PV System for a Bush Training Centre

Frank Jackson and Mark Hankins

Participants at Energy Alternatives Africa's Advanced PV and Off-Grid Energy course at the Centre for Wildlife Management Studies in Kenya.

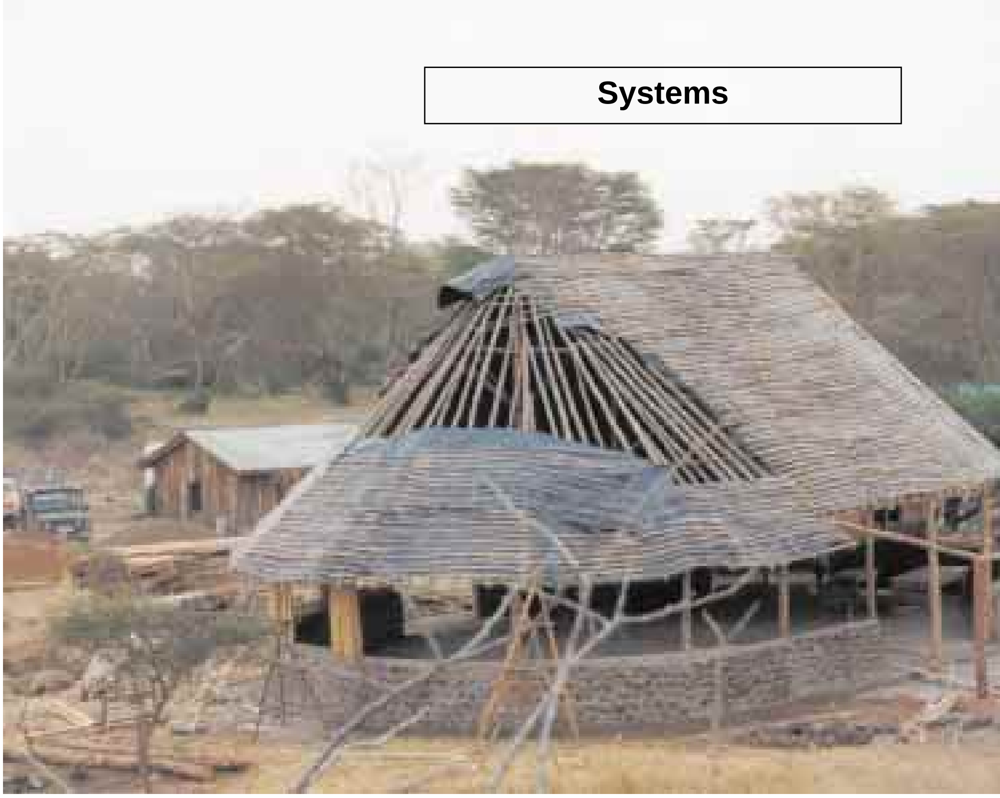
When planning their "bush camp" training site near Amboseli Game Park in Kenya, the Centre for Wildlife Management Studies (CWMS) didn't want to go the genset route. They wanted an energy system that would provide a sustainable model for the area. The surrounding communities use the site as a resource, and they are also almost 100 kilometers (60 miles) from the nearest power line. They were excited about solar energy, as it fits within the broad environmental education objectives that their institution promotes.

Petroleum generators still have a much larger share of the off-grid power market than PV in East Africa. Even where PV or hybrid PV would be cheaper, a majority of the market still goes for a generator. Why?

Sometimes gensets are the better choice. More often, the prospective customer doesn't have the facts about off-grid PV. Frequently, the "ramshackle" reputation of poorly functioning PV systems (so common in this region) blinds customers who have larger energy needs. Given the lightning-fast development of PV technology, it is understandable that the huge range of stuff available bewilders East African technicians and customers alike. So, despite tens of thousands of well-installed one-panel systems, there is still a lack of manpower to plan and install complex PV systems.

Making the Plan

Rodney Swatton was in charge of developing the bush camp training site for CWMS. He approached Energy Alternatives Africa, Ltd. (EAA) to plan an energy system for the camp. EAA is a consultancy specializing in rural



The chumba (main meeting hall) under construction at the CWMS training site near Amboseli Game Park, Kenya.

energy. Made up of five staff based in Nairobi, we build renewable energy infrastructure in East Africa through training, project management, project planning, energy system design, etc. We do not sell equipment.

Located near Loitokitok, a Kenyan town at the base of Mount Kilimanjaro, the camp's mission is to help international and Kenyan students gain experience in the management and control of flora and fauna in parks, reserves, and ranches. Students live and study in the fenced bush camp, which has twenty permanent tents, several offices, a library, a kitchen, a central thatched lecture hall ("chumba"), staff housing, and a generator house.

While the camp was still under construction, Bernard Osawa of EAA surveyed the site in June 1999, and we parlayed with CWMS to give them an idea of what is possible with PV. As is commonly the case, the customer wanted more power than there was a budget for. We had discussions about how to bridge the gap between the technically and financially possible. In the end, a hybrid system was designed which would get most of its power from PV, but might occasionally have to rely on the genset. CWMS then contracted Solagen, Ltd., the Nairobi BP agent, to supply the equipment.

Instructor Frank Jackson (right) and students Steven Muthanthi (left) and Peter Anthony (center) test modules.

An Educational Opportunity

Eager to help local technicians get experience with larger PV systems, EAA suggested that the installation be used as a training opportunity, and CWMS quickly agreed to the arrangement, as did Solagen. APSO (Agency for Personal Service Overseas, part of an Irish state aid programme), generously provided Frank Jackson's services as project leader. Frank, who works as a PV electrician in Wales under the name Green Dragon Energy, was eager to apply his ample African experience in another EAA training course. EAA arranged for eight local technicians from Kenya, Uganda, and Tanzania to attend the course.

Between June and August, equipment was ordered, and systems were brought from the drawing board to reality. Solagen finalised system design, and imported PV equipment, lights, and inverters. Frank Jackson handled electric circuits, while EAA oversaw the logistics of making sure things got put in place on time. There were two systems: the hybrid genset/PV system and the smaller "chumba" lighting system.

PV-Diesel Hybrid System

This system uses a Trace DR2424 inverter-charger to supply 240 VAC power to the office/library block for fluorescent lights and the students' twenty laptop computers. CWMS had the foresight to choose laptops rather than energy-guzzling desktop computers which would have required five times more power. The two largest loads, a photocopier and a welding machine, are connected directly to the genset.

Large safety signs in English and Kiswahili on the thatch-roofed battery hut.

The PV array is installed on three manually-turned rotating mounts made under EAA co-founder Daniel Kithokoi's supervision in Nairobi. Each holds four 85 Wp (watts peak) BP monocrystalline modules. PV charge is fed to the battery bank through a Trace C-40 charge controller. Energy is stored in twelve BP Powerbloc 2 VDC flooded deep-cycle lead-acid cells. Connected in a 24 V configuration, they provide 580 AH at a C10 discharge rate. The batteries and inverter are installed in a traditional East African thatch-roofed building. It also houses the site's radiotelephone power and control systems.

Both generator and inverter circuits are protected by 30 mA RCDs (residual current devices, known as ground fault interrupters in North America). For the battery and generator house, conspicuous safety signs—in English and Kiswahili—were painted by Frank's partner Clare (who was otherwise busy during the course sketching wildlife and the Kilimanjaro landscape).

All wiring accessories were bought in the local market, which meant we had to do some creative appropriate tech work. Still, we paid particular attention to safety and proper wiring, for two specific reasons. First, all the buildings in this dry area have flammable thatch roofs. Equally important was the fact that we were running a training course and wanted to set a good example.

All cables are in PVC conduit, and the ones below ground and between buildings are armoured. While the "armour" is used as an earth (ground), a main earth or "circuit protective conductor" is run separately to every consumer unit. This was done to be absolutely sure of good earthing. East African metal junction boxes are not particularly good, and while we did run earth wires from the tags of the armoured cable, Frank was not sure about their integrity over a longer period of time. So it was decided do to a main earth separately.

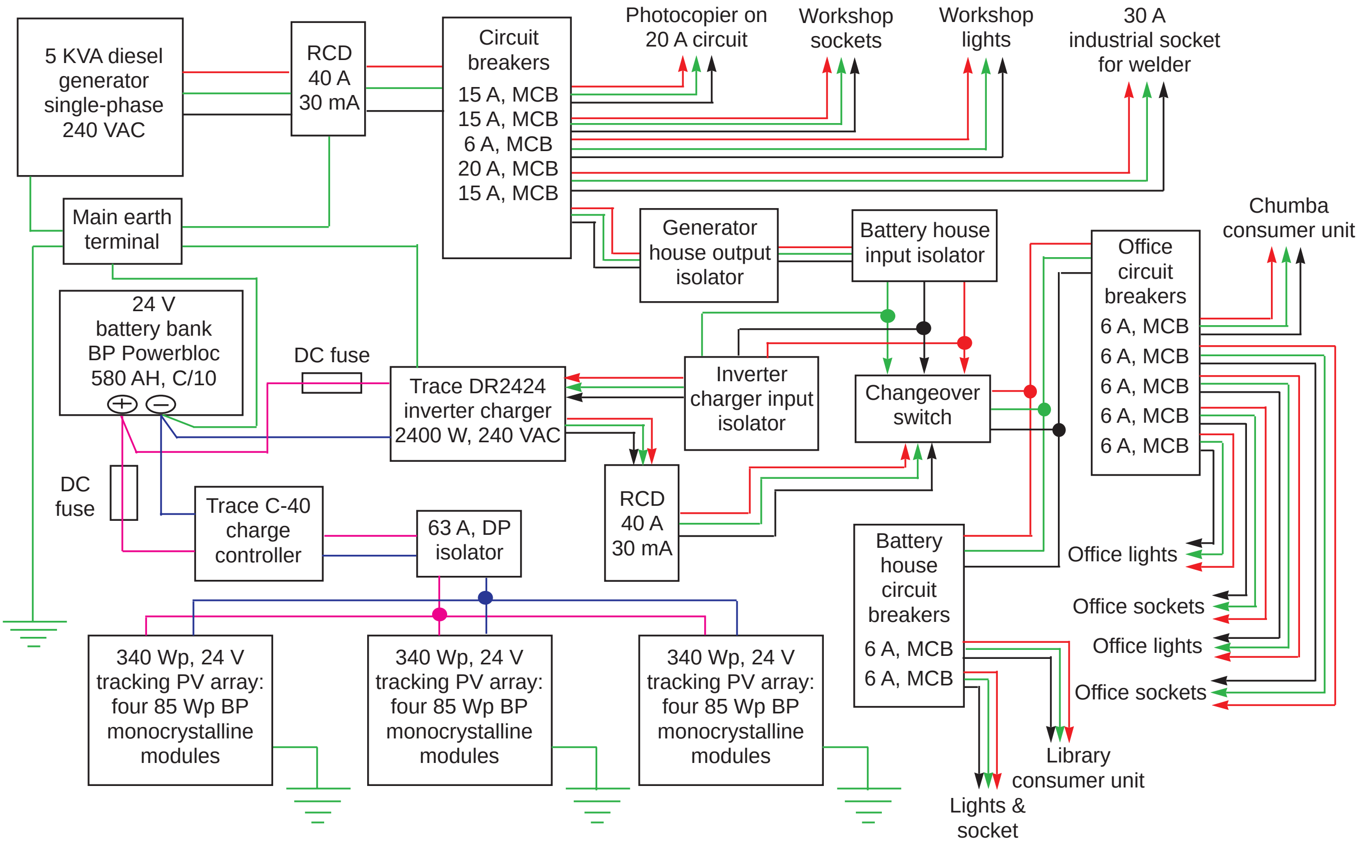
Goodhope Oscar from the KARADEA Solar Training Facility in Tanzania at work in the battery house.

The earth loop impedance values were well within those required by UK (and Kenyan) regulations, giving very fast tripping times on the circuit breakers (all AC circuits were protected by local circuit breakers rather than fuses). All system earths were connected to a single earth rod by the generator house. Each PV array was also separately earthed to provide lightning protection.

The Chumba System

The chumba is a large thatched hall with tables, audio visual equipment,

Solar-Diesel Hybrid Electric System
Centre for Wildlife Management Studies, Kenya, East Africa



white boards, dartboards, and a connected kitchen. It serves as the social centre of the camp, and we felt that it would be wise to provide it with a stand-alone lighting system rather than connect it to the office system. We saw benefit in having two systems so that if one crashed, the other would still be working. This also improves security.

This DC system is powered by three 75 Wp BP monocrystalline modules charging three BP L120 Solarbloc batteries through a BP 20 A charge controller. The chumba and the kitchen have twelve Sollatek PL 12 VDC lights. Light from the Sollatek fixtures is directed into the room by rustic white-painted wooden reflectors, attractively constructed by the site carpenter and students.

The Course

EAA, Green Dragon Energy, and eight students installed the two systems in August of 1999. Two of the students were from CWMS. This meant that the organisation would have a full understanding of the system after it was in place. When the course started, the camp was a construction site, with carpenters and masons everywhere. Classes were conducted in a makeshift classroom (which also served as a storage area for thatching material, and housed a bee colony and some black mambas during the course).

Over two intensive weeks, Frank led the course. Mark came down from Nairobi on the third day with last minute equipment from Solagen. Mark is a rural energy trainer and consultant who has been working in Africa since 1983. He is co-founder of EAA. Through training, projects, and promotional work, he has helped develop the PV market in East Africa. His textbook *Solar Electric Systems for Africa* is a well-known trade book. As is usual with EAA courses, mornings were spent in the classroom, while afternoons were spent on the installation, with students rotating from job to job. In the evenings, students worked on personal project assignments.

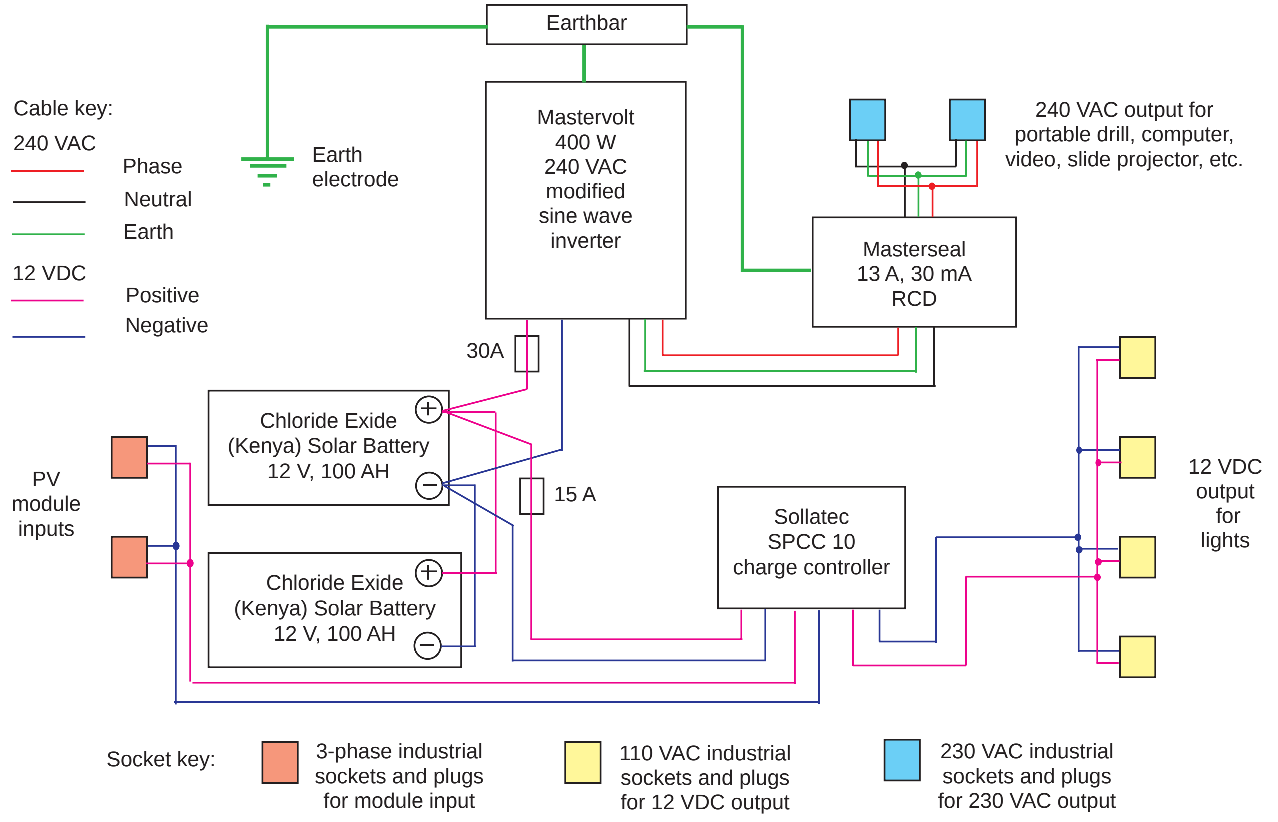
The course covered most aspects of off-grid hybrid PV design and installation: PV arrays, inverters, inverter-chargers, charge controllers, battery banks, diesel generators, circuit design and wiring, loads in off-grid systems, standards and codes, and testing and commissioning of systems. Frank also did one class on small wind turbines which generated considerable

Mobile Power Supply Unit for Energy Alternatives Africa

As there was no power on site at the beginning of the course, we used EAA's Mobile Power Supply (designed by Frank) to power lights for night classes, laptops, and tools. The unit was designed and assembled to enable EAA to have an electricity supply at hand when carrying out basic solar electricity courses in remote parts of East Africa. It is a self-contained, solar-powered unit providing lights and 240 VAC to power appliances such as computers, printers, VCRs, slide projectors, overhead projectors, small power tools, and other electrical appliances away from the grid.

About the size of a very large suitcase, it is robust, portable, user-friendly, safe, and easy on the environment. Essentially, the unit is a large box with a variety of sockets into which the PV modules, lights, and appliances can be plugged. Extension leads are provided. The electrical energy is stored in locally manufactured deep-cycle batteries.

In the darkness of the savanna night, Frank kick-started our workshop by holding a solar slide show which featured images of what PV can do—grid connected and stand-alone—from East Africa to Wales. The Mobile Power Supply, with non-interchangeable sockets and plugs for modules, AC output and DC output, and generous extension leads, did the job perfectly. When the lights from the Mobile Power Supply were switched off, the site was pitch dark, and the sounds of the African night took over. On several nights, lions were heard roaring at the perimeter of the camp.



interest, since this technology is comparatively unknown in East Africa.

In addition to product information from companies, the *Universal Technical Standard for Solar Home Systems,* and a technical information package, each student got several copies of *Home Power* from the EAA collection in Nairobi. The technical standard is intended to provide a basis for technical quality assurance procedures. The document is available for free download, and ETSI (see *Access)* will also send hard copies free of charge.

Each of the eight students chose a personal design project to complete over the two weeks of the course. These included bush hospitals, rural secondary schools, game park lodges, and a village market centre.

The temporary Trace DR1524 inverter in the battery hut.

Each student had to produce an overall system design for his particular project, including schematics, detailed calculations for the sizing of PV array and battery bank, and a wiring/cabling diagram of essential parts of the complete installation. On the last day, each student gave a thirty minute presentation to the class, and answered questions from peers. This formed one part of the assessment. The second part was a written test which students were given to complete in their own time at home. EAA awarded completion certificates when all of this work was completed.

Students and instructors stayed in tents which were pitched under thatched bays. When the clouds parted, students got an excellent view of the white glaciers on Mount Kilimanjaro's peak, with cool air, fresh sunlight, and bird songs everywhere. We were treated to scrumptious meals cooked "camp-style." The camp cook, Odero, whipped up pancakes, macaroni and cheese, game meat, fruit salads, chapati, and ubiquitous "ugali" (maizemeal) in an improvised temporary outdoor kitchen.

Complications

Most of the problems had to do with the logistics of delivering equipment from international sources to the remote site. In Africa, this is always tricky and expensive, and it is never fun. For example, due to Trace backlogs, Solagen/BP had trouble delivering the inverter to the site, and a smaller unit (a Trace DR1524) had to be substituted until the right one arrived.

Local screws are always a problem, but the team persevered. (Why do manufacturers never supply spares for that quarter-inch bolt that always falls off the roof?) The PVC conduit was easy to work with once everyone got the hang of it, but there were some compatibility problems with loop-in, loop-out junctions for the lights, and finding boxes for the sockets. There was also a problem with one of the modules, which Solagen fixed when they came down to inspect the installation with a representative of BP Solar Nairobi.

The other complications had to do with making sure that safety codes were followed. In East Africa, many designers and installers do not see a difference between 40 Wp systems and 2 KWp systems. Too often, they design and install using the same minimal codes.

We find that proper fuses and interconnects between battery and inverter are often not used. Earthing is done as a last minute thing, if done at all. Between inverters, gensets, and PV power sources, there are often no isolators, or the switches used are not properly rated. And, finally, in the generator/battery rooms where proper connections are so crucial, we often find snake-nests of unlabeled wires. Because the same companies that are not safety conscious also tend not to worry about educating end users, some dangerous situations are created in remote sites where large PV systems are installed.

As an example, we were unable to find proper DC fuses for battery-inverter systems in the Kenya market, and no suppliers have them (though many install inverters!). Suppliers in Kenya often leave safety products out of the system, or substitute the wrong products. This has created many potentially hazardous situations, and has given PV an unprofessional and ramshackle reputation. EAA is working with committed local companies to increase awareness of the need for design standards and codes-of-practice, and to increase the supply and use of safety equipment.

We Visit Later

Three months after the system was installed and commissioned, Bernard and Mark from EAA went down to see how it was doing. Driving across the savanna under a full moon, we got lost somewhere near the site. Fortunately, we were able to use the system lights to find our way. From a distance, the Sollatek 18 watt security lights seem brighter than kerosene pressure lamps.

Students David Omgacho and Peter M. Ngalu from CWMS check array voltage.

We parked, came in through the gates, and found students reading and studying in the chumba under the Sollatek lights. The cooks were making tea in the fully-lit kitchen. In the office, staff were using laptops and printers to produce the next day's class material. Other students were outside playing drums and enjoying lunar energy around a campfire, undisturbed by the noise of a generator!

Site manager Otieno reported that the chumba system had been overused once—the lights had been left on until the LVD cut them off. Afterward they had let the modules give the system a full week's charge before using it again. In short, we found the system in good order, and our measurements showed the batteries and all other parts of the system to be working well. They have not even used the generator yet to top off the batteries. We chalk this success up to good design, careful installation, and—most of all—good user education and discipline.

EAA will be holding occasional two to three week training courses at the bush camp over the next two years. Interested technicians should contact us.

Appropriate Power

Perhaps more than anywhere else, rural Africa needs appropriate power systems. Because of the poor reach of the grid, PV and generators will play a crucial role in supplying this power. This bush camp system is a high-quality demonstration of how PV can appropriately meet these needs, and a training system that enables people from the region to learn how PV works. The system shows that when you get both the technical hardware and the human software (training) right, there is no better power source than the sun.

Access

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