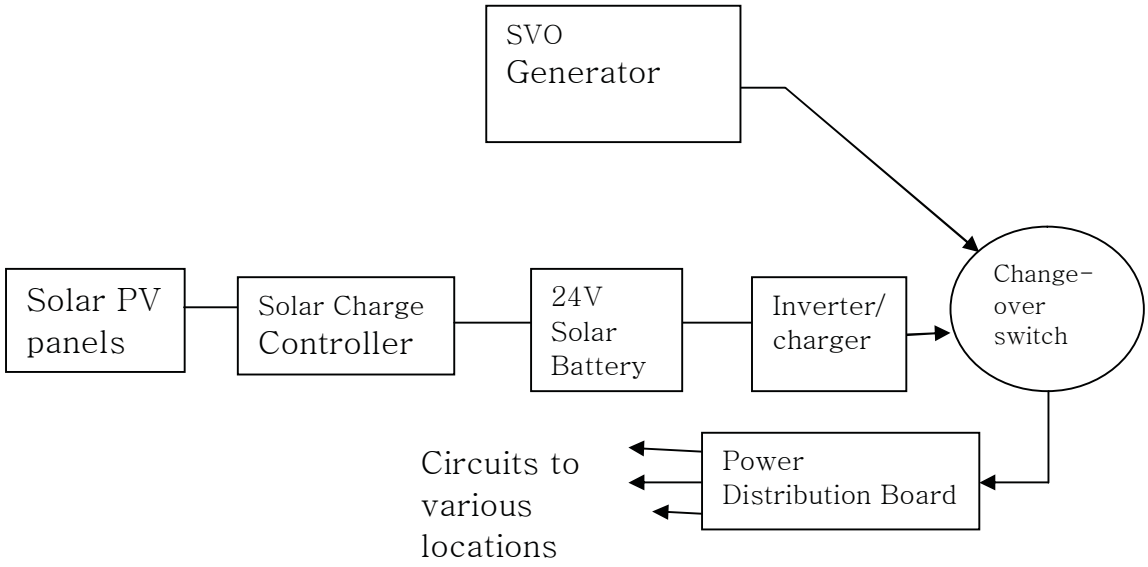

Figure 4.2.2: Power system configuration

The installed total system peak capacity is 9.8 kW broken down as under:

PV system = 1.8 kW
SVO = 8 kW

vi) Suppliers and equipment source countries

The power system was supplied and installed by Premier Solar Systems of India. The equipment and manufacturers and source countries are provided in Table 4.2.2.

Table 4.2.2. Equipment suppliers and source Countries

	Equipment/Component Description	***Supplier***	***Manufacturer***	***Source Country***
1	150W PV Panels,12 No.	Premier solar systems	Premier Solar Systems	India
2	Solar Charge Controllers, 2No.40A and 60A	Premier solar systems	Xantrex Corp	USA
4	Inverter / charger 2.4kW, 1No.	Premier solar systems	Xantrex	USA
6	Flooded Batteries type 350AH, 6V, 8 No.	Premier solar systems	Fulmen	France
8	System Controller/Stabilizer	Premier solar systems	Optisolar	USA
9	8 kW Duo-Fuel (SVO/Diesel) Raptor Generator	Premier Solar systems	Eternal Energy	Germany

NB: The source country refers to the country where the manufacturer's headquarters is based rather than where the equipment is made. Almost all the companies have subsidiaries in other countries.

Figure 4.2.3: Changara CPC system components: Power System Optisolar Controller – Inverter, storage batteries and a section of the SVO generator (yellow)

Figure 4.2.4: The 8 kW Raptor SVO Generator

The system installed loads are provided in Table 4.2.3.

Table 4.2.3: Changara CPC Installed Load

	Load Description
1	Mobile phones and LED lanterns charging bay
2	ICT Centre: 4 No. Dell desktop computers c/w keyboard, LCD screens; 1 Canon Photocopier; 1 HP Scanner; 2 HP Printer all c/w accessories and lighting
3	Social Hall: TV, DVD/CD Players
4	Workshops: Welding Machine, metal Grinder and wood working machine
5	Hatchery: Poultry Incubator
6	Soap making machine
7	Microgrid supplying various premises at the market. Mostly used for lighting, hair clipping, TV and charging.
8	Vegetable Oil expeller/press

Based on the above, the estimated the power demand after diversity is about 10kW. The power system is dequate to meet the demand.

The system was designed, installed and commissioned by UNIDO appointed contractors and Consultants. The main supplier and installer of the system was Premiew Solar Systems of India.

4.2.3 Operation and Maintenance status

i) Operation situation

The installation of the CPC was carried out in year 2009. The system was commissioned in May 2009.

According to the CPC manager, the solar system has operated fairly well. However, the SVO generator developed overheating problems from the start and an improvised water cooling system was installed.

Recently, it was discovered the generator gaskets are burnt. The Consultant advised the centre not to run it at all as this will ruin the engine resulting in very expensive repairs.

It is not clear how the engine cooling system would have escaped the installers.

Figure 4.2.5: Improvised Cooling system

Even when the SVO/Diesel generator was operational, it was used occasionally for the heavier loads because Diesel is very expensive. No vegetable Oil production and supply mechanism was established.

Currently only the solar PV system is operating well. However, it cannot meet the demand. The installed capacity would only be adequate if the SVO generator system was operating. The system frequently shuts down especially when the weather is cloudy mainly because of lack of bright sunshine which is critical to PV systems operation.

As far as operations are concerned, there are no established day to day operation procedures. The system is left in operation all the time and there is no control of usage. The businesses operate during the day but some shops use the system at night. The customers use the system as they deem fit and at any time.

ii) Maintenance Situation

No planned maintenance activities are carried out at the CPC. The CPC attends to breakdowns which have been common with the Generator.

In general very little maintenance activities are undertaken to keep the system in good working condition

It is expected that such a CPC would keep an inventory of consumables and spares for maintaining and servicing such power systems, even though the systems are low maintenance. No such inventory exists.

iv) Technical capacities for operation and maintenance

Well designed and operated RE systems require little attention to keep them in good operating condition. There is therefore a need to build appropriate technical capacities for operation and maintenance for such systems.

According to the CPC officials interviewed, CPC personnel were not provided with adequate training to operate and maintain the systems. Whenever the system has a problem, the CPC manager looks for ordinary technicians for help. The CPC contacts DBSC in Bungoma and UNIDO for assistance if the problem is beyond the technician's capability. Support by DBSC has however been minimal.

It is expected that user operation and user manuals would be provided to the CPC. No such manuals were provided.

In general, no significant technical capacity for proper operation, servicing and maintenance exists at the CPC.

v) Performance monitoring, evaluation and reporting

It would be expected that the CPC, being a centre generating and selling energy and related services would set up a monitoring system that would involve data capture, evaluation and reporting on the system operation. One would expect to see a record of energy generated, energy sold, record on servicing, repair and maintenance operations, monthly reports and even annual reports.

The CPC has kept records of daily income and energy meter reading for 6 months only.

This CPC has no adequate performance monitoring and evaluation system.

vi) Technical design, equipment procurement and construction plans

The Consultant did not gain access to the technical designs, procurement and construction plans used. UNIDO played the lead role in all cases and took charge of the technical designs, equipment procurement and construction planning of the CPC.

In this CPC, UNIDO used external consultants and contractors for the design, supply, construction and commissioning. That the systems were procured, installed and operate well other than for the SVO generator points to good planning by UNIDO.

4.2.4 Business Status

The CPC was set up to provide electricity for productive use and also for sale to businesses in the market centre.

The establishment of the Changara CPC was accompanied with the establishment of business activities which are provided in Table 4.2.4. Their status is also provided.

Table 4.2.4: Business activities at the CPC and current Status

	Business Activity	**Current Status**
1	Charging station	Operating
2	Electricity sales	Operating
3	Barber or Hair Clipping	Operating
4	ICT services	Not operating
5	Metal and wood workin workshop.	Not operating
6	Entertainment from Satellite TV and Video players	Occasionally operating
7	Soap manufacture	Not operating
8	Hatchery/Poultry Incubator	Not working
9	Electricity sales (micro-grid system)	Working

The nature and performance of each of the above business activities is briefly described hereunder

i) Charging station

This business started at the same time as the CPC and is run by the CPC management. A building at the market centre was rented to house the charging station. UNIDO also provided some LED rechargeable lamps, which were sold to the residents. These created a client base for the charging station.

The charging station is simply a bank of power sockets that are connected to the power supply. It is used to charge mobile phones, rechargeable LED solar lanterns and car batteries. Mobile phones and LED lamps have own power adaptors so one needs only plug them into the socket. Car batteries need a conventional mains Charger.

This business has been in operation for the two and half years the CPC has been in operation and it is still functional.

Customers pay KShs 10 per phone charging which is the main business of the CPC besides electricity sales to the other shops at the market.

About 40 mobile phones are charged per day.

Figure 4.2.6: Charging station. The LED lamps (Accendo from India, yellow) seen on the ground

The LED lamps charging business is small as few lamps are charged at the station.

This business is run by the CPC itself, which uses the income from the business to pay some allowance to the operator.

ii) Hair Cutting

A hair cutting business just needs a premise with power sockets that are connected to the power supply, chairs and Hair clippers and of course the Barbers.

There are three hair cutting businesses that are in operation. These are run by private entrepreneurs who pay for electricity supply from the CPC.

These businesses existed before the CPC came into being but quickly started using electrically operated Hair Clippers as soon as CPC became operational.

Figure 4.2.7: The Barber Shops

iii) Electricity sales to neighboring premises and a Shop.

The CPC sells electricity to three Barber shops, two restaurants and a Cybercafe.

This is straight forward business and the customers pay fixed amounts for electricity use per month.

Some businesses are now shifting to the grid power system which has been extended to the market.

iv) ICT services

This business started immediately the CPC was operational.

UNIDO facilitated the business by donating 4 computers, a Photocopier; a Scanner and two Printers.

Figure 4.2.8: ICT Centre

The photocopier became faulty and has never been repaired. The ICT business is no longer functional mainly because the system is performing poorly and lack of funds for hiring a Trainer. There is also the issue of management and ownership dispute with Bungoma DBSC.

v) Metal Welding, and Wood work and Poultry Incubator

UNIDO provided a welding and a woodworking machines to start this business.

Figure 4.2.9: Welding and woodworking machines provided by UNIDO

UNIDO also provided a poultry Incubator.

Figure 4.2.10: Poultry Incubator provided by UNIDO

These machines can only operate from the SVO generator which requires either Diesel or Vegetable Oil. Diesel is very expensive and vegetable oil is unavailable as no supply mechanism exists. These businesses never took off.

vi) Entertainment from Satellite TV and Video players

This is a free service which is available to the residents.

Figure 4.2.11: Residents watching TV at the Social Centre

vii) Soap Making

It was intended that the CPC would make liquid soaps and sell within and without the community. The equipment was provided by UNIDO and some people trained to make liquid soaps.

Figure 4.2.12: Soap making machine

This business never took off due to lack of adequate power supply.

4.2.5 Financial Analysis

The CPC project was fully financed by UNIDO and the total cost was US$ 208,500 (KShs 17.72 million). The community contributed the land the CPC occupies and some labour.

The CPC has not employed any accounting personnel and no formal financial records are kept and no financial information was provided by the CPC.

UNIDO donated the CPC equipment so the CPC does not have to pay it back and UNIDO does not expect any monetary returns from CPC investment. The CPC should at least generate adequate revenue to meet its recurrent expenses (i.e. salaries, routine maintenance, consumables etc.) and occasional equipment repair and replacement costs.

In the absence of financial information relating to the CPC operations, it was not possible to undertake any meaningful financial analysis..

4.2.6 Institutional Analysis

i) Ownership

It was anticipated that the CPC would be owned by the community through a CBO which

was established with a membership of 100 people. The involvement of the Government through the DBSC has created an ownership dispute.

The DSBC claims the CPC is Government property but the Changara multi-purpose CBO claims UNIDO donated the CPC to them. This dispute has not been resolved. The CPC was ordered to deliver cash collected to DBSC in Bungoma, which it does.

ii) Organization structure

The CBO has its management committee elected by the members. The board has three key officials, the Chairman, secretary and Treasurer. Currently, the Chairman is Mr. Julius Wamalwa, the Secretary is Mr. Livingstone Otwane who is also the CPC Manager and the Treasurer is Beatrice Opagala.

The DBSC sets the agenda for CPC operation but has not employed any staff to manage the CPC. Indeed the CBO committee pays the charging station operator. The CPC Manager is volunteering his services.

The CBO has decided to take care of the CPC equipment until the ownership of the CPC is resolved and proper organization structure is put in place.

iii) Management Challenges

The CPC is facing some challenges.

The first challenge is ownership of the CPC. Until this is resolved then proper operation is not possible.

The second major challenge is lack of properly trained and skilled technician to operate and maintain the system. The operation and maintenance training provided by UNIDO contractor and consultant was inadequate.

The third major challenge is lack of working capital. UNIDO simply handed over the CPC after commissioning and the CBO could not raise operating cash. With the exception of the Generator house, all other buildings are rented hence the CPC has to pay monthly rent.

Currently there are no ongoing plans for capacity build up for the community to address above management challenges.