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Environmental Code of Practice (Used Battery Disposal)

For Rural Electrification Project

Vanuatu

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Overview

List of Acronyms

DoE - Vanuatu Department of Energy

ECOP - Environmental Codes of Practice

EIA - Environmental Impact Assessment

GoV – Government of Vanuatu

IPP - Indigenous Peoples Plan

ISDS - Integrated Safeguards Data Sheet

LAB – Lead Acid Battery

Ni-Cad – Nickel Cadmium Battery

NERM – National Energy Roadmap

OP – Operational Policy

POM – Project Operations Manual

PV – Photovoltaic

VERD – Vanuatu Electricity for Rural Development

VREP – Vanuatu Rural Electrification Project

Overview

Introduction

The project development objective (PDO) of the Vanuatu Rural Electrification Project (VREP) is to increase access to electricity services for rural households, aid posts and community halls located in dispersed off-grid areas.

Of the 50,740 total households in Vanuatu, an estimated 21,500 are in grid-concession areas or in adjacent areas feasible for grid-extension and the remainder are in remote areas where connection to a grid is not possible in the short to medium term. The GoV and the two incumbent concessionaires Union Electrique du Vanuatu Ltd (UNELCO) and Vanuatu Utilities and Infrastructure Ltd (VUI) are working towards implementing the Improved Electricity Access Project, funded the Global Partnership for Output-Based Aid/World Bank, which will provide assistance to low-income consumers who are still not connected or currently share a connection, within the existing grid service areas. The remaining 29,240 households are in areas termed "off-grid". Approximately 10,000 of these households are relatively concentrated and are more likely to benefit from a micro- or mini-grid configuration, powered by local resources, such as hydro and other renewable energy technologies where available, diesel gensets, or hybrids. For the remaining 20, 000 households, access to modern energy in the near or immediate future is dependent upon off-grid power.

VREP will assist the Government in providing energy to many of these households by targeting 17,500 households, 230 aid posts and 2,000 community halls nationwide that are presently unelectrifiied and are located beyond the economic and feasible grid extension area and are too dispersed across the off-grid area to be considered in future projects for isolated micro or mini grid configurations. Project description and implementation arrangements are included in Annex 1.

Environmental and Social Impacts

Social Impacts

The increased access to electricity services that the proposed project will provide to rural households, aid posts and community facilities located in dispersed off-grid areas will build on the achievements of the recently completed Lighting Vanuatu project by providing improved functionality and enhanced benefits.

There will be no land acquisition for this Project since the installation of PVs will take place within existing households and public facilities. Indigenous Peoples OP/BP 4.10 has been triggered due to the presence of indigenous people (IPs) in the rural areas of the outer islands. However, since the overwhelming majority of the beneficiaries are IPs, the Project has integrated the elements of an Indigenous People's Plan (IPP) in the design of the Project, including consultations for broader community support of the Project, provision of culturally appropriate project benefits in the installation of PV panels in households, and gender-related considerations (e.g., specific consultations with women's groups and uptake of project services by female-headed households). Consultations undertaken during the design of Vanuatu Electricity for Rural Development (VERD), on which this project is based, indicated strong community support. Further, consultations during the preparation of NERM established affordable electrification of rural households as a key priority.

Environmental Impacts

Solar panels will be either installed on rooftops or mounted on pole, where roof orientation is not suitable. As such, there will be no construction related impacts.

The main environmental issues associated with the Project will be the recycle/disposal of spent storage batteries at the end of their useful lives (3-5years – check for consistency in Annex of PP). The Environmental Assessment OP/BP 4.01 is triggered to ensure proper disposal/recycling of lithium, lead-acid or lead-gel batteries, where used. Since legislation and regulations on disposal of solid wastes, such as lead acid batteries, is in early stage of development, this project-specific ECOP has been developed for the collection, transport, storage and disposal of used batteries. It is anticipated that this project-specific ECOP will supplement and accompany more detailed national legislation and regulations for disposal of solid wastes, including batteries during the Project period. No products will be "qualified" for, and included in, the product catalogue until processes for the collection, transport, storage and disposal of the batteries associated with the products are established in accordance with this ECOP.

The registered vendors will need to ensure that they have procedures in place to meet the requirements of this ECOP whether they are through central or industry established processes or vendor and product specific processes.

Environmental Code of Practice - Objectives

This ECOP has been developed specifically for all equipment to be financed under the VREP, namely solar PV systems of generally in the range of 5 Watts to 30 Watts peak capacity. The key environmental issue associated with the project is the appropriate management and disposal/recycling of used Ni-Cad and Lead Acid Batteries. To ensure effective application of the World Bank's environmental and social safeguard policies and to support the national regulatory requirements, the ECOP provides guidance on the approach to be taken to the collection, transport, storage and disposal of these types of batteries at the end of their useful life.

Importantly, the ECOP addresses management of spent/used batteries for a period of time until Vanuatu's waste management legislation and capacity is improved to a point where the ECOP becomes obsolete. To this end, the ECOP seeks to inform discussion and build awareness around battery management to assist continual improvement in battery management for in the country. It is likely that by the time the first batteries under the project need to be disposed of (3-5 years), that Vanuatu will have an effective regulatory framework (which is already well progressed) and the institutional capacity to effectively manage these batteries

Legal and Policy Framework

Vanuatu Legislation

Environmental legislation is at an early stage of development in Vanuatu. The Pollution Control Bill was passed in December 2013 and the Waste Management Bill was passed by Parliament in April 2014.

The Pollution Control Act

The Pollution Control Act is designed to control the discharge and emission of pollution ('the introduction by persons, directly or indirectly, of substances or things into the environment which may result in harm to the environment, and hazardous to human health).

The Waste Management Act

The Waste Management Act is designed to provide for the protection of the environment through encouragement of effective waste services and operations. The Act focuses mainly on solid waste which includes the following: garbage, household refuse, rubbish, scraps, electronic waste, trade and industrial waste, in solid form; or any other matter or thing determined in the Act to be waste. The Act does not include human waste except in the form of sludge or any other form intended for final disposal as a waste product. The Act defines waste as 'solid waste; or bulk waste; or any other matter or thing determined from time to time to be waste in accordance with the Act. The Act also specifies the roles and responsibilities of DEPC as a regulator and the designated waste management operators as operators, which includes the Municipalities or Provincial Government Councils. The Act also allows for licensing of private waste operators (either an individual or company) who wishes to operate a landfill site; or a waste dump; or waste facility.

These pieces of legislation represent the beginning of a legal framework to address the environmental degradation impacts of poor pollution control and waste management. Substantive additional work is required to prepare regulations to add more detail to the legislation and to strengthen the capacity of the institutions responsible for effective implementation of the legislation.

World Bank OP 4.01 - Environmental Assessment.

This operational policy (OP) requires an Environmental Impact Assessment (EIA) to be conducted of the projects proposed for Bank financing to help ensure that they are environmentally sound and sustainable with an objective to improve decision-making process. The OP also classifies the project on the basis of the type, location, sensitivity, and scale of the project and the nature and magnitude of its potential environmental impacts. The requirement to carry out an EIA as part of project preparation can be waived but, for projects with potential adverse impacts, an appropriated level of environmental and social assessment will be carried out before the project implementation. It is expected that by the time the first tranche of batteries needs replacement (at least 3 years after implementation begins), the environmental frameworks will be much stronger. Adopting the precautionary approach however, this ECOP defines minimum requirements.

Environmental Code of Practice Requirements

Batteries and potential environmental impacts

A central component of any remote solar power system such as those proposed under the project is the use of rechargeable batteries. These batteries store the power generated during the daylight hours for later use. Rechargeable batteries include lithium-ion (Li-ion), nickel metal hydride (NiMH), nickel cadmium (Ni-Cad) and lead acid batteries (LAB).

Lithium ion and nickel metal hydride batteries (as well as standard AA, AAA, C-cell and D-cell etc. dry cell batteries) are suitable for disposal in standard landfill and therefore are not covered by this ECOP. Accordingly, this ECOP applies specifically to LAB and Ni-Cad batteries. These batteries, if improperly transported, stored and disassembled/recycled, can create long lasting environmental impacts due largely to the chemical and heavy metals such as mercury, lead, cadmium and nickel which are central components of these batteries. If released into the environment (via incineration and/or leakage and leeching etc.) these chemicals and heavy metals can create a number of health impacts including headaches, abdominal discomfort, seizures and comas.

The main components of a lead-acid battery are lead (Pb) electrodes and lead dioxide (PbO2) electrodes immersed in a solution of water and sulphuric acid. These are generally contained in a plastic case made from polypropylene. In addition to lead which can create to a wide range of biological effects (including upon the kidneys, gastrointestinal tract, reproductive system and the nervous system) and is a recognized developmental and reproductive toxicant[1], lead acid batteries also contain sulfuric acid which is highly corrosive and can cause burns and damage to skin, eyes or the respiratory system. Both nickel and cadmium which are the central components to Nickel-Cadmium (Ni-Cad) batteries have potential negative impacts on both the environment and on human health. While the effects of nickel are generally less severe (in the absence of long term exposure to airborne nickel dust) and limited to skin irritations, cadmium is a carcinogen, which can lead to renal dysfunction and bone defects.

Effective management of batteries can ensure that these potential negative impacts are not realized as a result of this project. Indeed, through the increased awareness activities proposed, it is expected that the project, guided by this ECOP, will have the potential to have long-term positive impacts on communities and public health since many batteries of this type are used by these communities outside this project.

Battery Management Approach

The approach adopted seeks to avoid the potential environmental impacts created by improper management of LAB and Ni-Cad batteries. Mitigation measures proposed comprise two fundamental stages or approaches namely (i) Community and user awareness and (ii) Direct management of used nickel-cadmium (Ni-cad) and lead acid batteries (LABs) by the system suppliers.

Community and user awareness

As part of an initiative of informing the community of the risks associated with batteries under this project, the DoE will carry out a broad battery awareness campaign. This campaign will not only focus on project participants and beneficiaries. Instead, the campaign will target all community members and as such will result in improved knowledge of the environmental issues associated with spent batteries, whether they are from people's cars, boats, or other power supplies etc. Importantly, the communication campaign will

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include information on all the main battery types, irrespective of whether they are high toxicity (such as NiCad and LAB) or lower toxicity batteries (such as AA, or AAA batteries etc). The type of information to be included in the information campaign is included in Annex 2.

A campaign will be designed by the DoE, however it is expected that it will include initiatives such as:

- Information on the DoE website on disposal of all battery types;
- Appropriate local information campaigns including distribution of flyers and information sheets in local communities, awareness raising at community meetings and notices at shops selling batteries; and
- A media campaign including advertisements and awareness pieces in local newspapers

This campaign will run for the life of the project and will address issues such as:

- The differences between the battery types in terms of battery life and reliability;
- The safe handling of batteries including installation, removal, transport, storage and disposal;
- The environmental and health aspects of poor battery disposal; and
- Focused information on the environmental and health issues associated with high toxicity batteries and explanation as to why they must be stored, transported and disposed of in certain ways and therefore why it is in the interests of individuals, the community, the environment (and therefore future generations in communities) that the methods outlined in this ECOP be followed.

Direct management of used nickel-cadmium (Ni-cad) and lead acid batteries (LAB) by the system suppliers

The disposal and management of used batteries from solar PV systems will follow the Government of Vanuatu Waste Management Act and the provisions of this ECOP, which is to require the vendors of the systems to make arrangements to collect used Ni-Cad and LAB batteries and to properly dispose of them.

Notwithstanding this, the direct management process outlined below is focused on Li-ion, nickel-cadmium (Ni-cad) and lead acid batteries (LABs) as these batteries represent the greatest risk to human and environmental health if incorrectly managed.

The vendors will provide a Battery Management Plan which details arrangements for the collection, transport, storage and disposal of batteries for those systems proposed to be eligible under the Project as part of the product registration process. The DoE will assess these processes for compliance with the guidelines set out in this ECOP and may refuse to register vendors' products if they do not comply with the guidelines. A vendor may be refused registration by the DoE under the vendor registration program if the vendor fails to provide evidence on the arrangements for collecting/recycling batteries and redundant solar systems, or failure to compliance with this ECOP.

The Subsidy Implementation Agreement (Legal Agreement) between the vendor the DoE will require the vendors to comply with this ECOP as a condition of participation of the program. The DoE will monitor compliance with the ECOP in accordance with the processes detailed in the POM.

The Department of Environment and Conservation (DoEC) has a Waste Management and Pollution Control Unit which is responsible for waste and pollution control in Vanuatu.

The DoE, in conjunction with the Waste Management and Pollution Control Unit of the DoEC, will conduct checks on the vendors' compliance with the ECOP. The World Bank Team, as part of its supervision mission of the Project, will conduct random checks on the project's compliance to battery disposal and management consistent with the national regulations.

The Department of Energy, in consultation with the DoEC is working towards regulations for the collection and disposal of hazardous wastes, including LABs which is expected to be in place by the time batteries supplied under this project require disposal. This ECOP may be superseded by national legislation and detailed regulations on the disposal of batteries, if the requirements of the legislation and regulation meet or exceed the requirements of this ECOP.

Specific Direct Requirements under this ECOP

Before working with a battery

Training in proper handling procedures is very important. Key aspects include:

- Consult battery owners' manuals for instructions on battery handling and hazard identification
- Wear personal protective equipment (PPE) such as chemical splash goggles and a face shield
- Wear acid-resistant equipment such as gauntlet style gloves, an apron, and boots
- Do not tuck pant legs into boots because spilled acid can pool in the bottom of your boots and burn your feet
- Place protective rubber boots on battery cable connections to prevent sparking on impact if a tool does accidentally hit a terminal
- Clean the battery terminals with a plastic brush because wire brushes could create static and sparks
- Always remove your watches and jewelry before working on a battery. A short-circuit current can weld a ring or strap to metal and cause severe burns
- Cover maintenance tools with several layers of electrical tape to avoid sparking

Chemical hazards posed by batteries

Sulfuric acid (electrolyte) in batteries is highly corrosive and acid exposure can lead to skin irritation, eye damage, respiratory irritation, and tooth enamel erosion. Following the following principles will assist in managing this risk:

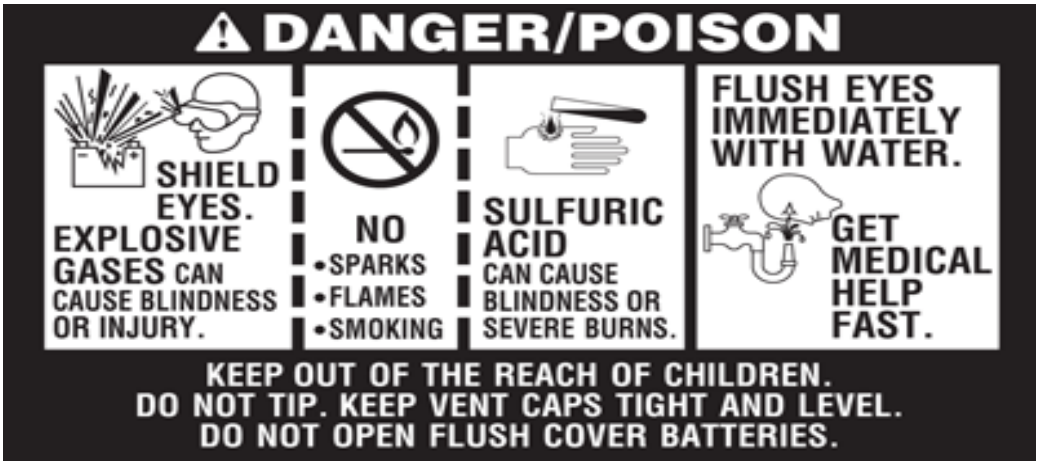
- Never lean over a battery while boosting, testing or charging it
- If acid splashes on your skin or eyes, immediately flood the area with cool running water for at least 15 minutes and seek medical attention immediately
- Always practice good hygiene and wash your hands after handling a battery and before eating. If you handle the lead plates in a battery and do not wash your hands properly, you could be exposed to lead. Signs of lead exposure include mood swings, loss of appetite, abdominal pain, difficulty sleeping, fatigue, headaches and loss of motor coordination.
- The chemical reaction by-products from a battery include oxygen and hydrogen gas. These can be explosive at high levels. Overcharging batteries can also create flammable gases. For this reason, it is very important to store and maintain batteries in a well-ventilated work area away from all ignition sources and incompatible materials. Cigarettes, flames or sparks could cause a battery to explode.

- Before working on a battery, disconnect the battery cables. To avoid sparking, always disconnect the negative battery cable first and reconnect it last. Be careful with flammable fluids when working on a battery-powered system. The electrical voltage created by batteries can ignite flammable materials and cause severe burns. Workers have been injured and killed when loose or sparking battery connections ignited gasoline and solvent fumes during system maintenance.

Safe Battery Movement

Lifting and moving batteries needs to be undertaken with care so as to avoid personal and environmental harm. Key principles include:

- Use proper lifting techniques to avoid back injuries
- Battery casings can be brittle and break easily; they should be handled carefully to avoid an acid spill
- Make sure that a battery is properly secured and upright in the vehicle or equipment
- If a battery shows signs of damage to the terminals, case or cover, replace it with a new one



Battery Disposal

For Lead Acid and NiCad batteries, the supplier will ensure that a system is in place to obtain and properly dispose of these batteries at the time of battery replacement.

Recycling

Lead recycling operations require a high degree of control because of the potential hazards from air emissions and wastewater discharges. There is currently one battery recycler (Recyclecorp) in Port Vila who has been recycling lead acid batteries over the past 3 years. Recyclecorp has collection points in Port Vila and Santo and pays for expired lead acid batteries and other metals received from any island. Batteries are collected and stored separately until there is enough for a full container to be shipped overseas. In the past batteries were shipped to Fiji for recycling but now Recylecorp has secured a better deal in Korea. A 20 ton container (approximately 1,000 batteries) of mostly car batteries is exported once every 3 months. It is envisaged that the batteries that are collected for recycling will be through this recycler. RecycleCorp has expressed interest in the VREP project and is willing to buy the batteries if they are transported to their collection points in Santo and Vila.

. There is one LAB recycler in Port Vila. As a preference, LAB batteries are to be recycled at this recycler as it removes the risks associated with further shipment and/or disposal.

Landfill Disposal (Hazardous Waste Facility)

If recycling of batteries is not chosen or possible, disposal in a secure landfill is the next preferred option. The acid should be removed from the casing and neutralized. Empty battery cases must be disposed of carefully because they can still contain significant amounts of lead. Batteries should then be wrapped in heavy duty plastic or encapsulated with concrete. The concrete and plastic serves the purpose of ensuring that lead will not leach out and become mobile in landfill leachate, thus reducing the environmental risk. The main centers such as Port Vila, Luganville, Tanna and Malekula have landfill sites operated by the local provincial councils that could be used for the disposal for batteries.

Capacity-Building and Monitoring of ECOP Implementation

As part of the capacity building to be provided for implementation of the proposed operations, the vendors and relevant staff of the concerned line departments may also receive training in the ECOP's application. The World Bank will monitor and provide guidance in the implementation of the ECOP. DoE will be responsible, besides other functions, to monitor and supervise the implementation of the ECOP. For this purpose, DoE will establish a monitoring mechanism as part of the project management system as part of its POM. In addition, DoE may also engage the support of the DoEC for the implementation of the ECOP and compliance with national legislation and regulations.

Disclosure

This ECOP will be shared with all relevant stakeholders, relevant line departments, concerned non-governmental organizations, and development partners. Subsequently, it will be disclosed in English by DoE, and made available on their websites. Copies will also be held at public buildings, such as libraries and offices of Provincial Councils, for the rural communities to access. Copies of the ECOP translated into Bislama will be shared vendors during the vendor registration program to ensure they are fully informed of their obligations. It will also be made available at the World Bank office in Port Vila and on the World Bank website.

ANNEX ONE – PROJECT DESCRIPTION AND IMPLEMENTATION ARRANGEMENTS

Project Description

The Project, which will run for 5 years, will target some 17,500 households, 230 aid posts and 2,000 not-for-profit community halls nationwide that are presently unelectrified and are located beyond the economic and feasible grid extension area and are too dispersed across the off-grid area to be considered in future projects for isolated micro- or mini-grid configurations. For the successful electrification of this off-grid area, the least cost, practical and near-term solution is likely to be solar photovoltaic (PV) systems. For this Project, such systems will be demand driven "plug and play" solar home systems for lighting with capability for mobile phone charging and other small uses. Experience from other rural programs in Vanuatu and other Pacific Island States indicates that the sustainable dissemination and maintenance of PV systems in remote areas is one of the most challenging tasks in rural electrification. The Project will employ subsidies and private sector led marketing, including a product catalogue, to enable access to solar PV systems for off-grid households, aid posts and community halls. There are presently 11 private sector PV providers in Vanuatu; approximately five have been established for the past 5 years at least.

The project will have two components:

Component One: Electrification of off-grid households, aid posts and community halls.

The Project will subsidize the retail cost solar photovoltaic (PV) systems by 50 percent. Initially the Project will focus on solar PV systems of between 5 Watts to 30 Watts peak capacity that are of "plug and play" type, installed easily by the consumer, require little to no maintenance other than replacing batteries, and provide lighting and phone charging capabilities. "Plug and play" systems of higher capacity are not ruled out in the future provided they meet the product registration criteria for this Project. The Project will not fund smaller systems such as solar lanterns; such systems were funded under the Lighting Vanuatu project, and the demand and awareness for those systems is considered self-sustainable.

Component Two: Technical assistance and project management.

The Project requires significant work on ensuring the integrity of the vendor supply chain, and of the products that are supplied to consumers/retailed, consumer awareness and training, collection and disposal of any hazardous or toxic materials, project management and independent verification to ensure the funds allocated under this Project are effectively directed towards achieving the PDO of this Project. The following key activities will be financed to address the above:

(i) Vendor and product registration arrangements, communications and microfinance products. The following activities will be financed to support the preparation and implementation of the investment activities under Component One: (i) establishment of vendor registration arrangements; (ii) development of product registration arrangements (for a product catalogue); (iii) development of program and product awareness, safety and product care training material for communities, and end users; (iv) establishment of

a grievance mechanism for end-user and communities; (v) support with the development of microfinance products to encourage lending in rural areas; and, (vi) development of legislation, regulations and amendments this Environmental Code of Practice (ECOP) for collection, transport and disposal of lithium and lead-acid batteries for rural electrification products under the Project.

(ii) Project management and support. The following activities will be financed for effective implementation, monitoring and reporting under the Project: (i) capacity building and implementation support to the DoE through technical experts and advisors; (ii) workshops and training for the DoE staff (and other Governmental departments, such as the Ministry of Infrastructure and Public Utilities) involved with off-grid electrification; (iii) execution of awareness programs to rural communities and consumers in Vanuatu; (iv) independent verification of subsidy claims prior to payments; and, (v) monitoring, evaluation and annual reviews of the Project.

Implementation Arrangements:

The Recipient and Executing Agency for the Project will be the Ministry of Finance and Economic Management (MoFEM), who will enter into a Financing Agreement with the World Bank. The Implementing Agency will be the Department of Energy (DoE), within the Ministry of Climate Change and Natural Disasters (MCCND). The DoE is currently implementing one other World Bank project in the energy sector, the Energy Sector Development Project (ESDP), and is the implementing agency for the recently approved Global Partnership for Output Based Aid (GPOBA) project.

The DoE has recently appointed an Off-Grid Officer who will provide support for the implementation of the VREP under the direction of the Director, DoE, including the oversight of this ECOP.

The delivery of the solar systems under this project will be through registered vendors supplying products on an approved Product Catalog in accordance with the procedures set out in the Project Operations Manual (POM):

Vendor Registration Program. In order for vendors to participate in the program and be eligible for claiming reimbursements of subsidies, the Project will establish a registration program for vendors. The program, at a minimum, will assess the vendors on their: (i) financial capacity of the business to ensure cash flows are sufficient; (ii) technical ability in providing after sales services to the consumer, such as maintenance and information on the systems and batteries; (iii) range of products stocked and supply channels and chains; (iv) number of staff and agents and communication links between them; (v) arrangements for collecting/recycling batteries and redundant solar systems, with particular focus on compliance with this ECOP and/or regulations; (vii) training programs in place for staff development and capacity building; and, (viii) geographic reach and existing networks in rural communities and outer islands

to ensure that all the target beneficiaries can access the products. The Project will encourage collaboration between the main center-based vendors and local communities for the distribution of the products. The vendor registration program will be developed as part of project implementation. Each registered vendor will enter into a Subsidy Implementation Agreement with DoE, which amongst other things require the vendors to comply with this ECOP.

Product Catalogue. To promote competition between the vendors in Vanuatu, across all regions and island groups, all eligible products supplied by the vendors will be listed in a product catalogue. The purpose of the catalogue is to present, transparently, to the consumers the range of products available in their area and in the main centers. A vendor must be registered under the vendor registration program (see above) before a product can be listed in the catalogue. Participating vendors will be allowed to market any solar system products in the catalogue and procure them from any source in accordance with standard business practice. However, for the product to be eligible under this Project, it must be a “plug and play” systems, initially in the capacity range of 5 to 30 Wp. Once consumer awareness and compliance with safeguards has increased, the capacity range will be reviewed and adjusted, if needed. The product “qualification” criteria will be established during project implementation, covering technical specifications, system performance, product and battery life, warranty, serviceability, product information and recycling needs and arrangements, etc., to enable vendors to register their products.

An Independent Verification Agent will be engaged by the DoE to verify the claims from the vendors, as set out in the POM.

ANNEX 2 – Information for Battery Awareness Campaign

Introduction

1. Most homes and businesses contain many pieces of equipment such as portable computers, cell phones, power tools, standby or backup power systems, cameras, security equipment, radios, torches, etc. that depend on batteries to operate. As a result, batteries have become integral to the functioning of our economy and support many aspects of modern lifestyles. These households and businesses use a number of different types of batteries which have different chemistries.
2. Non-rechargeable, single-use batteries used in clocks, toys, cameras and remote controls can be either alkaline and zinc-carbon (AA, AAA, D, C, 9-volt dry cell), mercuric-oxide (button, cylindrical and rectangular) or lithium (AA, C, button, 9-volt). These batteries are also known as "primary" or single-use batteries because they are normally not recycled and are disposed of after use.
3. Rechargeable batteries (also referred to as "secondary" batteries) use lithium-ion (Li-ion), nickel metal hydride (NiMH) or nickel cadmium (NiCd) chemistry. These are found in such products high end products as camcorders, mobile phones, laptops and cordless power tools, shavers, and electric toothbrushes.
4. Lead-acid batteries are the oldest type of secondary batteries. They are used to supply electrical power to cars, trucks, tractors, motorcycles, and boats. Small sealed lead-acid batteries are used for emergency lighting and uninterruptible power supplies.
5. Used batteries, whether primary or secondary, are potentially hazardous, so they need to be stored and handled carefully. Some of the materials inside a battery are toxic and may damage skin and clothes if the battery is damaged or leaking. Used batteries require careful handling to minimize safety hazard such as explosion and fire and good management to avoid pollution of soil, surface water and groundwater by storing them under cover and in a bunded area. The three main types of batteries in common use in solar energy systems are described below:

Lithium Batteries

6. There are two types of lithium batteries in common use: (i) primary (non-rechargeable) metallic lithium (Li) batteries, which are small in size and have a long life and are used to power toys and small electronic devices; and (ii) secondary (rechargeable) lithium ion (Li-ion) batteries, which are one of the lightest rechargeable batteries available and which are found in more expensive products such as laptops, cameras, mobile phones, power tools and now increasingly in solar powered devices. Large lithium batteries are found in other applications such as backup power, electric cars and some newer air planes. Lithium batteries use lithium in its pure metallic form while Li-ion batteries use lithium compounds which are much more stable than the elemental lithium used in lithium batteries.
7. Both types of lithium batteries can be recycled. During collection, they can be mixed with other battery types in the collection container as long as certain packaging requirements are met. Larger lithium batteries (>500g) batteries can be collected but require separate storage from smaller handheld batteries. The risks associated with lithium battery recycling include the potential for a fire or explosion if batteries become over-heated from sun or for example, if they short-circuit.

Nickel Cadmium / Nickel-Metal Hydride Batteries

8. Nickel-Cadmium (NiCd) batteries were the first reasonably priced rechargeable consumer batteries. They are being superseded by new rechargeables Nickel-Metal Hydride (NiMH) batteries. Nickel-metal

Hydride batteries are related to sealed nickel-cadmium batteries and only differ from them in that instead of cadmium, hydrogen is used as the active element at the anode. The energy density of NiMH is more than double that of Lead acid batteries and 40% higher than that of NiCd. Like NiCd batteries, Nickel-metal Hydride batteries are susceptible to a "memory effect" although to a lesser extent. They are more expensive than Lead-acid and NiCd batteries, but they are considered better for the environment.

Lead-Acid Batteries (LAB)

9. The main components of a lead-acid battery are lead (Pb) electrodes and lead dioxide (PbO_2) electrodes immersed in a solution of water and sulphuric acid. These are generally contained in a plastic case made from polypropylene. While LAB has a history of reliability, is available worldwide, and is widely recycled, it is also bulky and heavy, prone to gassing, and sulphation. The heavy metal element (lead) of the battery makes the battery toxic and improper handling and disposal of the acid and lead can be hazardous to health and the environment.

Why Recycle?

10. Batteries pose a risk to human health and the environment if disposed of inappropriately. They contain heavy metals that are toxic to human health and/or have eco-toxicity impacts if they exceed certain minimum concentrations in the natural environment. Lead, mercury and cadmium are particularly toxic, but other metals such as nickel can also be of concern if they leach into surface or ground water. Batteries also contain valuable metals such as cadmium, lead, zinc, manganese, cobalt and rare earth metals that can be recovered to minimize the use of natural resources and to reduce impacts on the environment which occur in the production, distribution and end-of- life phases of the battery life-cycle.
11. Single-use batteries have significant environmental impacts at every stage of their life cycle. The manufacture of batteries require use of chemicals to purify metals, extraction of resources by mining (with potential destruction of wildlife habitat) and production of power by burning fossil fuels; which in turn contribute to global warming, and creation of air and water pollution. The importation / transport of batteries require yet more infrastructure development and energy usage. In landfills, the chemicals inside batteries can leach from their casings and pollute soil and water with toxic heavy metals if the batteries are not properly recycled.
12. The technology for recycling secondary (rechargeable) batteries are well known and widely deployed in developed and some developing countries. Used LABs are widely collected and recycled (almost 96% collection in North America). NiCad and Lithium batteries are only now being recycled. However, in most developing countries, the economics of battery recycling is not sustainable. The cost of handling batteries (collection, storage, packaging), and transport, especially in rural areas, far exceed the cost of recycling the batteries. As a result, in most developing countries, lacking recycling facilities, used batteries are invariably discarded to the environment. Sometimes used LABs are collected, packaged and exported overseas for recycling, the economics depending on the price of lead and cost of transportation.
13. The technology for recycling primary (single use) batteries though available is not widely used, largely because of cost of recycling and because of battery collection (supply) problems. It is only now being deployed in North America, Europe and other developed countries.

14. Although recycling may not be a near term option, batteries – primary and secondary – should be collected and safely stored for transport to an environmentally safe and secure location for future processing or to a recycling facility.

Battery Comparison Table (II)					
Rechargeable (secondary) Batteries					
					
Battery Type	**Nickel Cadmium**	**Nickel Metal Hydride**	**Lithium-Ion**	**Lead Acid**	**Sealed Lead Acid**
Common Name(s)	Ni-Cd, Ni-Cad	NiMH, Ni-Li, Ni-Hydride	Li-Ion, Lithium Iron Phosphate	car battery, starting battery, wet cell, deep cycle	SLA, SSLA, valve-regulated, VRLA, Gel
Common Applications	modern off-grid lighting, powertools, cordless phones, professional radios, medical, household*	modern off-grid lighting, laptops, cell phones, household*	laptops, cell phones, handheld electronics	Cars, trucks, and other vehicles, standby/backup systems	off-grid lighting, wheelchairs, backup power systems
Estimated Cycle Life[1]	300-1000	500-1000	500-2000	200-700	300-1000
Advantages	Low cost, rugged, higher energy density than SLA	Higher energy density than Ni-Cd, no cadmium	light weight, high energy density	inexpensive, rugged	inexpensive, rugged
Disadvantages	contains cadmium memory effect	High self discharge higher cost compared to Ni-Cd	highest cost rechargeable, requires protection circuit	Heavy, low energy density, low cycle life, contains lead	Heavy, low energy density, contains lead
Toxicity[1]	Highly toxic- contains cadmium	Low to Moderate	Low	Highly toxic- contains large amounts of lead	Highly toxic- contains large amounts of lead
Disposal	Recycle or Hazardous Waste Disposal	Landfill in small quantities (<10 cells). Recycling recommended.	Landfill in small quantities (<10 cells). Recycling recommended.	Recycle or Hazardous Waste Disposal	Recycle or Hazardous Waste Disposal
Recycling[2]	Cadmium and ferronickel can be recovered which yield a moderate market price.	Recycle to recover nickel. NiMH is the most cost-effective battery to recycle because of the high market value for scrap nickel.	Cobalt and other metals can be recovered which have a high resale value, but the recycling process is more complex (ie more expensive).	The most commonly recycled battery worldwide. Lead and plastic casings can be recovered. Moderate market value for scrap lead and a mature resale market.	The most commonly recycled battery worldwide. Lead and plastic casings can be recovered. Moderate market value for scrap lead and a mature resale market.
[1]Battery University:http://www.batteryuniversity.com/partone-3.htm Product					
[2]Relative market prices for battery scrap metal were obtained from Todd Coy, Toxco battery recyclers, phone conversation, 24 June 2008.					
*Commonly found in AA, AAA, 9V, etc sizes for regular household use.					