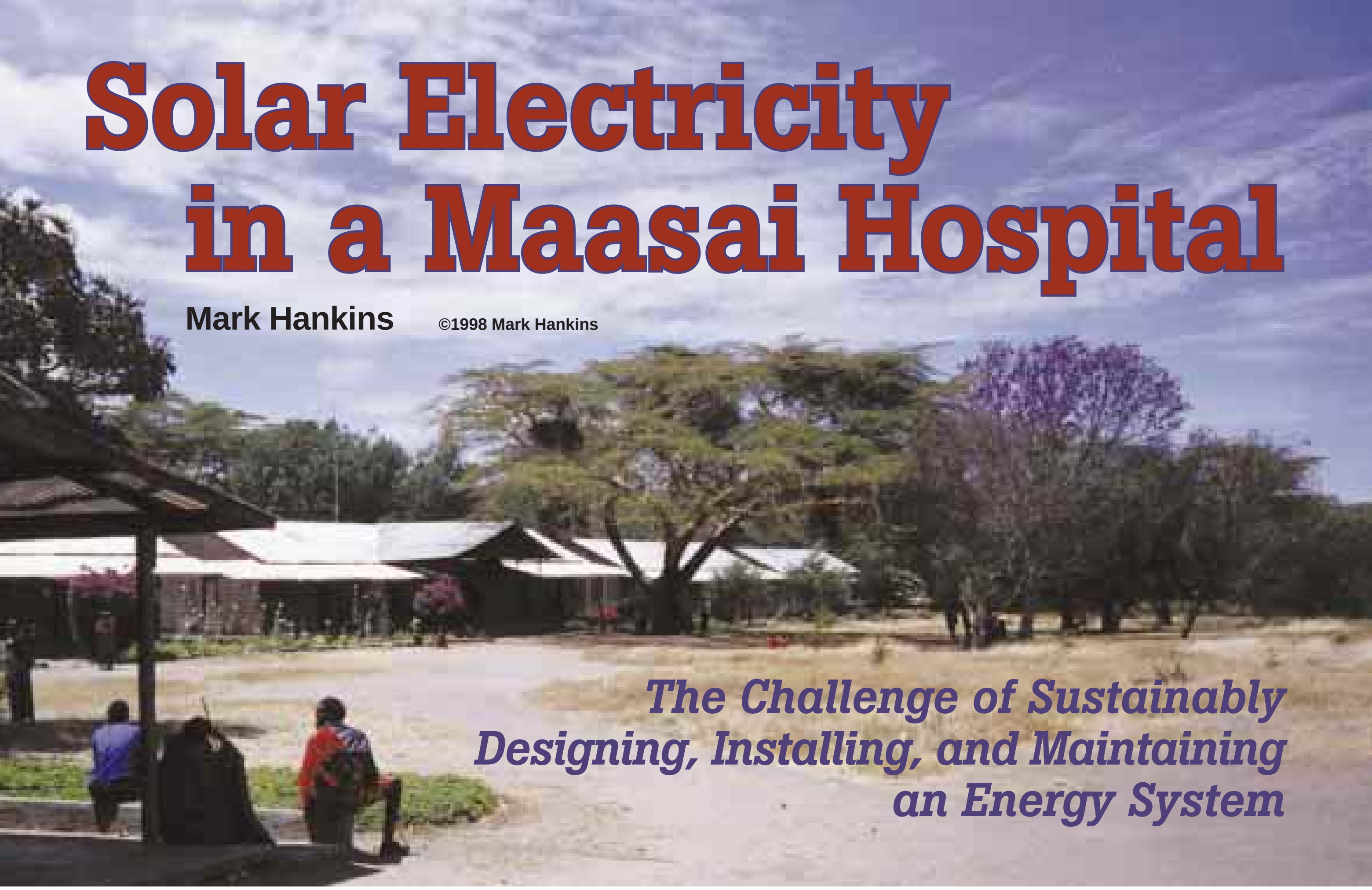
Solar Electricity in a Maasai Hospital

Mark Hankins



The Challenge of Sustainably Designing, Installing, and Maintaining an Energy System

Wasso Hospital is located in the deep bush of Maasailand, nestled along the Tanzania / Kenya border between three spectacular game parks—Serengeti, the Maasai Mara, and Ngorongoro Crater and the Loita Hills. Hundreds of miles from the nearest tarmac road, it is a mission outpost dreamed into being in Tanzania's early post-independence days by a celebrated Austrian priest / doctor / hunter named Wassenger.

The hospital was established in wilder days, when a mzungu (white) doctor could shoot game and swig sundowners in between bloody sessions in the operating room and when the Catholic sisters and volunteer orderlies would trek for picnics on nearby hills. Today, the head doctor doesn't carry an elephant gun and much of the old bush romance is gone, but Wasso is still one of the best hospitals in the region, providing primary health care services and front line treatment against the two most common local ailments—tuberculosis and STDs.

To get to Wasso one drives over savannah plains and through acacia woodland populated by wildebeest, zebra, gazelle, and giraffe; and the ubiquitous Maasai with their vast herds of long-horn cattle. Driving into the compound in the morning through a forest of riverine fever trees, one sees the buildings of the hospital compound with their tin roofs and neat flower gardens. On one side of the compound dozens of shuka-clad moran (Maasai warriors) sit in the shade of acacias and, on the other side, bangled women sit with babies awaiting post-natal check-ups.

Over the years, supplying power to the hospital has become a nightmare. As Wasso has grown, so have its energy requirements and, what with all of the other daily crises, there has been precious little time to think about energy systems. I was flown in last December to do an energy audit with a view to solving as many problems as possible with solar. At the time, the energy systems were inefficiently, and somewhat hazardously, ramshackled together. The genset was regularly run three hours a night and was switched on haphazardly when needed. The energy situation is truly out of hand when one must fire up a 25 kVA generator to run a bubble-jet printer.

Our report recommended a reorganization of the hospital's energy system. Six months later, the Energy Alternatives AFRICA team was hired to do the job with support from several donors. There were a number of ambitious tasks:

- Replace the lighting loads in the maternity, operation, and OPD wards with a battery buffer/inverter system. This uses an inverter and a bank of batteries which charges from the genset when it is running.
- Replace the generator wiring in the TB Ward and Male Ward with stand-alone solar lighting systems.
- Install stand-alone solar lighting systems in the seven staff houses.
- Install stand alone solar lighting and 240 vac power systems in two doctors' houses.
- Install a PV-powered deep-freeze in the doctor's house.
- Install a stand-alone PV-powered lighting and HF radio system in a distant clinic.
- Install solar water heating systems in the doctor's house, the patient ward and in the laundry (this was subcontracted to a Nairobi solar water company).

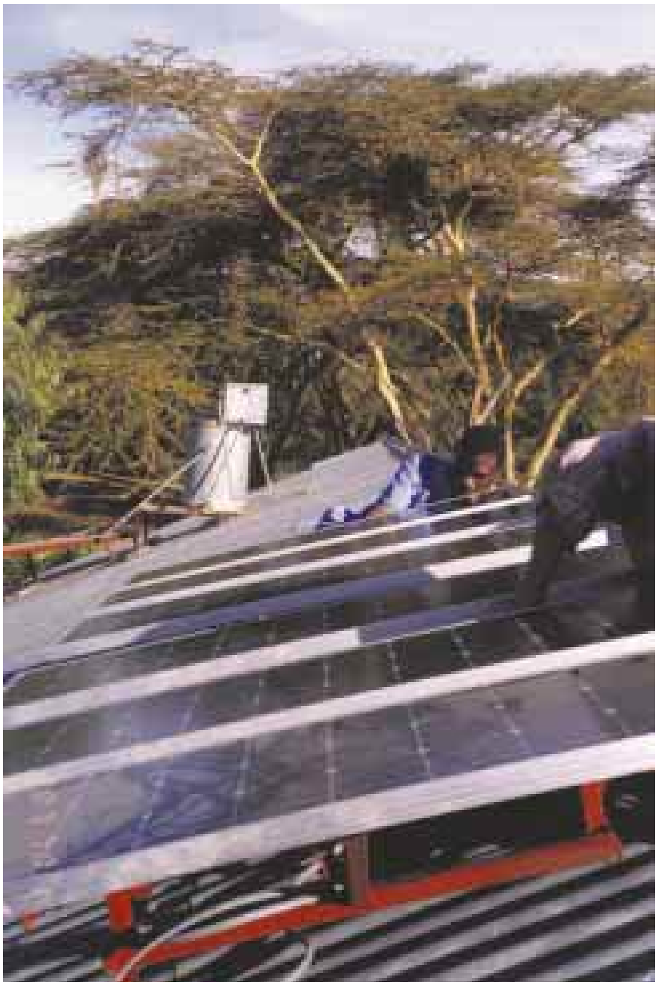
Above: Energy Alternatives Africa students and instructors. Mark Hankins wears the blue hat.

There is a huge difference between simply recommending an energy package and putting one in place. We of the West tend to be like Tarzan when it comes to technology dissemination in Africa. We swing in, take pretty pictures, thump our chests, and we make a lot of noise. But too often we simply parachute equipment in or we come in and do the installation ourselves while bemused locals watch. Then we dust ourselves off and swing out. Even when intentions are good, work without a long term maintenance plan is doomed. Europeans and Americans have left graveyards of renewable energy equipment in Africa. The real task of teaching locals to install, design, choose, maintain, and sell renewable energy equipment is far more daunting and time consuming than supplying equipment. In this project our team was spending several person-months on site to train 14 Maasai community members and hospital staff to install and maintain the systems.

Left: Most student had never used tools before.

Reworking of the hospital's energy system proved to be more of a learning exercise and adventure than a profitable venture. Just arranging the enterprise took weeks. Systems had to be designed and equipment had to be ordered from various countries. A qualified team had to be put together. A preliminary site visit had to be made. We had to deliver equipment from Norway, Nairobi, and Arusha to one of the most remote parts of East Africa. All this happened before the installation work began in early October, before November rains washed away the roads.

The team included myself (leader and chief instructor), Frank Jackson (consultant solar electrician provided by



Above: Gaspar Makale wiring PV modules on the Doctor's house.

the Irish aid organization), Daniel Kithokoi (EAA solar technician), Gaspar Makale (KARADEA Solar Technician), and Hans Gelly (German volunteer). After purchasing batteries, lamps, cables, conduit, and various spares in Nairobi, Frank rode with the lorry load of equipment across the border post in Namanga. He picked up the imported equipment (NAPS modules, charge regulators, and inverters) from Kilimanjaro airport outside Arusha. Then he followed a long circuitous route around Ngorongoro Crater and through the Serengeti to Wasso. Daniel, Hans and I, in the EAA Land Cruiser, took the more direct route through Narok and a hundred or so kilometers of rough tracks through the Loita Hills, somewhat illegally crossing the border on the unposted frontier. Gaspar, meanwhile, had to take a 24 hour bus ride from Mwanza across the Serengeti to Arusha, then back, to get to Wasso.

Installation work was integrated with a training course for community members. The idea fits with Energy Alternatives AFRICA's strategy of building a base of knowledge in the community where the technology is used. Each morning the student technicians, including staff members from two hospitals and four local development NGOs, had theory sessions in the classroom. After tea they completed long practical sessions on site when they were able to apply the theory. Things were a bit crazy as we were trying to complete professional work with limited means, and trainers often had to re-do student mistakes. The Maasai—God's own ecologically-sound people—inhabit cow dung bomas, live off milk, meat, blood, honey, and hardship; and are as proud and beautiful as a people can be. Elegance and beadwork, yes, but the Maasai are not known for building or wiring skills. Half of our students had never before picked up a hammer. Work proceeded slowly. In the process we enthusiastically smashed walls, shattered roofing tiles, hacked away at battery boxes, laid miles of wire, and mis-drilled holes on mount angle iron.

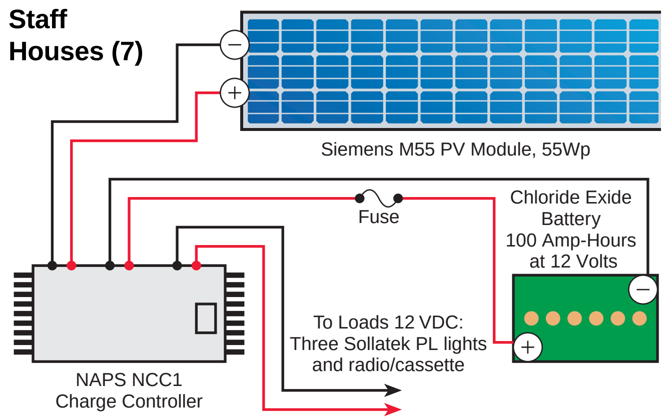
There were delays. Key battery interconnects were accidentally left out of the NAPS package meaning that work on the battery buffer system was paralyzed. We had to use the head doctor's satellite phone to make a call to NAPS in Norway. They promptly DHL'd the equipment to Arusha, where it sat for days awaiting a flight by Flying Doctors to the hospital. The solar water heaters got stuck in Mombasa customs. There wasn't enough battery acid, we forgot armoured cabling for the underground wire run, and one of the RCD's was defective; so we had to send a pickup to Nairobi.

Then there was the problem with generator wiring. The existing wiring in wards and staff houses was in horrible shape, brittle and coiled dangerously like snakes in the super-heated filthy attic spaces. Some PV systems had been installed previously by untrained people, we had to tear these out and rewire them. Finally, at the time of our work, the hospital was a busy building site. It was difficult to get time in the workshop for making the battery boxes, mounts, and peripherals we needed.

Excess work wasn't the only cause of delay. Three of five of the training staff were hit by tropical ailments. Daniel was struck down by malaria and Frank had tropical stomach problems. I lost two days due to infected insect bites on my legs that turned into deep, fever-inducing abscesses cured with a tandem treatment of antibiotics. It's lucky that we were in a well-run hospital.

The Systems

In all, we were to install more than ten systems and more than a kilowatt of PV. For most of the systems we concentrated on low-tech, easily maintained solutions that reduced or ended the need for generator back-up. On the seven stand-alone staff houses we installed



basic 55 Wp modules, 100 Ah Kenyan modified SLI "solar" batteries, NAPS charge regulators, and Sollatek (UK) fluorescent lights. Student technicians completed these 12 VDC systems under the supervision of Daniel, Gaspar, and myself.

The TB Ward and Male Ward each used 110 Wp arrays connected to 200 Ah battery sets through NAPS regulators. In addition to Sollatek PL-type lamps, we installed Jade Mountain yellow ultra-low consumption LED lights as "night lights" in the rooms of each ward.

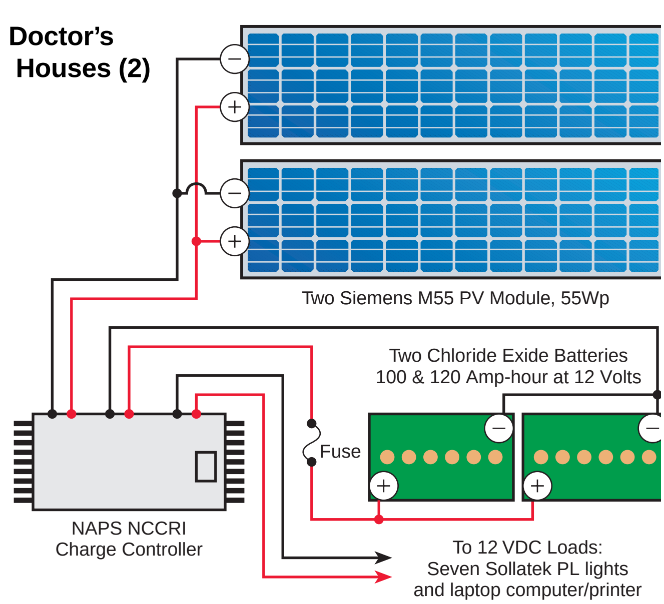
For the above systems, all of the batteries and regulators were mounted in lockable wooden boxes which prevent end users (the hospital owns the systems) from bypassing the regulator. The Siemens modules were mounted at 15° facing North on fixed pole mounts. EAA always mounts modules well off tin roofs, as African heat significantly reduces output of modules mounted on metal.

In the head doctor's house we installed two independent systems after straightening out the generator wiring and tearing out the previous poorly installed PV system. One 165 Wp system powers 8 lights, a rather powerful stereo, a laptop computer, and, through a 400 watt inverter, a TV and video set. The second 220 Wp NAPS freezer system is used to keep blood plasma frozen and to freeze meat for guests in a separate compartment. In the second doctors' house a 12 V 110 Wp system is used for lighting, powering laptops, and bubble-jet printers.

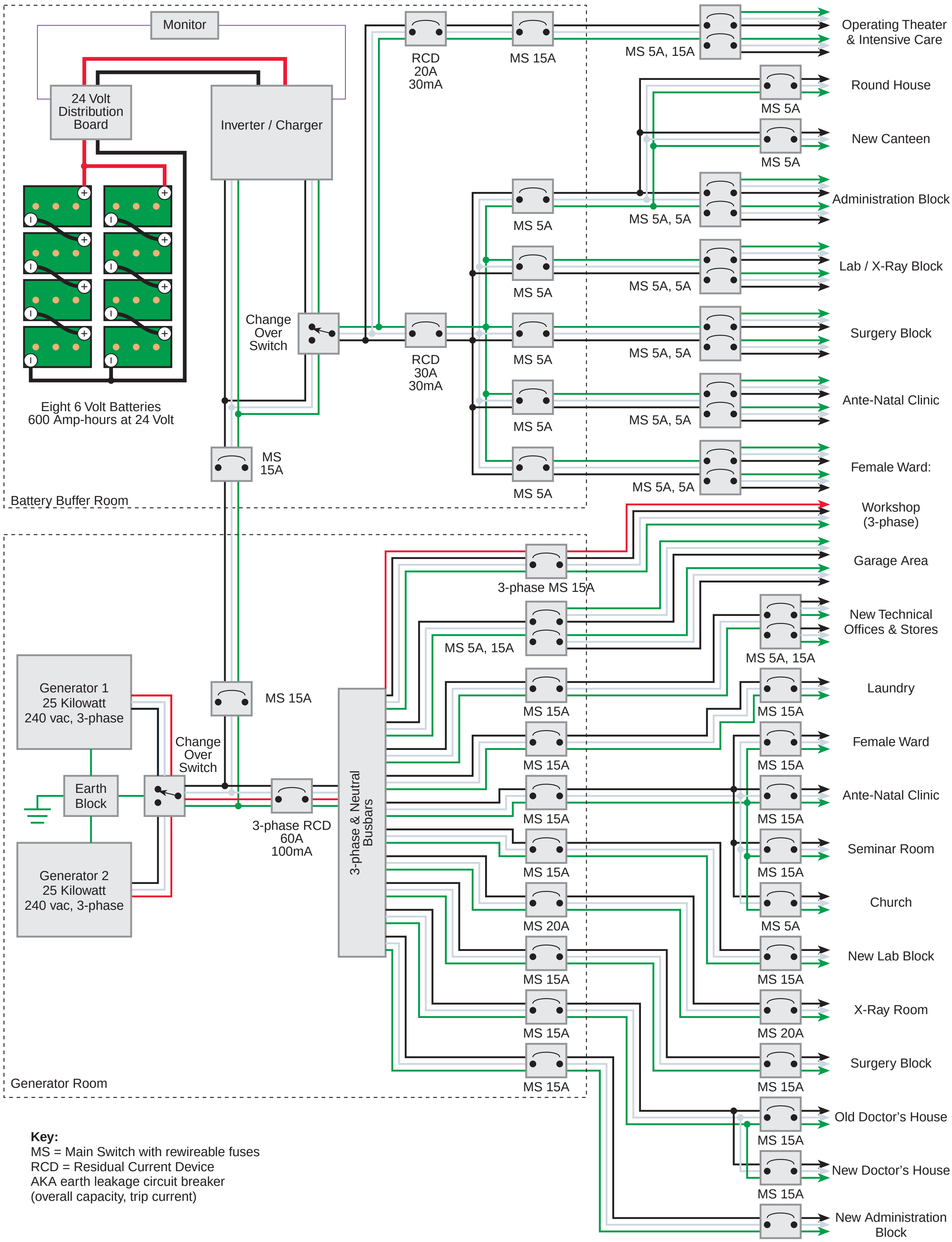
The most complicated and vulnerable part of the system is the inverter battery buffer which uses excess generator power to charge Tudor deep discharge batteries. The batteries are used to run compact fluorescent lighting and low-power loads in the Female Ward and delivery room (and eventually in the operating theatre). It is less costly to charge batteries with excess generator power than with expensive modules. For equivalent power supply we would have needed ten or more modules. The 25 kVA genset is routinely run each day, usually at well below 25% of rated capacity, to power workshop tools (i.e. the compressor and welding tools) and the X-ray machine. The generator is a permanent, necessary part of the hospital energy system and should be used as efficiently as possible.

We were reluctant to install a 2,400 watt inverter-battery charger in such a remote hospital for the simple reason that repairing or replacing the unit, should it break down, would be a logistical nightmare. We know of many failed inverters in remote East Africa as lightning knocks out even properly grounded units. If the inverter goes down on a 240 vac battery powered system, everything goes down. Nevertheless, the alternatives were continued reliance on the generator (which would limit light availability to a few hours each night) or use of a direct-wired 24 VDC lighting system (which would not be able to power 240 vac hospital appliances). We discussed the possible alternatives with the hospital and donors, and they agreed that it would be worthwhile to take the risk and to get experience with inverter/battery chargers at Wasso. This installation would be a carefully monitored pilot project and the lessons learned could assist other hospitals in the future.

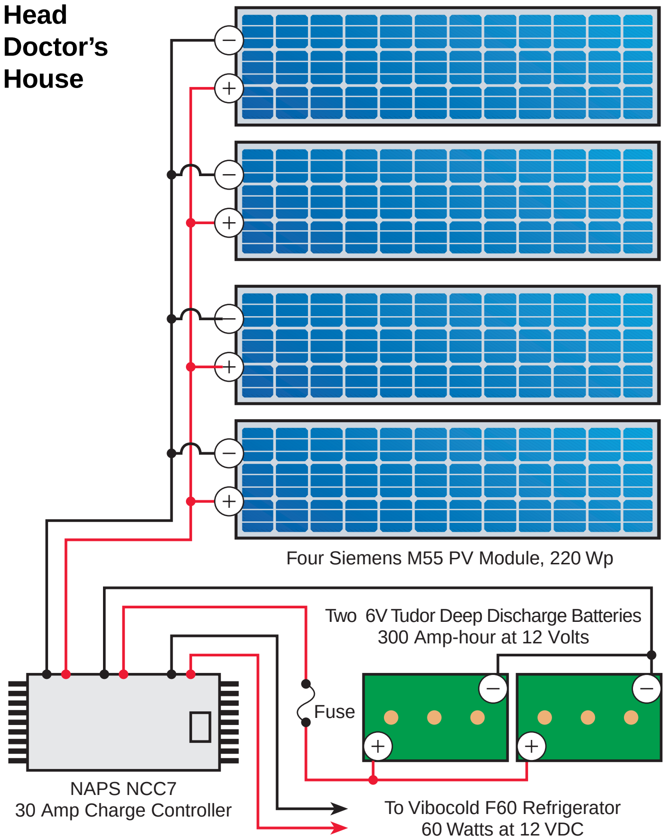
Frank Jackson installed the Mastervolt inverter/battery charger in the specially designated battery buffer room in the back of the Female Ward. First, the ward's wiring had to be isolated from the rest of the hospital wiring and upgraded. Given the poor state of the existing wiring (and its confusing and twisted arrangement), this took time. Then all of the 30 light fixtures in the ward were replaced with compact fluorescents. A 600 Ah 24 V Tudor battery bank was installed in the buffer room

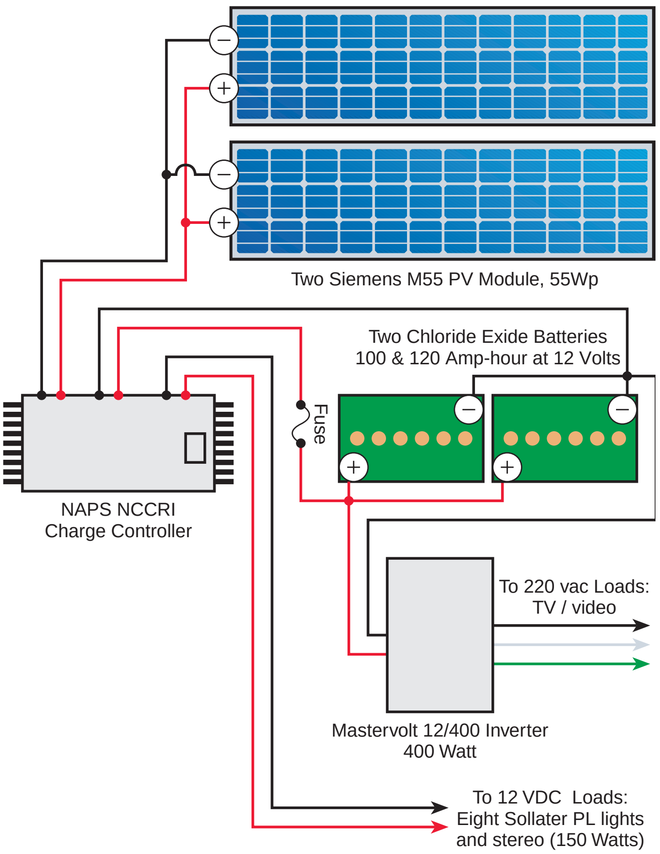


Hospital Generator / Battery System



Key:
MS = Main Switch with rewireable fuses
RCD = Residual Current Device
AKA earth leakage circuit breaker
(overall capacity, trip current)





and the Mastervolt inverter/charger was wall-mounted nearby. When they arrived, the battery interconnects, 250 A fuses, and DC switches were assembled with the shunt and remote monitor between the battery bank and the inverter. A change-over switch was installed to enable the hospital staff to switch between the inverter and genset in the event of inverter failure (the inverter switches automatically in normal mode). Appropriate RCDs were also put in place.

Follow-up

As mentioned, EAA works as a training and infrastructure development body and does work that is non-commercial in nature. This project involved many more person-days of time than an ordinary company would be able to offer. But the after-service and training was a crucial element of the work.

After the scheduled training and installation work was completed, Frank Jackson remained behind for an additional three weeks to tie up loose ends, monitor system performance, and assist in the establishment of a maintenance and operation routine. Hans Gelly also remained behind as a volunteer at the hospital for several months, working with the hospital electrician, Estomih John, to maintain the systems and to sort out some of the generator wiring problems. From Nairobi, I made sure that the solar water heaters made the journey to the hospital. They are being installed as I write this.

Two of the NGOs involved in the course received 55 Wp demonstration solar lighting systems for use in their projects. The purpose of the demonstrations is to give the NGOs' technicians installation and operational

Above: The battery / inverter system..

Above: Daniel Kithokoi and students installing a radio call system.

experience with PV. One course is never enough, technicians must do a number of installations before gaining proficiency. Hans and Frank assisted the trained technicians in installing the systems in areas near Loliando.

Six weeks after the installations were completed things were still functioning smoothly. Staff now has light all night long (instead of only three hours per night), the doctor can work all night (or watch videos with staff), and babies can be delivered any time in the Female Block without having to fire up the generators. Although we found that the Mastervolt charger was delivering slightly less power than we anticipated, the records kept over the first six weeks indicated that there is plenty for the lights. Most importantly, there is a base of knowledge on site which can maintain the power systems and handle basic problems as they come up.

Above: Frank Jackson wiring the doctor's system.

As Energy Alternatives AFRICA continues to build solar energy infrastructure in the region through demonstration and training, we realize that there is more to remote system installation in Africa than good equipment. First, design and planning must be rigorous. Second, the team must be able to cope with all manner of unforeseen and unavoidable crises which range from missing parts to malaria attacks and washed out roads. Third, local skills and knowledge must be raised to acceptable levels for long-term upkeep of systems. On this project, EAA didn't get a perfect score in all categories, but the team did install all the systems to a high standard and we did address the sustainability issues.

The energy problems of the hospital are not over. The generators need to be serviced and much of the wiring still needs to be redone. An energy plan and maintenance programme needs to be put in place. But this needs to be done in a manner that slowly improves the existing skills, services, and structures and which taps into the lively spirit of the Wasso Hospital staff.

Access

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