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ELECTRICAL POWER SITUATION AND ALTERNATIVE ENERGY OPTIONS FOR SACCOs

FINAL REPORT

JULY 2006

This publication was produced for review by the United States Agency for International Development. It was prepared by Chemonics International Inc.

Rural SPEED

Rural Savings Promotion & Enhancement of Enterprise Development

ELECTRICAL POWER SITUATION AND ALTERNATIVE OPTIONS OF SACCOs

FINAL REPORT

Rural SPEED
A USAID funded project
Contract No. PCE-I-00-00003-00 TO 826

This report submitted by Chemonics International Inc. / July 2006

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LIST OF ACCRONYMS

AC - Alternating current
AVR - Auto –voltage regulator
BUDS - Business Uganda Development Scheme
CRT - Cathode ray Tube
DC - Direct current
ERT - Energy for rural transformation
ICT - Information and communication technology
KWH - Kilowatt hour
LAN - Local area network
LCD - Liquid crystal display
MAMIDECOT – Masaka Micro-finance Development Cooperative Trust
MIS – Management Information Systems
NPV - Net present value
PC - Personal computer
SACCO - Savings and Credit Cooperative Organization
UGX – Uganda Shillings
VAT - Value Added Tax

Executive Summary

This report details out the activities undertaken, analysis done and recommendations reached on the alternative power and computing options for five selected SACCOs affiliated to the USAID funded Rural SPEED Project. The report also gives a general recommendation on how to determine the suitable options for any given rural SACCO.

Contracted by Rural SPEED to undertake the assignment, FRIENDS Consult visited the SACCOs, observed power behaviour, interviewed SACCO managers and vendors of power and computing equipment, visited relevant sites on the internet, and made calculations and analyses that led to the recommendations made.

The technically feasible options examined are:

- Maintaining existing computing equipment
- Replacing existing computer monitors with more energy-efficient ones
- Replacing existing PCs with laptops
- Replacing the existing PCs with thin client terminals in a client server environment

For SACCO and for each of the above options, the following sub-options were examined:

- A combination of existing (if applicable) but unreliable grid power with a generator
- A combination of existing (if applicable) but unreliable grid power with a generator, and the addition of an inverter/ battery system
- Purchasing solar panels with an inverter battery
- Manual generation of power from a stationery bicycle, with an inverter battery system
- Replacement of an existing generator with a new one.

After analyzing the NPVs of the costs related to the above, recommendations have been made for each of the five SACCOs.

The general recommendations, applicable to SACCOs in different situations of grid power access, are:

SACCOs on the grid with generators as backup power source- For every SACCO on the electricity mains grid presently using a generator as a backup source of power, the most economically viable option is to install batteries and inverters as the primary backup source. They should then use the generator only as a secondary backup (emergency standby). After installing the inverters and batteries, such SACCOs should expect their grid power consumption to go up (by approximately 100%), but their overall energy cost to go down because they are no longer burning as much fuel in their generator. Grid power costs only about 5% of the overall generator running costs per KWh of power output.

SACCOs not on grid power – For every SACCOs not on the grid, the most economically viable option is to purchase generators alone rather than purchasing hybrid systems with batteries and inverters. For these SACCOs, they could save on fuel costs by using the inverter, but the additional capital costs would render the overall NPV of the costs more expensive.

1.0 BACKGROUND

1.1 Introduction

The Uganda Government and private sector are losing lots of revenue because of power crisis in the country. Since February 2006, consumers have had electricity for at most 24 hours of every 48 hours and businesses have been forced to rely on costly generators to urn their operations.

Consequently, smaller Ugandan Financial Institutions, particularly in the rural areas have suffered prolonged lack of electrical power throughout their normal working days, making it difficult to rely on computers to post accounting entries and generate operational and managerial reports. Rural financial institutions' procurement of computer and alternative power equipment has in many instances been done in well-intentioned but poorly informed ways. This means that with the persistent power shortages, use of electronic ICT equipment becomes very costly for these rural financial institutions. The lack of reliable electricity in the rural areas is key constraint to the operations and sustainability of many rural financial institutions.

Seeking to address this problem in ways that could be replicable, the USAID funded Rural SPEED hired FRIENDS Consult Ltd. (FCL) to carry out an informative study on alternative power backup options. Costs and other considerations of various power and computing options explored and the most efficient power back-up option recommended for each of the five SACCOs that Rural SPEED wanted to procure power back-up options for. This would enable Rural SPEED decide on what electrical power coping backup option to secure for each of the SACCOS

The study was carried out in five Savings and Credit cooperative organizations (SACCOs):
i) Masaka Microfinance Development Cooperative Trust Ltd. (MAMIDECOT)
ii) Muhame Financial Services Cooperative Ltd.
iii) Kyamuhunga Peoples Savings & Credit Cooperative Society Ltd
iv) Rubabo Peoples Cooperative Savings & Credit Society Ltd
v) Nyarwanya Cooperative Saving and Credit Society Ltd.

The consultants also interviewed vendors of power and ICT equipment and did extensive internet research as well as analysis to accomplish the assignment.

1.2 Objective of the Study

FCL worked together with Rural SPEED and alternative power vendors like ULTRATEC and Terrain to identify and evaluate various power and computing options available in the local market that can help these institutions. The main objectives of the study were:

a) To quantify the electrical power required for each of the five selected SACCOs to operate optimally
b) To identify and recommend the most cost effective power backup solution in terms of both investment and operating costs for each of the SACCOs,
c) To identify and recommend low power consumption computing equipments.
d) To come up with power backup models that can be replicated to other SACCOs.

2.0 SCOPE AND METHODOLOGY

In fulfillment of the *terms of reference*, the consultants carried out the following tasks and recommended best practice-based power options where relevant:
The assignment was accomplished in four major phases: the SACCO field study, power vendor survey, Low power equipment research and the construction of a costing model for analysis..

2.1 SACCO Field Study

All the five SACCOs ie Masaka Microfinance Development Cooperative Trust Ltd. (MAMIDECOT), Muhame Financial Services Cooperative Ltd., Kyamuhunga Peoples Savings & Credit Cooperative Society Ltd., Rubabo Peoples Cooperative Savings & Credit Society Ltd. and Nyarwanya Cooperative Saving and Credit Society Ltd were surveyed.
This involved the use of interview, physical observations and power measurement. Below are highlights of the SACCO field study:

- Power measurement and interviews were done for two days in each SACCO. Physical observation covered six days(Monday to Saturday), most of it done by the staff of the SACCOs after seeing the consultants do it during the first two days.

- The consultants directly administered questionnaires and recorded answers during interview process. The questions were meant to establish the SACCO's current and projected volumes of operations. These were supplemented by review of copies of documents like the portfolio reports and financial statement.

- The questionnaire also covered issues like background information, stock of power drawing equipments such as computers, data switches, teller utility machines, light and, their power rating, minimal work hours, existing power backup options and grid power availability/supply voltages.

- The consultants used an AVO DC1001 Clamp on Meter to measure amount of current/Voltage drawn each ICT equipment.

- The consultants also made observations on daily transaction volumes and probed the behavior of equipment users.

2.2 Vendor Interviews

Ten vendors were interviewed using both a self-administered questionnaire and technical discussions based on a pre-formatted spreadsheet file with various scenarios. The vendors interviewed were drawn list of quality alternative power equipment suppliers recommended by BUDS-ERT Uganda.

2.3 Low Power Equipment Research

This was done through vendor website research and physical interview with some vendors with relevant knowledge and skills (builders of low powered systems). Research was done on a number of computer vendor websites, some of which are presented in Appendix 7 of this report. The objective in this task was to come up with a number of feasible low power ICT equipment that could be used to minimize power consumption.

2.4 Review of a Previous USAID Funded Study Report

The consultants visited, studied and got valuable information from a previous study on *Sustainable Backup Power Solutions for CIC in Rwanda.* This report gave the consultants some leads, general technical approaches to power back-ups and other information that was used in the assignment. The report can be viewed at http://www.dot-com-alliance.org.

2.5 Construction of the Costing Model

On the basis of the information gathered (regarding the investment and running costs of the various power options), the consultants constructed an elaborate spreadsheet model to determine the net present values (NPVs) of the up to 20 power solution options for each SACCO. The three most cost-effective solutions were then recommended, in order of preference, for each SACCO.

3.0 FIELD FINDINGS

3.1 SACCO Operations

The SACCOs, also called village banks, fall under Tier4 in the Ugandan financial sector categorization. They are member based. They are regulated by the Cooperative Statute and differ from other MFIs in that they are user-owned and user-governed in principle. Below are the briefs of each of the visited SACCOS

MAMIDECOT

- Operates for a minimum of 10 hrs a day (8:30 am to 6:30 PM) for weekdays and for a min of 4 hours (9:00 am to 1:00 pm) on Saturdays.
- The banking hall is open to members till 5:00 pm on week days and till noon on Saturday.
- Total membership is currently about 5,000 with annual growth rate of 15%, its main attraction being the long hours of operations
- Annual loan portfolio growth rate of around 20%.
- The current loan portfolio size is a bout 850 million
- Membership is projected to grow to about 10,000 with a portfolio of 2.1 billion in the next 5 years.
- The loans/savings/shares transactions are tracked on a visual FoxPro Database application system called Finance Solutions. Because of system bugs, a manual system is run in parallel.
- Daily average transactions is 500 transactions.
- When grid power is off, they switch on their generators for the entire operational period.
- The SACCO plans to improve on the MIS and purchase 4 more computers, and a server within the next five years.

Kyamuhunga

- Operates for a minimum of 10 hrs a day (8:30 am to 6:30 am) for weekdays and for a min of 5 hrs (9:00 am to 2:00 am) on Saturdays.

- The banking hall is open to members till 3:00 pm on week days and till 1.00 pm on Saturday.
- Total membership currently is 5,176 with annual membership growth rate of 10%.
- This SACCO is generally growing with an annual loan portfolio growth rate of 16%. The current portfolio size is a bout 376 million.
- Membership is projected to grow to 8,500 with a portfolio of 790 million in the next 5 years.
- The loans/savings/shares transactions are tracked using Finance Solutions although it is reportedly not stable.
- Account reports are generated manually on spreadsheet file.
- Daily transactions average 543.
- When grid power is off, they switch on their generators for the entire operational period. Because their generator can't run the entire load, only 3 computers are used when on the generator.
- Plans to improve on its MIS and purchase 1 server in the next two years, and to make all replacements for the existing stock of computers in the next five years

Muhame

- Operates for a minimum of 10 hrs in a typical a day (8:00 am to 6:00 pm) for weekdays and for a minimum of 4 hours (9:00 am to 1:00 pm) on Saturdays.
- The banking hall is open to members till 4:00 pm on week days and till noon on Saturdays.
- Total membership currently is 2,800 with annual growth rate of just below 15%.
- An annual loan portfolio growth rate of 15%. The current portfolio size is a bout 213 million.
- In the next 5 years membership will be 5,600 with a portfolio of 450 million.
- The loans/Savings/Shares transactions are tracked manually.
- The SACCO is currently feeding member bio data onto an Access database Application system called SACCO Loan Track(SLT).
- The accounts are done using an excel based Waste Sheet.
- Transactions average 150 per day.
- When grid power is off, they switch on their generators for the entire operational period, including the night at times.
- Plans to improve on their MIS and purchase one cheap computer within a year, 2 branded PCs in the next 2 years. Also plans to replace the server in the 2 years, one printer in 3 year, and 4-Port PABX in the 4 years.

Rubabo

- Operates for a minimum of 7 hours a day (8:30 am to 5:00 pm with lunch break).
- Total membership currently is 2,100 with annual growth rate of 11%.
- Annual loan portfolio growth rate is 13%.
- The current portfolio size is a bout 395 million.
- Membership is projected to grow to 3,500 with a portfolio of 728 million in the next five years.
- The loans/savings/shares transactions are tracked using Finance Solutions, reported not to be stable.
- Accounting reports are generated manually on spreadsheet file.
- Daily transactions average 150, usually posted in the afternoons.
- Since they are not connected to grid power, they only switch on their generator for 3 hrs and usually during transaction posting.

- No future plans to purchase any ICT equipment.

Nyarwanya

- Operates for a minimum of 8 hrs a day (9.00 am to 5:00 am), six days from Monday to Saturday.
- Total current membership is 3,020 with annual growth rate of 11%.
- This SACCO is generally growing but percentage portfolio growth figures were not readily available because lack of reports.
- Operations are purely manual.
- Daily transactions average 70.
- No electronic ICT of the sort.

3.2 Profile of SACCO ICT Equipment

Four of the five SACCOs surveyed had computing and other electronic equipments. These ranged from computers, printers, data backup devices, lighting, money counting machines, counterfeit money discerner machines, electronic calculators, data switches and phones. The equipments have the following prevalent characteristics:

- Most of computers deployed are clones with Cathode Ray Tube(CRT) Monitors.
- Printers used are mostly laser jets.
- Use 18 and 36 watt tube lights and these are installed in banking halls, manager's office, and back office and as security lights.
- Two of the SACCOs (MAMIDECOT and Muhame) use external Iomega Zip drives.
- Three of the five SACCOs have a peer to peer LAN infrastructure.

Table I below highlights the details of equipment profile for each SACCO.

Table I(Profile of SACCO ICT Equipments)

SACCO	# PCs	#f Printers	# backup devises	# Data Switches	# of Lights	Others(Phones, machines etc)
Masaka Microfinance Development Cooperative Trust Ltd	3	1	1	1	6	6
Muhame Financial Services Cooperative Ltd	4	1	0	1	5	1
Kyamuhunga Peoples Savings & Credit Cooperative Society Ltd	6	1	1	1	7	1
Rubabo Peoples Cooperative Savings & Credit Society Ltd	2	1	0	0	0	3
Nyarwanya Cooperative Saving and Credit Society Ltd	0	0	0	0	0	0

Source : SACCO Field Survey by consultants

3.3 Power Loads

During the survey, the consultants noted that most of the electronic devises deployed by the SACCOs are power-hungry equipments. The existing clone computers consume an average of 220.8 Watts of power compared to low powered ones that consume 30 – 120 Watts. Effective hours of use for each equipment were determined by observation and interview, measurement of current drawn by equipments and total power load in watt hours computed for each equipment. Table II below summarizes the load capacities for each SACCO.

Table II(Daily Load at the SACCOs)

SACCO	DC Load Wh per day	AC Load Wh per day	Total Load Wh per day
Masaka Microfinance Development Cooperative Trust Ltd	2,034	3,656	5,690
Muhame Financial Services Cooperative Ltd	1,812	3,078	4,890
Kyamuhunga Peoples Savings & Credit Cooperative Society Ltd	2,163	6,649	8,812
Rubabo Peoples Cooperative Savings & Credit Society Ltd	5.4	1,201	1,206
Nyarwanya Cooperative Saving and Credit Society Ltd	0	0	0

Source : SACCO Field Survey by consultants.

3.4 Grid Power Conditions

Three of the SACCOs visited; Masaka, Muhame and Kyamuhunga are connected to main power grid. This however has proved ineffective as frequent power outages adversely affect their operations. This makes them incur heavy costs in running alternative power sources. The other two SACCOs (Rubabo and Nyarwanya) have no grid power connection. Rubabo has to rely entirely on a generator.

Power quality deteriorates more in the rural areas more than in the urban and peri urban areas. In Masaka the measured voltages ranged between 215-265v compared to measurements taken at Muhame and Kyamuhunga which ranged from 192 to 228v. Since most UPS's in the rural based SACCOs are fitted with automatic voltage regulator (AVR), they cannot cope with these low voltages and consequently their batteries have been permanently discharged.

In all the three locations connected to mains, grid power is unreliable as can be inferred from the table below:

Table III(Grid Power Availability)

	Power Availability During Operational Hours by Day of Week						
	Monday (8AM–6PM)	Tuesday (8AM–6PM)	Wednesday (8AM–6PM)	Thursday (8AM–6PM)	Friday (8AM–6PM)	Saturday (9AM–1PM)	Total Hours in Week
MAMIDECOT (Masaka)	0.5	10	0	3	9.5	4	27
Muhame Financial Services Cooperative Ltd	10	0	4	10	0	4	28
Kyamuhunga Peoples Savings & Credit Cooperative Society Ltd	10	0	10	0	10	0	30
Rubabo Peoples Cooperative Savings & Credit Society Ltd	No Grid Power						
Nyarwanya SACCO	No Grid Power						

Source : SACCO Field Survey by consultants

3.5 Existing Power Backup Options

Kyamuhunga and Muhame use diesel engine generators while Masaka and Rubabo operate petrol engine generators. While a generator is the most obvious alternative power source, it is often among the most expensive ones in running costs. The fuel prices in the SACCOs towns as below:

Table IV(Fuel Prices as of April 2006)

Town	Petrol UGX	Diesel UGX
Masaka	2,150 -2,250	1,800 – 1,940
Muhamme	2,300 – 2,500	2,030 – 2,200
Kyamuhunga	2,300 – 2,500	2,030 – 2,200
Rubabo	2,300 – 2,500	2,030 – 2,200

Source : SACCO Field Survey by consultants

Some of the existing generators could not support the operational loads. These generators are poorly located and don't have proper generator houses. Only Muhame SACCO has proper generator cabling and change over switch. Because of heavy use, the frequency of servicing is high. In all the SACCOs, generator servicing is done by local technicians ("Kamyufus") who probably do not have technical knowledge generator operations. Table V below summarizes the generators used by the SACCOs.

Table V (Existing Power Backup Options)

SACCO	Power Option	Output Capacity KW	Capital Cost UGX	Annual Operating Costs. UGX	Run Period	Remarks
Masaka Microfinance Development Cooperative Trust Ltd	5.5KVA Honda HX 6500E Petrol Engine Generator.	3.5	1,800,000	8,222,000	Entire work hours so long as there is no power	It was in a relativ good condition exc that it consumes m Fuel. This will need replacement.
Muhame Financial Services Cooperative Ltd	6.3 KVA Honda HX 6500E Diesel Engine Generator	4	4,900,000	3,092,000	Entire period(night and day) so long as there is no power.	It was in a relativ good condition. This need an overhaul.
Kyamuhunga Peoples Savings & Credit Cooperative Society Ltd	3.2KVA Honda GX270 Diesel Generator	1.5	4,928,000	5,872,000	Entire work hours so long as there is no power	It was in a very condition and coul handle operating loa Replacement neede
Rubabo Peoples Cooperative Savings & Credit Society Ltd	2.8KVA Honda GX160 Petrol Generator	1.6	1,400,000	2,692,000	3 hrs daily	It was in a relativ good condition but need replacement business is to scale u

Source : SACCO Field Survey by consultants

3.6 User Behavior.

- Most of the SACCOs use 18 and 36 watt tubes for lighting. The lights are however switched on even when not necessary, like during the day or overnight.
- Computers are often switched on all day even when the effective hours of usage is fewer.
- There are no hardware purchase policies to help guide the SACCOs in selection of quality equipments with low power consumption, specifications, warranty.

- No proper maintenance contracts for the ICT equipment and generators. This reduces operational efficiency. In most of the SACCOs, any person claiming to be a technician is allowed to service/repair the generators without vetting his expertise.
- In all the SACCOs, the generator rotation per minute (RPM) has been tampered with.
- In Muhame the generator runs overnight when there is load shedding.
- There is little concern for power costs.

3.7 SACCO Expansion Strategy

All these SACCOs have plans to grow, serve more members and provide better returns on investments to them. They are, however, checked by inadequate funds for internal capacity building like in the areas of power and ICT equipment. Some of the SACCOs like Masaka, Muhame and Kyamuhunga operate satellite offices which they hope to grow and expand within the next five years. These SACCOs have plans to overcome limitations like inefficiencies in MIS, low staff capacities, grid power and infrastructure. The expansion target for next five years is tabulated in the table VI below.

Table VI(Five year Targets)

	Masaka SACCO	Muhame SACCO	Kyamuhunga SACCO	Rubabo SACCO	Nyarwanya SACCO
Current Portfolio size (UGX)	850 Millions	213 Millions	376 Millions	395 Millions	na[1]
Portfolio in 5 years time (UGX)	2,100 Millions	450 Millions	790 Millions	728 Millions	
Current Number of Members	5,000	2,800	5,176	2,100	3,020
Total Members over next five years	10,000	5,600	8,500	3,500	

Source : SACCO Field Survey by consultants

There are plans to expand the hardware infrastructure and this will have direct bearing in the operational power loads. The table below shows the planned acquisition over the next five years.

Table VII(Planned Acquisitions over next 5 years)

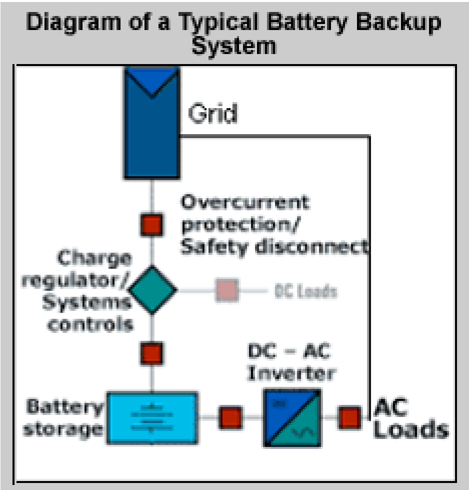
SACCO	Number of Computers	No. of Servers	No. of Printers	Others	
Masaka Microfinance Development Cooperative Trust Ltd	4 (Additions to existing Stock)	1 (Addition)	1 (replacement)		
Muhame Financial Services Cooperative Ltd	3(Additions)	1	1 (replacement)	4 Port PABX	
Kyamuhunga Peoples Savings & Credit Cooperative Society Ltd	6 (Replacements)	1			
Rubabo Peoples Cooperative Savings & Credit Society Ltd	1 (addition if cheap power is installed)		1 (replacement)		
Nyarwanya Cooperative Saving and Credit Society Ltd	Didn't have any plans				

Source : SACCO Field Survey by consultants

[1] Not ascertained

3.8 Alternative Power Backup Solutions

3.8.1 Alternative 1. Battery Inverter Backup



This system uses number of deep cycle batteries (depending on the SACCO operational load capacity) to store energy while grid power is operational, and deliver electricity from batteries to the loads when grid power is out. The inverter plays a central role in this solution by converting AC from grid power to DC to charge the batteries; by regulating the battery charging and by converting DC from the batteries back into AC to power the load when the mains power is out. In designing this solution, the following set of equipment is used::50mm DC battery ,cabling materials, deep cycle batteries 100 Ahr@ 12v, inverters OUTBACK 2024, battery rack, class II protection , class III protection and other installation materials.

<u>Capital Cost</u>

The capital cost for each SACCO was computed based on the current load.
Table below summarizes the costs

Table VIII(Capital Cost for Alternative 1)

SACCO	Capital Cost (UGX)	Annual Running Cost (UGX)	Days of Autonomy Used
Masaka Microfinance Development Cooperative Trust Ltd	13,577,865	811,963	2 days
Muhame Financial Services Cooperative Ltd	12,463,159	506,389	2 days
Kyamuhunga Peoples Savings & Credit Cooperative Society Ltd	17,917,198	759,088	2 days
Rubabo Peoples Cooperative Savings & Credit Society Ltd	10,058,271	830,685	3 days
Nyarwanya Cooperative Saving and Credit Society Ltd	Rubabo Solution replicable here.		

Source : Vendor Field Survey by consultants

<u>Installation Costs</u>.

The installation costs include labour and transport. This varies according to geographical distance of the SACCO from the supplier(mainly based in Kampala). As of May 2006, a uniform total cost of UGX 600,000 (Labour UGX 230,000 and transport UGX 370,000 including out of pocket allowances) per SACCO has been applied.

<u>Replacement Costs & Life Expectancy of the Solution</u>

Deep Cycle batteries are designed to withstand repeated and deep discharge of up to 80% of capacity, thus, providing more power over their lifetimes than standard batteries. Battery replacement frequency will depend on how deep the batteries have been depleted and how quickly the current is drawn from the batteries during depletion. If maintained within 75% depth of discharge, this system can last for five to seven years.

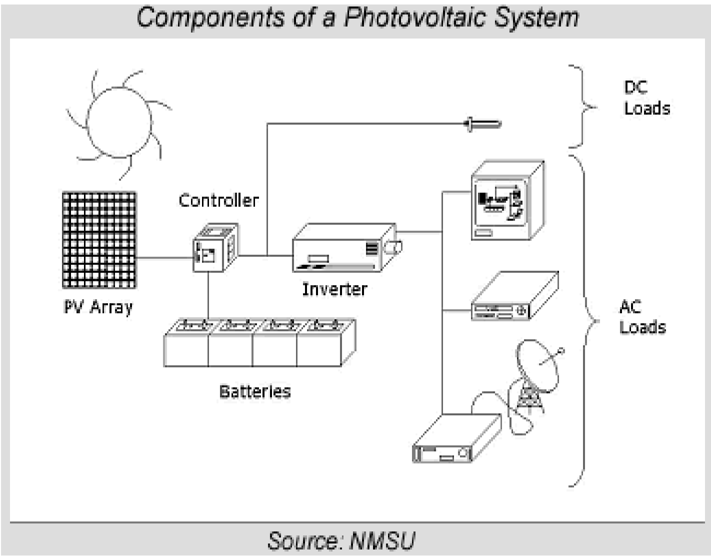
Expected Annual Maintenance Cost

This solution is maintenance free because deep cycle batteries don't need any kind of maintenance.

Operating Conditions

The batteries are automatically charged while grid power is available. At full capacity, the respective battery banks can run the SACCO loads at indicated days of autonomy. SACCOs that use generator for battery charging should be consistent in running the generator for required number of hours (average 5 hrs per day of charge). For grid powered areas, just in case the transformer is down for more than two days, a generator should be quickly available. The whole objective will be to maintain the batteries at 75% depth of discharge to ensure longevity in battery life.

3.8.1 Alternative 2: Solar Powered Battery Backup



This solution uses the photovoltaic (PV) system also known as solar system to produce electric current at the junction of two substances exposed to light. Photovoltaic systems consist of solar arrays (solar panel) that convert sunlight into direct current (DC) electricity, which can be used directly or stored in batteries. Most DC systems are 6, 12 or 24 volts and by using an inverter can be converted to alternating current (AC).

Most solar arrays begin delivering power or charging batteries with as little as 10% of sunlight with each cell of the array converting approximately 14% of the available energy to DC power. In considering this solution, the consultants zoned the country into 3 main segments based on *radiation field* to come up with the following zones:

Table IX(Peak Sun Shine Hours for the SACCOs)

Zone	SACCOs in these Zones	Peak Sunshine Hours(PSH)	Days of Autonomy Used
Hot Zones		6	2
Moderate Zones	Masaka, Muhame & Kyamuhunga	5	2
Cold Zones	Rubabo & Nyarwanya	4	3

Source : Vendor Field Survey by consultants

Note : Days of Autonomy are days for which battery power backup can safely supply power.

This solution uses the following equipment:

- 50MM DC battery Cabling materials,
- Deep Cycle Batteries - 100 Ahr,
- Inverters OUTBACK 2024,
- Class III protection,
- Class II protection,
- Battery rack,
- Stecca charge controller-30A,
- UV cables,
- Frames,
- Shell solar panel 85W
- other installation materials.

Capital Cost

The capital cost for this energy solution accounts for most of it's lifetime acquisition, operation and maintenance cost. Careful selection, planning and management of the equipment loads are critical to managing the overall cost of this alternative. Table below summarizes the costing for the five SACCOs surveyed.

Table x(Capital Cost for Alternative 2)

SACCO	Capital Cost (UGX)	Annual Running Cost (UGX)	Days of Autonomy Used
Masaka Microfinance Development Cooperative Trust Ltd	59,480,013	0	2 days
Muhame Financial Services Cooperative Ltd	51,893,010	0	2 days
Kyamuhunga Peoples Savings & Credit Cooperative Society Ltd	89,014,725	0	2 days
Rubabo Peoples Cooperative Savings & Credit Society Ltd	36,878,680	0	3 days
Nyarwanya Cooperative Saving and Credit Society Ltd	Rubabo Solution replicable here.		

Source : Vendor Field Survey by consultants

Installation Costs.

Since this solution involves integrating the battery inverter system with Solar Panels, the installation cost structure is similar to that of battery inverter system ie UGX 600,000 (labour UGX 230,000 and transport UGX 370,000 including out of pocket allowances) per SACCO.

Replacement Costs & Life Expectancy of the Solution

By the design of this solution, the equipments can last 15 to more than 25 years. This solution is also scalable to accommodate growth in power need. In this case, appropriate number of solar panels and batteries can be added. Both the Inverter outback and stecca charge controller can be replaced/added in parallel to ensure corresponding amperage.

Expected Annual Maintenance Cost

Since there are no moving parts and with use of deep cycle batteries, there is almost no maintenance cost.

Operating Conditions

The solar panels should be cleaned fortnightly depending on the dust conditions of the environment. This should be done by someone trained on equipment usage. The recommended maximum load should be adhered to at all times and where the more load is to be supported, upgrade should be done. When in cloudy weather, the battery should only supply power the load for two days of autonomy.

3.8.2 Alternative 3: Generator

SDMO SD6000E DIESEL GENERATOR, 4800W, 6KVA, YANMAR DIESEL ENGINE

This would give a peak efficiency of 3.6 KWh/litre.

= *(Output in KW x Max Run Hours for Full Tank) divided by Tank Capacity in Litres*

Assuming this generator will only be 90% efficient for the initial year and thereafter it declines by 10% annually, in five years this would be 2.4 KW sufficient to run the existing power loads. This power option is useful for off-grid and under-electrified areas

Table XI(Projected Operational Efficiency)

	Current Year	Year II	Year III	Year IV	Year V
% Efficiency	90%	80%	70%	60%	50%
Output Wattage	4.3 KW	3.8 KW	3.4 KW	2.9 KW	2.4 KW
Operational Peak Efficiency	3.2 KWh/Litre	2.9 KWh/Litre	2.6 KWh/Litre	2.2 KWh/Litre	1.8 KWh/Litre

Source : Vendor Field Survey by consultants

Capital Cost

This generally has low capital costs but high running costs due to the need to purchase fuel and provide regular maintenance. This generator will cost UGX 9,440,000 including VAT.

Operating Conditions

The generator should be housed in a properly ventilated and dust free room outside the main building where there is sufficient aeration. A service log book and register should be maintained to track service records. For safety, the generator house should have adequate security comprising of burglar proof materials. A simple operational manual can drawn from the vendor manuals and hang on the wall.

Installation Costs.

This covers the cost of change- over switch, cabling materials, labor and transport. This would sum to UGX 1,267,000 per generator installation.

Replacement Costs & Life Expectancy of the Solution

This system can last for 5 to 10 years depending on the operational care provided. After the generator has served its useful lifetime, the new power load should be determined and a new generator with matching load capacity purchased. It should be noted that generators always depreciate in efficiency over time.

Expected Annual Maintenance Cost

Throughout the lifespan of this equipment, it should be consistently serviced. During servicing the engine oil is drained and changed, air cleaner is changed, fuel and oil filters are changed. The following items are used during each service

Table XII(items used during generator service)

Replaceable Items	Unit Price UGX	Quantity Required Per Service
Air Cleaner	50,000	1
Fuel Filter	10,000	1
Engine Oil	12,000	2 litres
Oil Filter	10,000	1
Labour	50,000	1
Total	132,000	

Source : Vendor Field Survey by consultants

These service items should be ordered directly from the generator vendors and labour hired locally. The recommended run hours before each service is between 200 and 400..

The following table summarizes the cost of generator use under different scenarios of combination with other alternative power sources,

Table XIII(Annual Service Cost Based on different Business Scenarios. 300 Run Hrs used.)

	Existing generator + grid			Existing generator + grid + battery inverter			New generator + grid + battery inverter		
SACCO	Run Hrs	Service Freq	Total Cost UGX	Run Hrs	Service Freq	Total Cost UGX	Gen. Run Hrs	Service Freq	Total Cost UGX
Masaka SACCO	1,520	26	**1,300,000**	45	1	**50,000**	45	1	**132,000**
Muhame SACCO	1,520	6	**300,000**	45	1	**50,000**	45	1	**132,000**
Kyamuhunga SACCCO	1,520	12	**720,000**	45	1	**60,000**	45	1	**132,000**
Rubabo & Nyarwanya SACCO	915	6	**300,000**	780	3	**150,000**	780	3	**396,000**

Source : Vendor Field Survey by consultants

<u>Fuel Cost.</u>

In a calendar year the SACCOs work for about 305 days. The three SACCOs with grid power only have power available for about 150 days. The assumption is that the generator will only operate at 80% capacity and at peak efficiency of 2.88 KWh/Litre.

The following table shows the fuel consumption by the SACCOs

Table XIV(Fuel consumption by SACCOs)

	Existing generator + grid			Existing generator + grid + battery inverter			New generator + grid + battery inverter		
SACCO	Gen. Run Hrs	Total Litres	Total Cost UGX	Gen. Run Hrs	Total Litres	Total Cost UGX	Gen. Run Hrs	Total Litres	Total Cost UGX
Masaka SACCO	1,520	3,698	**8,320,000**	45	219	**492,632**	45	18	**39,886**
Muhame SACCO	1,520	1,446	**2,964,000**	45	86	**175,500**	45	15	**31,217**
Kyamuhunga SACCCO	1,520	1,332	**2,730,000**	45	79	**161,645**	45	27	**56,288**
Rubabo (only generator).	915	1,087	**2,392,000**	780	556	**1,223,449**	780	114	**250,028**

Source : Vendor Field Survey by consultants

Alternative 4: Generator with Battery Back-up

This is hybrid solution. It combines the use of battery inverter system with a generator. In this solution, the generator is run only to charge the batteries and then it's switched off. The charge hours depend on factors like battery discharge rate, battery bank size etc. This solution is ideal for non grid powered areas.

Table XV(Capital Cost of Alternative 4)

SACCO	Capital Cost (UGX)	Annual Running Cost (UGX)	Days of Autonomy Used
Masaka Microfinance Development Cooperative Trust Ltd	24,492,865	531,767	2 days
Muhame Financial Services Cooperative Ltd	23,378,159	472,962	2 days
Kyamuhunga Peoples Savings & Credit Cooperative Society Ltd	28,832,198	746,803	2 days
Rubabo Peoples Cooperative Savings & Credit Society Ltd	24,973,271	830,685	3 days
Nyarwanya Cooperative Saving and Credit Society Ltd	Replicable to Rubabo		

Source : Vendor Field Survey by consultants

Installation Costs.

This covers the cost of Change over switch, cabling materials, labour and transport. This sums to UGX 1,600,000.

Replacement Costs & Life Expectancy of the Solution

This option can operate for 5 – 7 years after which new power solution sizing is done.

Expected Annual Running Costs

The servicing costs will be only incurred on the generator (*See tables xiv & xiii above for detailed costs)* .For extreme grid power outages like in Muhame SACCO, this option can be applicable.

Operating Conditions

The generator should be housed in a properly well aerated and dust free room outside the main building. A service log book and register be maintained to track service record. For safety, this house should have adequate physical security. A simple operational manual can be drawn from the vendor manuals and hung on the wall.

3.8.5 Alternative Five: Solar Powered Battery With Diesel Generator

This is a super hybrid solution. ie combination of Solar Powered Battery Inverter System with a Generator. In this solution, solar system converts sunlight into direct current which is stored in the batteries and may be used directly for certain appliances. The generator can then be used to charge the batteries in cases when sunshine hours drop drastically. Again the charge hours can depend on factors like battery discharge rate, battery bank size etc. This solution is ideal for areas without grid power or with very low grid power.

Table XVII(Capital Cost for alternative 5)

SACCO	Capital Cost (UGX)	Annual Running Cost (UGX)	Days of Autonomy Used
Masaka Microfinance Development Cooperative Trust Ltd	70,395,013	531,767	2 days
Muhame Financial Services Cooperative Ltd	62,808,010	472,962	2 days
Kyamuhunga Peoples Savings & Credit Cooperative Society Ltd	99,929,725	762,803	2 days
Rubabo Peoples Cooperative Savings & Credit Society Ltd	43,793,680	407,219	3 days
Nyarwanya Cooperative Saving and Credit Society Ltd	Replicable to Rubabo		

Source : Vendor Field Survey and power consummation analysis by consultants

<u>Installation Costs.</u>

This covers the cost of change over switch, cabling materials, labour and transport and sums up to about UGX 1,600,000.

<u>Replacement Costs & Life Expectancy of the Solution</u>

This option can operate for more than ten years with generator overhaul expected in the tenth year.

<u>Annual Maintenance Cost</u>

Only servicing costs will be only incurred on the generator (See table xiv & Xiii above).

<u>Operating Conditions</u>

The generator should be housed in a properly ventilated and dust free room outside the main building. A service log book and register be maintained to track service record. For safety, this house should have adequate security. A simple operational manual can be drawn from the vendor manuals and hang on the wall.

The solar panels cleaned on biweekly basis though this will depend on the location of the SACCO. A register book should be maintained.

3.8.6 Alternative Six: Inveneo Bicycle Generator

The bicycle generator is an involving source of energy that can be experimented. It uses a combination of a bicycle, an alternator, diode, wiring and someone to pedal the bicycle. This solution however has not been used before in the Ugandan economy. The following are the subcomponents of this energy solution.

<u>Bicycle</u>

A manual bicycle with gears would be preferable, as this makes it easier for the person pedaling to reach the speed that works best at their ability level for the battery to charge. As only the rear wheel, seat and pedals are used, a bike with a damaged (or even missing) front end can be used.

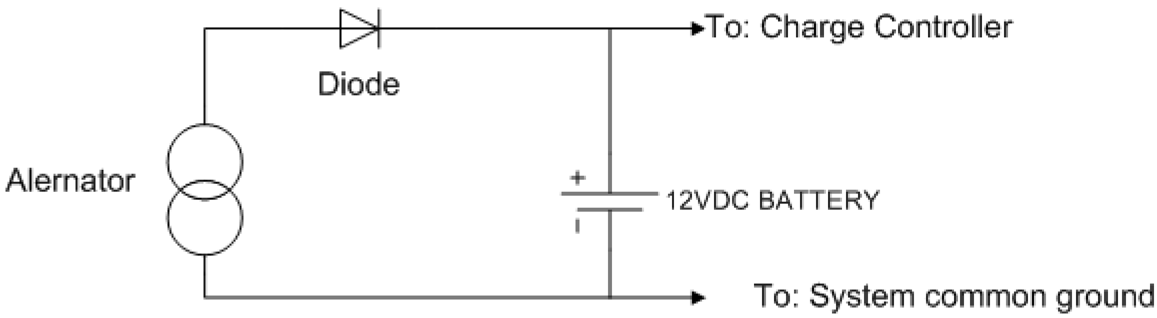
Alternator

A 12V alternator from a small car or truck will work. Inveneo prefers the nearly ubiquitous Toyota pickup truck alternator, although the Corolla or Nissan small pickup truck units will also usually work.

Diode and Wiring

Some alternators use an external diode whilst others have one that is internal. In any case, a series diode is necessary somewhere in the charging circuit to prevent current from flowing back from the battery to the alternator. The diode should be rated for a maximum current of 10A to avoid overheating or overloading. The connecting wire should be of a large enough gauge to handle an average current of 5A – 10A peak. Typically, 18ga "lamp cord" will work fine for lengths up to 20 ft. (6m).

Circuit Diagram for this Solution.



Generally, using a small car or truck alternator, pedaling for about 15 minutes will charge a lead-acid battery enough to operate the Inveneo communications station PC and display for 30 to 60 minutes, depending on pedaling effort.

This solution can be redesigned to accommodate large loads

4.0 LOW POWER CONSUMPTION ICT EQUIPMENT

Power consumption will depend on type of equipment, manufacturer and components attached. The following low voltage computing options were evaluated:

4.1 Use of Low Voltage Thin Client Terminals with High Speed Data Network Radio Links

This is a low power computing solution that uses server-based computing .Client terminals share the hardware and software resources of a central computer or server. Server-based computing solutions can support all of the standard applications that run on personal computers like Internet access, email and word processing. The server can be configured with additional processing power and memory in order to run software applications requested and used by

the clients. Because most of the processing is done on the server, the client terminals don't have to include all of the components of a standalone computer. Server-based computing can reduce total power consumption compared to a fully distributed computing model by reducing the number of power-consuming components in the client terminals and by increasing the utilization rate of network resources through sharing. This solution consumes only 22 Watts of instantaneous power. Because thin client systems are not as common as standard PC networks, these solutions may require specialized configuration, training and technical support skills. In the Ugandan market, this solution is provided by Bushnet.
To set up this solution, the following are the requirements for each user/client.

Table XIX(Requirements to set up client server computing environment using thin client terminal)

Item	Unit Price UGX
Thin Client Terminal	1,110,000
50 Watt Solar Panel for each terminal	370,000
Stecca Regulator	37,000
Radio	1,110,000
Battery	92,500
Bandwidth of 32 Kbps(if using Bushnet Server Space)	647,500 per Month
Central Server.	

Source : Vendor Field Survey by consultants

This solution has a life span of 3 -4 years. It uses thin print like the ones used in Point of sales transactions.

If this computing solution is integrated into the existing solution, the implications would be as follows:

- All the computers would be replaced with thin client terminals connected to central server at service provider offices (could be Bushnet or other).
- If the central server is hosted at the SACCO, technical personnel resources will be required since these solutions require specialized configuration, training and technical support skills. All the SACCOs surveyed don't have this kind of resource.
- The existing loan tracking system (Finance Solutions) would be upgraded to a web based platform.

The following is the capital cost per SACCO assuming their data is to be hosted at Bushnet servers.

SACCO	# of thin Clients	# of 50 W Solar Panels	# of Batteries	# of Stecca Regulators	# of Radios	Total Cost UGX
Masaka SACCO	3	3	3	3	3	7,159,500
Muhame SACCO	4	4	4	4	4	9,546,000
Kyamuhunga SACCO	6	6	6	6	6	14,319,000
Rubabo SACCO	2	2	2	2	2	4,773,000
Nyarwanya SACCO	2	2	2	2	2	4,773,000

Source : Vendor Field Survey by consultants

If all the computers were replaced with this computing option, the daily power loads would greatly reduce, thereby reducing energy costs as shown in table below.

SACCO	New Daily Power Load	Old Daily Power Load
Masaka SACCO	2.8 KW	5.7 KW
Muhame SACCO	2.4 KW	4.9 KW
Kyamuhunga SACCO	4.1 KW	8.8 KW
Rubabo SACCO	0.9 KW	2.6 KW

Running Cost.

The only running cost would be monthly payment of $ 350 for bandwidth. A 32 Kbps dedicated connection is recommended.

Advantage of this solution

- No significant energy recurrent cost
- Not dependent on grid power.
- Data hosting free.

Disadvantage

- Require specialized skills which the SACCOs don’t have now.
- Involves replacement or upgrade of existing loan tracking system to web based platform.

4.2 Use of LCD (Liquid Crystal Display)

LCD monitors typically consume one third to one half the power of a comparably-sized CRT monitor. The 15” standalone LCD monitors typically has a maximum power rating of about 30 W and reported normal active power consumption of 20-25 W. The price range in the local market is about UGX 500,000. Table below shows the size and wattage consumption for various 15” standalone LCD Monitors.

Table XX(LCD monitor power consumption)

Monitor		Power Consumption (W)				
Manufacturer	Model	Size (in.)	Max (Watts)	Typical (Watts)	Min (Watts)	Sleep/ Suspend (Watts)
NEC/ Mitsubishi	MultiSync LCD1560V+	15	--	20	--	2
Dell	E151FPp	15	23	--	10	<2
Compaq	TFT1520	15	<30	--	--	<2
Hp	L1502	15	<30	--	--	<2
Dell	1504FP	15	30	25	--	<5

Source: Manufacturers' specifications.

In integrating this option into the existing solution, all the CRT monitors would be replaced with LCD monitors.

Table XXI(Capital cost for LCD monitors)

SACCO	# of 15" LCD Monitors	Total Cost (UGX)
Masaka SACCO	3	1,500,000
Muhame SACCO	3	1,500,000
Kyamuhunga SACCO	4	2,000,000
Rubabo SACCO	2	1,000,000
Nyarwany SACCO	2	1,000,000

Source : Vendor Field Survey by consultants

If all the CRT monitors in the SACCOs are replaced with LCD monitors, the daily power loads would be as follows

SACCO	New Daily Power Load	Old Daily Power Load
Masaka SACCO	4.6 KW	5.7 KW
Muhame SACCO	3.9 KW	4.9 KW
Kyamuhunga SACCO	6.8 KW	8.8 KW
Rubabo SACCO	0.9 KW	2.6 KW

<u>Running Cost.</u>

The only running cost is the usual servicing of the equipment.

<u>Advantage of this solution</u>

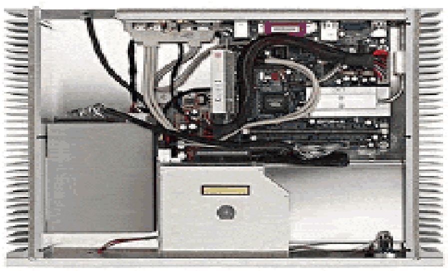
- No anti glare glass required.
- Uses only 25 Watts of power as compared to 110.4 Watts consumed by existing CRTS
- Occupies less space.

<u>Disadvantage</u>

- High capital cost compared to CRT monitors. A 15" LCD monitor costs about UGX 500,000 while a CRT monitor costs about UGX 150,000.

4.3 Use of Low Powered Desktops.

The consultants considered low-power desktop computers to be those models with low-power CPUs and average power consumption between 20 W and 40 W, excluding the monitor. All-in-one desktops, in which the motherboard and an LCD monitor are integrated into a single casing, provide additional energy benefits because the LCD monitor uses the same power supply as the computer and therefore consumes less energy.



Inside view of a low-power desktop. Passive cooling enables fanless operation, which helps reduce power consumption.

Source: HUSH Technologies, Ltd.

Low-power desktops often include custom-built and off-the-shelf models based on the Mini-ITX or VIA EPIA series motherboards. Because the availability of low-power desktop models and the manufacturers who produce them change with market conditions, one way to identify low-power desktop options is to search the web sites of low-power chip manufacturers such as Transmeta Corporation, VIA Technologies, and Intel for links to desktop systems based on their low-power products, such as those listed in the table below.

Examples of Low-Power Desktop Computers

Model Characteristics				Power Consumption (W)	
Model Name	CPU	Speed (MHz)	RAM (MB)	Active Mode	Sleep Mode
Wincomm WPC-650	VIA Ezra	933	256	33-36 (average) [1]	18
NEC PowerMate eco	Transmeta Crusoe	900	n.d.	31 (including monitor)[2]	13.3

Source [1] Tested at Winrock International, June 2003.
Source[2]: Manufacturer specifications and U.S. Energy Star product data for the NEC PowerMate Eco personal computer. This model includes a built-in 15" LCD monitor whose power consumption is included in the figures listed above.

A local firm in Uganda (Key Skills Ltd) and its partner in USA currently build these kinds of computers. The consultants interviewed the local contact, Norbert (0772 639376). A set costs about $ 820. Another relatively low powered small forms of DELL computers (OptiPlex Series) also draw averagely low power(124 Watts) and cost about $1,200.

Integrating into the existing solution:

- All the computers will be replaced with these low powered computers.

Table XXII(Capital cost for low powered computers)

SACCO	# of Low powered Computers	Total Cost (UGX)
Masaka SACCO	3	4,551,000
Muhame SACCO	4	6,068,000
Kyamuhunga SACCO	5	7,585,000
Rubabo SACCO	2	3,034,000
Nyarwany SACCO	2	3,034,000

Source : Vendor Field Survey by the consultants

If the existing stock of computers were replaced with low powered computers, the daily power loads would change as follows

SACCO	New Daily Power Load	Old Daily Power Load
Masaka SACCO	3.4 KW	5.7 KW
Muhame SACCO	3.1 KW	4.9 KW
Kyamuhunga SACCO	5.3 KW	8.8 KW
Rubabo SACCO	1.3 KW	2.6 KW

Running Cost.
The only running cost is the usual servicing of the equipments estimated at about UGX 20,000 per unit.

Advantage of this solution

- Uses only 61 Watts of power compared to 220.8 watts consumed by clone computers. This saves a lot of expenses on power.

Disadvantage

- Computing capacity is relatively low especially for querying bigger databases. Since most SACCO databases are aggressively growing, this could pose limitation at certain periods.

4.4 Use of Notebooks/Laptops

Notebook computers consume much less power than desktop systems because.

- Notebook computers use energy-saving LCD monitors,
- the CPU, components and software in a notebook computer are designed to conserve power so as to maximize battery operation times,
- Notebooks use external power supplies that are much more efficient than the power supplies used in most desktop systems.

The user can choose settings that guarantee maximum processor performance, maximum battery life, or settings in between. The exact settings depend on the type of processor, manufacturer, the applications and the operating system installed on the notebook.

Integrating into the existing solution:

- All the computers would be replaced with these Notebooks/ Laptops.

Table XXIII(Capital cost for notebooks)

SACCO	# of NoteBooks	Total Cost (UGX)
Masaka SACCO	3	11,100,000
Muhame SACCO	4	14,800,000
Kyamuhunga SACCO	5	18,500,000
Rubabo SACCO	2	7,400,000
Nyarwany SACCO	2	7,400,000

Source : Vendor Field Survey by consultants

Replacing the existing stock of computers with Notebooks, the daily power load consumption would change as follows

SACCO	New Daily Power Load	Old Daily Power Load
Masaka SACCO	4.4 KW	5.7 KW
Muhame SACCO	2.6 KW	4.9 KW
Kyamuhunga SACCO	4.1 KW	8.8 KW
Rubabo SACCO	1.0 KW	2.6 KW

Source : Vendor Field Survey and SACCO power consumption analysis by the consultants

<u>Running Cost.</u>
The only running cost is the usual servicing of the equipments..

<u>Advantage of this solution</u>

- Uses only 16 - 54 Watts of power depending on the modal.

<u>Disadvantage</u>

- The capital cost is very high.

The following tables show power consumption for different models of notebooks .

Table XXIV(Power consumption for various Dell Notebooks)

Model Characteristics				Power Consumption (W)				
Model	CPU	Speed (GHz)	RAM (MB)	Max	Min	Sleep	Off	Power Supply
Inspiron 8500	P4m	1.9	128	54.41	32.20	1.47	0.67	0.5
Inspiron 4150	P4	n.d.	n.d.	54.70	28.05	2.73	1.17	0.4
Inspiron 2650	P4	1.6	n.d.	52.89	26.00	3.32	2.11	0.4
Inspiron 500m	P4m	1.5	128	42.87	25.14	2.17	0.50	0.0
Inspiron 300m	Pm	1.2	256	32.96	23.07	1.15	1.46	0.4
Latitude D800	M	1.4	512	54.35	35.75	1.49	1.34	0.5
Latitude C640	P4-M	n.d.	n.d.	54.7	28.05	2.73	1.17	0.5
Latitude D400	P4m	1.7	128	45.85	24.17	1.63	0.34	0.5
Latitude C610	Intel	n.d.	n.d.	43.67	22.98	2.78	2.13	0.4
Latitude C510	Celeron	n.d.	n.d.	37.72	21.02	3.26	2.19	0.4
Latitude X300	Pm	1.2	256	30.78	20.15	0.95	1.48	0.4
Latitude X200	PIII	n.d.	n.d.	23.66	15.19	2.91	2.8	0.9

Source: Dell product specifications.

Table XXV(Power consumption for various HP Notebooks models)

Model	Power Consumption (W)				
	Operation	Standby	Sleep	Off	Date of Report
HP Compaq nx7000 (running on battery power)	15.8 (avg) 38 (peak)	<0.8	<0.1	n.d.	12/2003
HP Compaq nx7000 (running on AC power or auto/airplane DC adapter)	23 (on/idle)		2.5		3/2004 [1]
Compaq Evo N610c	32	10	4	1	1/2003
Compaq Evo N620	32	10	4	1	3/2003
Compaq Evo N600	32	27	9	1	1/2003
Compaq Evo N1015v	30-50	20-40	18-30	0-5	1/2003
Compaq Evo N1020v	30-50	20-30	18-30	0-5	2/2003
Compaq Presario 1500	30-50	20-40	18-30	0-5	11/2002
Compaq Presario 900	30-50	20-40	18-30	0-5	11/2002
Compaq EVO N400	30	26	6	1	n.d.
Compaq NX9010 / Presario 2500	29.7	n.d.	1	1	9/2003
Compaq Evo N800c	27.8	2.2	2.2	0.1	11/2002
Compaq Evo N800v	27.8	2.2	2.2	0.1	1/2003
Compaq Presario 2800	27.8	2.2	2.2	0.1	10/2002
Compaq NX9000 / NX9005 / Presario 2100	27	n.d.	1.2	1.2	9/2003
Compaq Evo N800w	26	n.d.	2	<1.0	10/2003
HP Compaq TC1000 Tablet PC	23.1	15.7	1.3	0.974	8/2003
HP Compaq NC4000	16.2	16.2	0.37	0.41	11/2003
Compaq Evo N410c	30	15	6	1	1/2003
HP Compaq nc8000 / nw8000 Mobile PC	18	n/a	7.6	0.77	12/2003
HP Compaq NC6000	10.5	8	0.4	0.05	11/2003

Source: HP product specifications; http://www.dot-com-alliance.org/POWERING_ICT/Text/hotwords/Data_on_Power_Consumption.html#Table5

Table XXVI(Power consumption for various IBM Notebooks models)

CELERON70045186.53MODEL	CPU	SPEED (MHZ)	MAX	NORMAL	SLEEP	OFF
IBM I SERIES 1200 (1161-43S)	CELERON	700	45	18	6.5	3
IBM A SERIES 2628 QSS	PIII	800	48	15	8.5	1
IBM X SERIES 2662 64S	PIII	700	32	11	9	1
IBM TRANSNOTE 2675	PIII	600	62	9	3	1

Source: IBM Environmental Declarations

4.5 Use of Dot Matrix/ Inkjet Printers

These generally consume less power compared to LaserJet printers. There is a 40% to 60 % power reduction in using these kinds of printers (http://www.dot-com-alliance.org/powering_ict/). The power consumption varies greatly in capacity, speed of printing, technological type and quality of output. HP DeskJet 6540 InkJet prints 30 pages per minute with 5,000 pages of monthly duty cycle will consume about 32 Watts while operational and 4 watts in standby mode.
Integrating into the existing solution:

- All the printers will be replaced with HP Deskjet 6540.

Table XXVII(Capital cost for HP DeskJet 6540 printer)

SACCO	# of Low powered Computers	Total Cost UGX
Masaka SACCO	1	333,000
Muhame SACCO	1	333,000
Kyamuhunga SACCO	1	333,000
Rubabo SACCO	1	333,000
Nyarwany SACCO	1	333,000

Source : Vendor Field Survey by consultants

<u>Running Cost.</u>
Replacement of ink cartridges. HP96 black cartridge costs about $40 while HP97 tri color cartridge costs about $41

<u>Advantage of this solution</u>

- Uses only 32 Watts of power
- Printing speed of 30 pages per minute
- Can print up to 10 reams of papers per month(ie 5000 pages).

<u>Disadvantage</u>

- Cost per paper printed would be UGX 120 per page compared to that of LaserJet 1300 which is at UGX 54 per page. Suitable for SACCOs printing 2 to 3 reams of paper per month.

Table XXVIII(Various printers with their power consumption)

Printers			Power Consumption (W)		
Model	Description	Pages per minute	Max	Average	Standby
hp LaserJet 1000	Laser jet, black & white	10	n.d.	213	7
hp LaserJet IIISi	Laser jet, black & white	17	1100	n.d.	240
hp LaserJet 1300	Laser jet, black & white	20	320	n.d.	7
Lexmark T520 laser jet	Laser jet, black & white	20	435	n.d.	12
hp deskjet 3420	Ink jet, color	10	n.d.	23	8
Lexmark Z43 Inkjet	Ink jet, color	15	17.6	n.d.	7.9
hp officejet 6110	Ink jet printer, copier, scanner, fax	19	60	n.d.	n.d.
hp business inkjet 2230	Ink jet, color	15	68	n.d.	8
HP Deskjet 6540	Ink jet, color	30	32	n.d.	4
Lexmark Forms Printer 2490	Dot matrix, black & white	409 cps*	n.d.	38	7

*characters per second
Source: Manufacturers' specifications

Since printer are used only a small portion of the working time in a typical SACCO, printer-based power saving solutions are not considered among the options in the recommendations under section 5 below.

5.0 RECOMMENDATIONS FOR SOLUTIONS

5.1 General

This study had the overriding objective of recommending the most suitable solution for each of Rural SPEED's five affiliated SACCOs, and generally highlighting researched ways of developing power solutions for rural SACCOs. In doing this, the consultants and the client (Rural SPEED) frequently got and incorporated new insights of the possible options. This section gives a summary of the available options and sub-options[2], with the respective costs. The costs are stated in terms of the total net present value of the investment costs (net of the residual value of investment where applicable) and all running costs of each option for five years.. On the basis of the most cost-effective option, recommendations are then made for each SACCO.

For cost analysis, the five SACCOs are grouped into:

a) SACCOs with existing computerized MIS Solutions with power solution.
b) SACCOs without computerized MIS with and no power solution.

2

The findings indicate that with use of battery inverters, the annual grid power cost for mains connected SACCOs approximately double since on a grid day, an amount of energy equal to what is consumed is stored in the battery bank. However, as can be seen in table below, the overall energy costs go down because of the enormous savings made by using stored grid power compared to generator fuel.

SACCO	(1 Day of Autonomy by Practice) Existing Generator+Grid (UGX/Year)			(2 Days of Autonomy by design) Existing Generator+Grid+Battery Inverter. (UGX/Year)			(2 Days of Autonomy by design) New Generator+Grid+Battery Inverter. (UGX/Year)		
	Grid Costs	Fuel +maint' Costs	Total Operational Costs	Grid Costs	Fuel +maint'	Total Operational Costs	Grid Costs	Fuel +maint'	Total Operational Costs
Masaka SACCO	188,993	9,620,000	9,808,993	367,858	444,105	811,963	367,858	163,909	531,767
Muhame SACCO	162,345	3,264,000	3,426,345	315,989	190,400	506,389	315,989	156,973	472,962
Kyamuhunga SACCCO	292,731	3,450,000	3,742,731	569,772	189,316	759,088	569,772	177,030	746,803
Rubabo (only generator).	0	2,692,000	2,692,00				0	596,022	596,022
Grid Days = 152 Gen. Run Days = 153				Grid Days = 298 (99 Days Actual Grid, 199 Days Equivalent output stored on battery) Gen. Run Days = 7			Grid Days = 298 (99 Days Actual Grid, 199 Days Equivalent output stored on battery) Gen. Run Days = 7		

Note :

1 Day of Autonomy by Practice. The SACCOs are using generator on an equal rotation with UMEME
2 Days of Autonomy by design. The design option used.

From the table below, it is evident that grid power cost per Kwh is much cheaper (about 5%) as compared to operational (fuel + maintenance) cost per Kwh. The table bases on the existing situation of Muhame SACCO, but its conclusions hold for any other SACCOs.

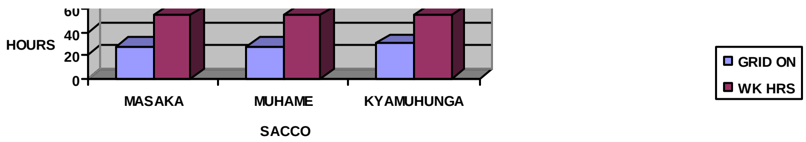
SACCO	1 Day of Autonomy by Practice: Existing Generator + Grid (UGX/Year)		
	Grid Costs/KWh	Fuel & maintenance Costs/KWh	Total Operational Costs/KWh
Muhame SACCO	216	4,355	2,293

SACCOs not on grid power are better off using non hybrid power backup systems. They are better off using only the generator, because power generation using the generator is expensive and this, added to the initial capital costs of the inverter, would push the NPV of the overall costs up beyond the NPV of using only the generator. From the findings, grid energy is the cheapest(in terms of total cost of ownership[TCO} primary source of energy and this is ideal for integrating with other power solutions such as battery inverter power systems. Most of the SACCOs in non- grid areas have less/few ICT equipments and with availability of energy source can spontaneously grow the ICT base to match the rapid portfolio growing levels. In design, a 6.0 KVA output diesel generator was found to be ideal as this would grow with the SACCO in the next 5 years or so and not forgetting operational peak efficiency drop at a rate dependent on use, operating conditions and maintenance.

5.2 SACCOs with Existing Computerized MIS Solutions and Power Solutions

Of the five surveyed SACCOs, three cases fall under this category ie MAMIDECOT, Muhame and Kyamuhunga SACCOs. These SACCOs only have grid power for 50% of the operational time, meaning that grid power as an energy source is not reliable.

Grid Power Availability Vs Operational Hours in Week



The costing of the alternative solutions has been based on the following computing options:

i) Maintaining the current computing options
ii) Replacement of existing CRT monitors with 15" LCD monitors
iii) Replacing existing PCs with Laptops
iv) Replacing existing PCs with thin client terminal in a client server environment

Costing for five energy options based on four computing options were evaluated and the following assumptions made.

- Peak Sunshine hours are 5
- Days for which the energy options can continuously supply power without grid is 2. This is sometimes referred to as days of autonomy.
- In the bicycle generator, running the bike for 15 minutes generates 15 Whr of energy. The cost of building one bike estimated at UGX 300,000 and labor cost is 5000 per man for maximum of 5 hours per day.
- The discount rate used is 14%
- These energy solutions to run for the next 5 years

For these SACCOs to use technology effectively to drive their business processes in meeting the rural sector financial services demand, five sub- options are further examined for each of the five SACCOs, with five alternative sub-options. Of the 20 sub-options available to each SACCO, the three most effective are recommended in order of reference, the first sub-option being the priority recommendation.

i) Masaka SACCO *(MAMIDECOT)*

Option 1. Using Existing Computing Equipments

Daily Energy Consumption	Power supply via:	NPV of investment & 5-year op' costs
5.7 KWh	Option 1.1 = Existing combination of grid power and generator	62,022,026
	Option 1.2 = Option 1.1 with the addition of a inverter/battery system	15,190,080
	Option 1.3 = Solar panels with an inverter/battery system	40,424,590
	Option 1.4 = Manual generation of power from stationary bikes with an inverter/battery system	74,272,060
	Option 1.5 = Option 1.2 but replace existing generator with a brand new one with better fuel consumption	24,198,325

Option 2. Replacement of Existing CRT monitors with LCDs

Daily Energy Consumption	Power supply via:	NPV of investment & 5-year op' costs
4.6 KWh	Option 2.1 = Existing combination of grid power and generator	52,234,492
	Option 2.2 = Option 2.1 with the addition of a inverter/battery system	15,732,272
	Option 2.3 = Solar panels with an inverter/battery system	35,955,255
	Option 2.4 = Manual generation of power from stationary bikes with an inverter/battery system	63,080,681
	Option 2.5 = Option 2.2 but replace existing generator with a brand new one with better fuel consumption	24,931,556

Option 3. Replace Existing PCs with Laptops

Daily Energy Consumption	Power supply via:	NPV of investment & 5-year op' costs
2.9 KWh	Option 3.1 = Existing combination of grid power and generator	45,476,269
	Option 3.2 = Option 3.1 with the addition of a inverter/battery system	23,901,668
	Option 3.3 = Solar panels with an inverter/battery system	36,882,430
	Option 3.4 = Manual generation of power from stationary bikes with an inverter/battery system	54,293,744
	Option 3.5 = Option 3.2 but replace existing generator with a brand new one with better fuel consumption	33,377,024

Option 4. Replacing Existing PCs with thin client terminals in a client Server Environment

Daily Energy Consumption	Power supply via:	NPV of investment & 5-year op' costs
5.1 KWh	Option 4.1 = Existing combination of grid power and generator	69,103,934
	Option 4.2 = Option 4.1 with the addition of a inverter/battery system	27,874,985
	Option 4.3 = Solar panels with an inverter/battery system	50,391,169
	Option 4.4 = Manual generation of power from stationary bikes with an inverter/battery system	80,592,502
	Option 4.5 = Option 4.2 but replace existing generator with a brand new one with better fuel consumption	36,986,853

Recommendation:

The most cost-effective solutions for Masaka SACCO in order of preference are

a) Retain the existing computing equipment and add an inverter/ battery system to the power equipment
b) Replace the current CRT with LCD monitors, and add an inverter/ battery system to the power sources
c) Replace the existing PCs with laptops and add an inverter/ battery system to the power equipment

ii) Muhame SACCO

Option 1. Using Existing Computing Equipments

Daily Energy Consumption	Power supply via:	NPV of investment & 5-year op' costs
4.9 KWh	Option 1.1 = Existing combination of grid power and generator	21,752,790
	Option 1.2 = Option 1.1 with the addition of a inverter/battery system	13,122,804
	Option 1.3 = Solar panels with an inverter/battery system	35,455,209
	Option 1.4 = Manual generation of power from stationary bikes with an inverter/battery system	64,530,117
	Option 1.5 = Option 1.2 but replace existing generator with a brand new one with better fuel consumption	22,978,229

Option 2. Replacement of Existing CRT monitors with LCDs

Daily Energy Consumption	Power supply via:	NPV of investment & 5-year op' costs
3.9 KWh	Option 2.1 = Existing combination of grid power and generator	19,683,709
	Option 2.2 = Option 2.1 with the addition of a inverter/battery system	13,973,716
	Option 2.3 = Solar panels with an inverter/battery system	31,584,572
	Option 2.4 = Manual generation of power from stationary bikes with an inverter/battery system	54,512,422
	Option 2.5 = Option 2.2 but replace existing generator with a brand new one with better fuel consumption	23,853,403

Option 3. Replace Existing PCs with Laptops

Daily Energy Consumption	Power supply via:	NPV of investment & 5-year op' costs
2.6 KWh	Option 3.1 = Existing combination of grid power and generator	29,484,992
	Option 3.2 = Option 3.1 with the addition of a inverter/battery system	27,435,019
	Option 3.3 = Solar panels with an inverter/battery system	39,127,725
	Option 3.4 = Manual generation of power from stationary bikes with an inverter/battery system	54,350,643
	Option 3.5 = Option 3.2 but replace existing generator with a brand new one with better fuel consumption	37,345,117

Option 4. Replacing Existing PCs with thin client terminals in a client Server Environment

Daily Energy Consumption	Power supply via:	NPV of investment & 5-year op' costs
4.7 KWh	Option 4.1 = Existing combination of grid power and generator	36,446,782
	Option 4.2 = Option 4.1 with the addition of a inverter/battery system	28,366,448
	Option 4.3 = Solar panels with an inverter/battery system	49,810,080
	Option 4.4 = Manual generation of power from stationary bikes with an inverter/battery system	77,727,880
	Option 4.5 = Option 4.2 but replace existing generator with a brand new one with better fuel consumption	38,226,440

Recommendation:

The most cost-effective solutions for Muhame SACCO in order of preference are:

a) Maintain the computing equipment and power options and add an inverter/ battery system to the power sources
b) Replace the existing CRT monitors with LCDs and add an inverter/ battery system to the power sources
c) Replace the existing CRT monitors with LCDs, and operate using the existing grid power and generator

iii) Kyamuhunga SACCO

Option 1. Using Existing Computing Equipment

Daily Energy Consumption	Power supply via:	NPV of investment & 5-year op' costs
8.8 KWh	Option 1.1 = Existing combination of grid power and generator	21,886,419
	Option 1.2 = Option 1.1 with the addition of a inverter/battery system	18,972,271
	Option 1.3 = Solar panels with an inverter/battery system	59,769,416
	Option 1.4 = Manual generation of power from stationary bikes with an inverter/battery system	112,195,534
	Option 1.5 = Option 1.2 but replace existing generator with a brand new one with better fuel consumption	28,900,276

Option 2. Replacement of Existing CRT monitors with LCDs

Daily Energy Consumption	Power supply via:	NPV of investment & 5-year op' costs
6.8KWh	Option 2.1 = Existing combination of grid power and generator	19,935,819
	Option 2.2 = Option 2.1 with the addition of a inverter/battery system	18,990,865
	Option 2.3 = Solar panels with an inverter/battery system	49,864,178
	Option 2.4 = Manual generation of power from stationary bikes with an inverter/battery system	89,537,736
	Option 2.5 = Option 2.2 but replace existing generator with a brand new one with better fuel consumption	28,929,129

Option 3. Replace Existing PCs with Laptops

Daily Energy Consumption	Power supply via:	NPV of investment & 5-year op' costs
4.1 KWh	Option 3.1 = Existing combination of grid power and generator	38,037,100
	Option 3.2 = Option 3.1 with the addition of a inverter/battery system	39,189,057
	Option 3.3 = Solar panels with an inverter/battery system	59,494,902
	Option 3.4 = Manual generation of power from stationary bikes with an inverter/battery system	85,588,801
	Option 3.5 = Option 3.2 but replace existing generator with a brand new one with better fuel consumption	49,138,246

Option 4. Replacing Existing PCs with thin client terminals in a client Server Environment

Daily Energy Consumption	Power supply via:	NPV of investment & 5-year op' costs
6.4 KWh	Option 4.1 = Existing combination of grid power and generator	32,667,723
	Option 4.2 = Option 4.1 with the addition of a inverter/battery system	32,850,095
	Option 4.3 = Solar panels with an inverter/battery system	58,042,202
	Option 4.4 = Manual generation of power from stationary bikes with an inverter/battery system	90,415,163
	Option 4.5 = Option 4.2 but replace existing generator with a brand new one with better fuel consumption	42,794,233

Recommendation:

The most cost-effective solutions for Kyamuhunga SACCO in order of preference are:

a) Maintain the current computing equipment and add an inverter/ battery system to the power sources
b) Replace the current CRT monitors with LCDs, and add an inverter/ battery system to power sources
c) Replace the CRT monitors with LCDs, and keep the existing power source (grid plus generator)

5.3 SACCOs Without Computerized MIS Solutions And No Power Solution

Rubabo and Nyarwanya SACCOs fall in this category. Costing for four energy options based on three computing options were evaluated and the following assumptions made.

- Peak Sunshine hours are 4
- Days for which the energy options cam continuously supply power without grid is 3. This is sometimes referred to as days of autonomy.
- In the bicycle generator, running the bike for 15 minutes generates 15 Whr of energy. The cost of building one bike estimated at UGX 300,000 and labor cost is 5000 per man for maximum of 5 hours per day.
- The IRR is estimated at 14%
- These energy solutions to run for the next 5 years

The computing options used:

i) Purchase of standard PCs with 15" LCD panels
ii) Purchase of laptops instead of PCs
iii) Purchase of thin client terminals with a low powered server

i) Rubabo SACCO

Option 1. Purchase of standard PCs with 15" LCD panels

Daily Energy Consumption	Power supply via:	NPV of investment & 5-year op' costs
2.8 KWh	Option 1.1 = Diesel Generator	18,381,129
	Option 1.2 = Option 1.1 with the addition of a inverter/battery system	26,009,604
	Option 1.3 = Solar panels with an inverter/battery system	28,492,100
	Option 1.4 = Manual generation of power from stationary bikes with an inverter/battery system	39,549,638

Option 2. Purchase of laptops instead of PCs

Daily Energy Consumption	Power supply via:	NPV of investment & 5-year op' costs
1.5 KWh	Option 2.1 = Diesel Generator	20,439,832
	Option 2.2 = Option 2.1 with the addition of a inverter/battery system	26,766,486
	Option 2.3 = Solar panels with an inverter/battery system	22,624,651
	Option 2.4 = Manual generation of power from stationary bikes with an inverter/battery system	27,800,017

Option 3. Purchase of 3 thin clients with a low power server

Daily Energy Consumption	Power supply via:	NPV of investment & 5-year op' costs
3.3 KWh	Option 3.1 = Diesel Generator	26,456,124
	Option 3.2 = Option 3.1 with the addition of a inverter/battery system	35,278,322
	Option 3.3 = Solar panels with an inverter/battery system	43,835,093
	Option 3.4 = Manual generation of power from stationary bikes with an inverter/battery system	60,286,373

Recommendation:

The most cost-effective solutions for Rubabo SACCO in order of preference are

a) Use a diesel generator for all computing power needs, purchase standard PCs with LCD panels for computing needs
b) Purchase laptops for instead of PCs and run them on the generator as the sole source of power
c) Purchase laptops for computing and run them on a solar with inverter/battery system.

ii) Nyarwanya SACCO

Since this SACCO doesn't have any computing equipment and is non grid area, the recommended power solution for Rubabo should be replicated here.

5.4 General Application of the Principles

Generally the following matrix can be used to make choice in the power backup solutions

Energy Solution	Costs	System Life Time	Target SACCOs
Battery Inverter Backup System	• Low capital cost • No operational and maintenance costs	5 to 7 years	• SACCOs in grid powered areas with at least 200 Volts of supply and 30 hrs of power availability in a week.
Solar Powered Battery Backup	• Very high Capital Costs • No operational and maintenance costs	15 to 25 years	• SACCOS in off grid areas with at least 5 hours of sunshine per day. Offers reliable
Diesel Generator	• Lowest capital costs • Highest operational and maintenance costs	5 to 10 years	• This option is generally suitable for all SACCOs if price of diesel is low.
Diesel Generator with Battery Backup	• High Capital Costs • High operational and maintenance costs	5 to 7 years	• SACCOS in areas with no grid power and sunshine hours per day is really low(below 3 hours) • SACCOs with unreliable grid power both in supply volts and hours of availability in a week(below 30 hours).
Solar Powered Battery with Generator	• Highest capital cost • Low operational and maintenance cost	> 10 years	• SACCOS in areas with no grid power and sunshine hours per day is a bit low(below 3-4 hours)

To determine the best power/ computing equipment option for each SACCO or other institution, is useful to carry out the following steps of analysis:

1. Determine the technically feasible options
2. For each technically feasible option, find out the capital costs (i.e total purchase of all the equipment required)
3. Estimate the annual running/ operating costs
4. If any of the equipment has a lifetime beyond five years, apply straight line depreciation for five years, deduct the figure[3] from the purchase price and use it as the residual value of the investment after the five-year PNV period
5. Determine the present value of all the investment (year 0) and the operating costs, at a discount rate equivalent to the bank prime lending rate or 5% point above inflation
6. Choose the option with the lowest NPV of the costs

[3] Accumulated depreciation for 5 years

Appendices

Appendix 1: SACCO general description table:

SACCO	Branch Location	Members	Staff	MIS Type	Remarks on MIS
Masaka Microfinance Development Cooperative Trust Ltd(MAMIDECOT)	Former UCB Building, Kampala-Masaka Road, Nyendo.	5,000	13	Semi Manual	Parallel Manual and Computerised loan and savings tracking used. For Accounts, excel is used to generate the reports.
Muhame Financial Services Cooperative Ltd	Masheruka Road, Kabwohe, Bushenyi	2800	7	Semi Manual	Account Reports generated by an intelligent spreadsheet modal. Still at earlier stages of data entry onto Access Database loans tracking system
Kyamuhunga Peoples Savings & Credit Cooperative Society Ltd.	Butare, Ishaka-Kasese Highway	5,176	8	Semi Manual	Finance Solutions used for loans/shares/savings tracking. Excel sheet used for accounts reporting
Nyarwanya Cooperative Saving & Credit Society Ltd	Bugangari SubCounty, Rukungiri District	3,020	9	Manual	Everything here is totally manual. No grid power to Office premises. No single computer.
Rubabo Peoples Cooperative Savings & Credit Society Ltd	Nyarushange Stage, Rukungiri District.	2,100	6	Semi Manual	Finance Solutions used for loans/Shares/savings tracking. Account reporting is based on excel spreadsheet.

Appendix 2a : Available Grid Power, by time of Day and day of week for Masaka Microfinance Development Cooperative Trust Ltd as of 1st week of April 2006.

Weekday	Midnight-6AM	6AM-Noon	Noon-6PM	6PM-Midnight
Monday	40 Mins	30 Mins	0	50 Mins
Tuesday	6 hrs	6 hrs	6 hrs	5 hrs 20 Mins
Wednesday	0	0	0	2 hrs 30 mins
Thursday	6 hrs	2 hrs 38 mins	2 hrs 25 mins	6 hrs
Friday	6 hrs	3hrs 30 mins	6 hrs	45 mins
Saturday	5 hrs 12 mins	1 hr 20 mins	6 hrs	3 hrs 52 mins
Sunday	6 hrs	6 hrs	6 hrs	0

Appendix 2b : Available Grid Power, by time of Day and day of week for Muhame Financial Services Cooperative Ltd as of 2nd week of April 2006.

Weekday	Midnight-6AM	6AM-Noon	Noon-6PM	6PM-Midnight
Monday	6.0 hrs	6.0 hrs	6 hrs	1 hr 42 mins
Tuesday	0	0	0	2 hrs 15 mins
Wednesday	0	2 hrs 43 mins	1 hr 10 mins	6 hrs
Thursday	6 hrs	6 hrs	6 hrs	0
Friday	3 hrs 28 mins	0	0	6 hrs
Saturday	6 hrs	6 hrs	6 hrs	0
Sunday	3 hrs 51 mins	6 hrs	6 hrs	6 hrs

Appendix 2c : Available Grid Power, by time of Day and day of week for Kyamuhunga Peoples Savings & Credit Cooperative Society Ltd as of 2nd week of April 2006.

Weekday	Midnight-6AM	6AM-Noon	Noon-6PM	6PM-Midnight
Monday	6	6	6	6
Tuesday	0	0	0	5 hrs 40 Mins
Wednesday	6.0	6.0	6.0	0
Thursday	0	0	0	0
Friday	5	4.5	6	6
Saturday	0	0	0	0

Sunday	6	6	6	6

Appendix 3a . Masaka Microfinance Development Cooperative Trust Ltd ICT Equipments and their power draw and daily usage.

Equipment	User	Power rating	Power consumption	Usage (hours per day)
Clone Computer with 15" CRT Monitor	Manager	100-240 Volts 50- 60 Hertz 2.0 Amps	220.8 Watts	4
External Zip Drive	Manager	5 Volts 50-60 Hertz 1.5 Amps	7.5 Watts	1
Clone Computer with 15" CRT Monitor	Loan Section	115-230 Volts 50- 60 Hertz 2.0 Amps	220.8 Watts	4.5
Laserjet 4m Printer	All Staff	220-240 Volts 50 Hertz 3.1 Amps	660 Watts(Printing) 55 Watts(Standby)	0.2 hrs(Printing) 5 Hrs(Standby)
Data Switch	Network	12 Volts 50 Hertz 1000 Milliamps	3.6 Watts	7
Clone Computer with 15" CRT Monitor	Teller	100-240 Volts 50- 60 Hertz 1.5 Amps	193.2 Watts	7
Money Counting Machine	Teller	250 Volts 50-60 Hertz 2.0 Amps	150 Watts	2
Counterfeit Money Discerner	Teller	210-230 Volts 50- 60 Hertz 0.026 Amps	1.44 Watts	2
Electronic Calculator	Accountant	220-230 Volts 50- 60 Hertz 0.12 Amps	6.6 Watts	5
Electronic Calculator	Accounts Assistant	220-230 Volts 50- 60 Hertz 0.12 Amps	6.6 Watts	5
Electronic Calculator	Banking Assistant	220-230 Volts 50- 60 Hertz 0.12 Amps	6.6 Watts	5
Lighting		Banking hall(36x2) Manager's Office(18x1) Accounts(18x1+36x1)	162 Watts	10

Appendix 3b . Muhame Financial Service Cooperative Ltd ICT Equipments and their power draw and daily usage.

Equipment	User	Power rating	Power consumption	Usage (hours per day)
Dell Dimension 3000 with 15" LCD Monitor	Manager	200-240 Volts 50- 60 Hertz 1.5 Amps	120 Watts	4
HP Deskjet 845c	Manager	18 Volts 1100 mAmps	30 Watts	0.2
Dell Dimension 3000 with 15" CRT Monitor	Loan Section	200-240 Volts 50- 60 Hertz 1.5 Amps	170 Watts	4.5

Laserjet 1300 Printer	All Staff	220-240 Volts 50 Hertz 3.1 Amps	320 Watts(Printing) 7 Watts(Standby)	0.3 hrs(Printing) 0.7 Hrs(Standby)
Data Switch	Network	100-240 Volts 50-60 Hertz 0.3 Amps	16.56 Watts	7
Dell Dimension 3000 with 15" CRT Monitor	Accountant	200-240 Volts 50- 60 Hertz 1.5 Amps	170 Watts	7
Clone Computer with 15" CRT Monitor	Back Office	100-240 Volts 50- 60 Hertz 1.8 Amps	209.8 Watts	2
Lighting		Banking hall(36x2) Manager's Office(36x1) Back Office(36x1)	180 Watts	10

Appendix 3c. Kyamuhunga People's Savings and Credit Cooperative Ltd ICT Equipments and their power draw and daily usage.

Equipment	User	Power rating	Power consumption	Usage (hours per day)
Clone Computer with 15" CRT Monitor	Front Office	115-230 Volts 50- 60 Hertz 1.8 Amps	193.2 Watts	4
Clone Computer with 15" CRT Monitor	Cashier 1	115-230 Volts 50- 60 Hertz 1.8 Amps	193.2 Watts	7
Dell Dimension 3000 with 15" LCD Monitor	Cashier 2	200-240 Volts 50- 60 Hertz 1.5 Amps	120 Watts	7
Dell Dimension 3000 with 15" LCD Monitor	Accountant	200-240 Volts 50- 60 Hertz 1.5 Amps	120 Watts	7
Data Switch	Network	100-240 Volts 50-60 Hertz 0.3 Amps	16.56 Watts	7
Dell OptiPlex GX270 with 15" CRT Monitor	Manager/Multiused	100-240 Volts 50- 60 Hertz 0.8 – 1.6 Amps	158 Watts	7
Clone Computer with 14" CRT Monitor	Back Office	100-240 Volts 50- 60 Hertz 1.4 Amps	215.3 Watts	7
HP Laserjet 1300 Printer	All Staff	220-240 Volts 50 Hertz 3.1 Amps	320 Watts(Printing) 7 Watts(Standby)	0.3 hrs(Printing) 0.7 Hrs(Standby)
External Zip Drive	Manager	5 volts 0.5 Amps	7.5 Watts	1
Lighting		Banking hall(36x2) Manager's Office(36x1) Back Office(36x2) Board Room(18x1) Corridor(18x1)	216 Watts	10

Appendix 3d . Rubabo People's Cooperatives and Savings Society Ltd ICT Equipments and their power draw and daily usage.

Equipment	User	Power rating	Power consumption	Usage (hours per day)
Clone Computer with 15" CRT Monitor	Manager	100-240 Volts 50- 60 Hertz 1.5 Amps	193.2 Watts	3
Clone Computer with 15" CRT Monitor	Cashier/Secretary	100-240 Volts 50- 60 Hertz 1.5 Amps	193.2 Watts	3
HP Laserjet 1300 Printer	All Staff	220-240 Volts 50 Hertz 2.5 Amps	214Watts(Printing) 7 Watts(Standby)	0.15 hrs(Printing) 0.1 Hrs(Standby)
3 Electronic Casio Calculators	All Staff	6 Watts	1.8 Watts	3

Appendix 4: Backup power options (give range of costs for smallest to largest SACCO surveyed):

Backup power option	Investment cost UGX	Operating cost for 5 years UGX	Load capacity KW/hrs
Battery inverter backup without solar power or generator;	10,096,460 – 13,568,460	0	2.6 – 8.8
Solar powered battery backup without generator;	14,704,060 - 76,721,540	0	2.6 – 8.8
Generator without battery back-up;	10,707,000	5,490,950 – 28,498,620	2.6 – 8.8
Generator with battery backup, and;	15,623,700 – 24,378,460	5,197,825 – 18,178,540	2.6 – 8.8
Solar powered battery backup with generator.	25,744,060 - 86,076,500	2,327,560 – 13,887,600	2.6 – 8.8

Appendix 5: Low voltage computing options

Equipment detail	Investment cost per unit (hardware + installation)	Power consumption (Watts)	Estimated power savings compared to 220 Volt alternative (Watts)
Low voltage DC power supplies for PCs	1,517,000	36	184.8
LCD displays (15") instead of CRTs	500,000	25	85.4
Low voltage thin client terminals and high speed data network radio links	2,756,500	22	198.8
Dot matrix and inkjet printers	333,000	32	188
Notebooks	3,700,000	30	190

Appendix 6 . List of Individuals met during Consultancy

	Full Names	Full Address
1.	Abhay Shah m.i.e.e	Director; UltraTec(U) Ltd Kampala 256 (0) 772 200007
2	Joseph Zabasajja	Manager; MAMIDECOT Masaka, Nyendo 256 (0) 772 518640
3	Patrick Kasozi	Lines Man; UMEME Masaka 256(0) 752 807285
4.	Hope Komujuni	Manager; Muhame SACCO Kabwohe Bushenyi 256(0) 772 571306
5.	Stephen Kisekka	Terrain Plant Ltd; Tank Hill Road, Muyenga Tel: 041266749/031260086 077 2200951
6.	Malcolm Brew	Bushnet ; Plot 1000 Baka Close Tank Hill Muyenga Tel : 0312225200/0772212042
7	Frobisha Mukiibi	Solar Energy Uganda; Nandee Towers Plot 12 Wilson Rd 041232114/0712783626
8.	Sekalegga David	Energy Systems; Get-in House Plot 3 William Street 041250920/0772610904
9.		

Appendix 7 . List of reading materials reviewed

Reference	Research Topic
http://www.dot-com-alliance.org/	Sustainable Backup Power Solutions for CIC in Rwanda
http://www.energyalternatives.ca/systemDesign/	Batteries, inverters, Battery Chargers,
http://www.rpc.com.au/	Renewable Energy Systems
http://www.siemenssolar.com	Solar systems
http://www.solaronline.com.au/page/solar_system_basics.html	Solar systems
http://www.transquilpc.co.uk	Low power PC
http://www.news.zdnet.co.uk/hardware	Low power PC
http://www.buds-ert.org/	Energy Resources in Uganda
http://www.inveneo.org/	Thin Client Terminals, Bicycle Generators