ENERGY BACKUP SYSTEMS MAINTENANCE TRAINING FOR HOSPITAL TECHNICIANS IN HAITI

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Summary

To improve chances for sustainability of the backup power systems installed in Haitian hospitals under USAID's Improving Health Facility Infrastructure (IHFI) project, the project staff designed and implemented a training workshop for hospital technicians in key power backup systems being installed in Haitian health facilities (batteries, inverters, diesel generators). IHFI worked with the Ministry of Health Project Management Unit (UGP) which sponsored and co-funded the training, including bringing 21 hospital technicians and some administrative and other technical staff from facilities throughout Haiti to Port-au-Prince for four days of training. Materials from the US were adapted/translated to Creole, and US trainers, IHFI staff, and instructors from a local vocational school made up the teaching team.

Workshop materials and basic electrical tools were provided to each technician, and interactive, hands-on sessions were designed to meet the training objectives. In addition, participants were taught how to measure and log readings in logbooks and sheets designed for this purpose.

Workshop evaluation was undertaken not only by a participant evaluation form, but by follow-up visits to the participants' installations approximately two months after the workshop. During this visit, the battery/inverter and generator systems were observed, and a review questionnaire was applied. This helped confirm the extent of learning during the workshop, and identified areas to cover in more detail in the next training. Equally important, the site visits improved the relationships between IHFI staff and the MSPP technicians, and validated the new skills they learned. The visits confirmed that training, combined with ongoing contact and communication, is fundamental to long-term improvements in maintenance and operations of energy systems.

Following are some of the key conclusions and achievements of this training workshop:

- 21 hospital technicians and some administrative and other technical staff from 14 hospitals and two office facilities were trained on maintenance and data logging on battery, inverter and diesel generator systems. Travel and expenses including the hotel stay in Port-au-Prince were paid for all the participating technicians.

- The workshop generated good will and a sense of empowerment among technicians, something that has typically been lacking in many health facilities in Haiti.

- The follow-up site visits by instructors after the training were a key step in maintaining communication with technicians and confirming to them that this is an ongoing process.

- Data collection and logging, in addition to providing valuable data on operations, challenges technicians to be responsible and know their equipment better; this should become one of the underpinnings of the IHFI program in Haiti.

- Creole curriculum materials developed for this workshop were a major step in reaching the technicians at their experience level.

- This workshop can be considered as a pilot for future workshops in Haiti; the Creole curriculum materials can be reused, expanded and built upon for additional training; participants' comments provided valuable feedback on how to proceed.

- Participation of the Ministry of Health and a local vocational school were key contributors to the success of this workshop, and to the expected continuation of more workshops.

Introduction

As part of USAID's Improving Health Facility Infrastructure (IHFI) program in Haiti, Tetra Tech (Tt) worked with the Project Management Unit (UGP) of the Haitian Ministry of Health and Population (MSPP) to organize and deliver a hands-on training workshop for MSPP hospital technicians on maintenance and upkeep of backup power systems in hospitals and clinics. The workshop focused on maintenance and operation aspects of lead-acid batteries, inverters/rectifiers, and diesel engine generators, spanning four full days. This workshop was designed as the first of several such workshops, with the following objectives:

- teach hospital maintenance technicians how to properly maintain battery/inverter and diesel generator electricity systems in order to increase the reliability and availability of electric power to their facilities

- develop and test a basic training approach and curriculum that can eventually be repeated in country to reach all MSPP and other health facility technicians

- begin development of a local in-country instructor capacity for future technician trainings, including a local vocational school where much of this capacity could reside; Haiti Tec, a vocational technical school serving Haiti's industrial sector, was selected as the local counterpart for the training and the site of the workshop

- begin introducing the concepts and habits of measurement, logging and documentation of key operating parameters of backup power systems, as part of a process to develop data bases of system performance throughout MSPP health facilities.

As part of the follow-up of the workshop, the majority of technicians were visited by the Tt team at their facilities, to maintain communication, answer questions and evaluate their application of the skills learned in the workshop.

Organization of the Training

Logistics

The training took place on March 28-31, 2011 at the Haiti Tec facilities in Port-au-Prince, Haiti. Twenty-one technicians from all over Haiti were invited to participate. Organization and funding were shared between IHFI and UGP: IHFI covered a small per diem for the participants, while UGP paid for the lodging, the bus transport between hotel and Haiti Tec, and the technicians' travel to Port-au-Prince. IHFI also paid for instructors, materials and the participation of Haiti Tec and their facilities.

The Tt team provided an Outback inverter and batteries, and worked with Haiti Tec staff to install the system on a practice board for participant access and practical exercises.

As part of the class, each participant received a binder with course materials, a battery maintenance tool kit, a CD of inverter manuals and all course materials, laminated graphics to keep at the hospital for general education, and an annual logging binder to be completed by the technician. The tool kit provided by IHFI to each technician included: insulated wrenches, goggles, gloves, and a wire brush, anticorrosion spray for the battery terminals, a hydrometer, and a volt meter. Diplomas for course completion were provided.

Participants

Twenty-one technicians from 16 different hospitals and institutions attended the four-day training. The full list of the institutions represented at the training can be found in Appendix A.

Instructors

The class was structured to be interactive with direct questions to the participants designed to gauge comprehension, learn about their existing maintenance practices and elicit their participation.

The training was instructed by Carol Weis (Tt), Jude Juste (Tt), Loby Gratia (Tt), Lesly Theard (Tt), Christopher Freitas (Tt), Armand Gerald (Haiti Tec) and Ernst Zulmé (Haiti Tec). Translations between English and Creole were provided by Jude Juste, Loby Gratia and Leslie Theard.

Carol Weis works part-time as a solar photovoltaic (PV) system instructor and consultant on international projects in countries such as Haiti, Ecuador, Mexico, Nicaragua and Pakistan. She also works part-time as an instructor and PV curriculum developer for Solar Energy International (SEI). She is a Certified Master PV Trainer by the Institute of Sustainable Power & Quality, she has her PV Installer Certification with the North American Board of Certified Energy Practitioners, and she has worked as a licensed electrician and solar installer in Colorado. For over a decade, Carol has been a lead member of SEI's PV technical team creating a world class PV curriculum for a mainly U.S. market, and now brings that same training rigor to programs in developing countries.

Jude Juste is an electrical engineer on the IHFI project with 3 years of experience in the sizing, design, installation, commissioning and maintenance of battery/inverter systems, with specific experience in Outback inverter installations.

Loby Gratia is an electrical technician on the IHFI project with nearly 20 years of experience with electrical installations and inverter repair.

Lesly Theard is an electrical engineer who works as the IHFI in-country project coordinator in Haiti. He has nearly 20 years of experience in batter/inverter systems design and installation, and ran an inverter repair business in Port-au-Prince for many years. He helped pioneer the installation of solar PV systems in Haiti

Christopher Freitas has been working with Sun Energy Power International (SunEPI) since October of 2008 and has participated in many projects in Haiti working as a project engineer. Christopher was a co-founder/co-owner of Outback Power Systems, a leading U.S. manufacturer of solar power electronic components used on many of the systems installed by SunEPI. Prior to starting Outback Power, he was the Director of Engineering at Trace Engineering, another inverter manufacturer, where he worked from 1994 to 2001.

Armand Gerald is an independent expert on diesel generators and generator systems who teaches this subject at Haiti Tec.

Ernst Zulmé is an electrical engineer on staff at Haiti Tec where he teaches electrical technology to technicians in training.

Tetra Tech employees instructing hospital technicians with a live demonstration Outback inverter system at the Haiti Tec classroom

Course Structure and Content

Summary Agenda

The following table provides a brief description of the course structure. The detailed agenda of the training can be found in Appendix B.

Day #	Structure	Title	Instructors
Day 1	Classroom lecture	General System Overview and Batteries	Carol Weis Jude Juste Loby Gratia Ernst Zulmé
Day 2	Classroom lecture	Hospital Loads & Inverters	Carol Weis Jude Juste Loby Gratia
Day 3	Classroom lecture	Inverter Operation	Carol Weis Christopher Freitas Jude Juste Loby Gratia
Day 4	Classroom lecture + visit	Generator and System Logging	Leslie Theard Armand Gerald

General System Overview and Batteries – Day 1

The first day of class began by reviewing general hospital electrical configurations, reviewing why systems failed, and looked at configuring no-contact and contact inverter battery systems. Most of the day concentrated on batteries, including topics such as battery terminology, determining the state of charge (SOC) of batteries, discussion of the importance of reaching 100% SOC, how to do routine maintenance, and understanding the importance of and the proper use of safety equipment around batteries. A laminated pictorial aide on batteries was given to each participant to bring back to his site.

Each participant in the class had an opportunity chance to read battery voltage and test the specific gravity of the battery to check the battery state of charge. The class reviewed the monthly logging that needed to be done with batteries: cleaning battery tops and terminals, checking water levels, recording the amount of water added, and equalizing batteries, along with the importance of always documenting all of these activities.

Hospital Loads & Inverters – Day 2

The second day of class began with a quiz reviewing the previous day's topics. The morning session evaluated loads on batteries. It focused on energy efficiency, calculating power and energy draws, and then looked at an example hospital system load profile in comparison to the battery size. For an exercise, the technicians split into small groups to calculate energy consumption at the sample hospital site after some conservation measures were taken. From their calculations, a discussion was held about how energy conservation would need to be done at hospitals during times of no utility or generator availability to prolong battery life. At the end of this exercise, each technician was given their specific hospital load analysis sheet and their battery size. From this information, they were asked to look at their load consumption in comparison to their battery size and to come up with possible solutions to prolong their battery life if needed. The instructors also reviewed the hospital's alarm system parameters, and what the technician needs to do if the alarm goes off, which also includes shutting off all non-critical loads.

The second half of the day in the classroom was spent opening up the Outback system to trace out wires and to discuss what all the breakers and individual equipment and communication parts are responsible for. The technicians were also introduced to the daily and monthly logging responsibilities, and each technician practiced retrieving the daily recorded operating data on the inverter/battery system's MATE (data interface).

The class also reviewed how to get to the equalization screen of the MATE.

Inverters – Day 3

The third day started with another open book quiz, testing the technicians on the information from the previous day. The classroom lecture in the morning reviewed different types of inverters, common inverter failures, the purpose of a bypass switch, the function of the internal transfer switch, and stacking inverters for 240V. The instructors also reviewed how to detect and clear an "Error" and "Warning" on the Outback system, and how to find the messaging screens on the MATE in order to diagnose the problem.

In the afternoon, the class followed along with the description and discussion of the "Errors and Warnings" laminated diagram that depicts each problem that the inverter can diagnose, why the error would occur, and what the solution is to fix it. After this was complete, we set up the lab to create 2 different false errors that the technicians reviewed one by one. Each technician navigated the MATE screen to find the error, and then demonstrated how to clear the error. The instructors set up and ran the mini lab on errors on the side, while the class continued to listen to presentations and asked questions on inverter operational issues through the afternoon.

Generator and System Logging – Day 4

On the final day, Armand Gerald from Haiti Tec conducted the presentation on generators and led a tour of the generator tour at the school. Teaching aids included PowerPoint slides and a

demonstration generator front plate in the classroom. The generator tour was short and simple, reviewing the gauges, readout screens and major components of the generator. An important part of this day was dedicated to the importance and the details of daily logging, copying operational data of the generator into a logbook. The generator section lasted about 6 hours, and the end of the day was dedicated to reviewing the daily and monthly logging duties binders.

The Tetra Tech team presented the daily and monthly logging binders at the end of class. The full list of training materials provided to the participants, as well as some examples, can be found in Appendix C.

Evaluation of the Training

Participants' Evaluation

All the participants filled out an evaluation form; results are provided in Appendix D. Instructors got excellent marks, averaging 4.6 out of 5. Similarly the topics covered were clearly in line with the participants' satisfaction. The inverter topics (which were the most complicated) were the ones on which most participants would like more details, or even a future training course. Most of the participants answered that they would review all of the materials provided.

General Comments from the Participants

During the battery maintenance section, the technicians raised the issue of distilled water supply, stating that they do not always receive it in a timely manner from the administration. Tt discussed how having a monthly log of how much water is required by the batteries would help administrators plan for the amount that they needed to give the technicians each month.

During the battery loads section, there was a lot of discussion about the lack of authority of the technicians to tell medical staff that they could or could not use energy, and how the technicians needed the hospital administrator to play that role.

On the last day, there was discussion with the participants about some of them wanting to get paid more money for having these new responsibilities and duties. Some felt like the daily and monthly logging was an unreasonable amount of additional work to add on to their jobs without extra pay. The instructors responded by framing the logging as only a small amount of additional work and that it was already in their job duties of keeping their system working.

Summary and Recommendations

The overall assessment of this technician training workshop is extremely positive. This was really the first such training focusing specifically on technicians in a group. The atmosphere was positive and there was enthusiastic participation in all of the exercises. This training, while successful in itself, was also carried out as a pilot for a larger scale of training projects to cover hospital technicians across Haiti. As such, a number of areas were identified as lessons or items to follow-up to improve future trainings, as discussed in the points below.

1. Partner with Haiti Tec: Haiti Tec looks to be a good partner for future trainings. Their facility is in a good location in Port-au Prince, they have a supportive administrative team, they already have a program that teaches similar classes, and we have identified several professors that expressed interest in using this system in their future classes.

Follow-up: Follow-up needs to be done with Haiti Tec to ensure that there is a person in charge of maintaining this system both for their classes and for our future classes. Follow-up needs to be done to make sure that the inverter battery system is relocated to a permanent classroom site that is secure, has a locked battery box with adequate venting to the outside, and to make sure that the school has a maintenance plan for the batteries and system. A follow-up check on the system's MATE programming should also be done, as well as supporting them with future training opportunities on Outback equipment.

2. Build local training capacity: One of the goals for this training session was to identify future local trainers that would eventually take over the hospital technician trainings. This was being explored both with Haiti Tec professors and with the Tetra Tech staff. Several instructors at Haiti Tec have potential to be the trainers for these short duration hospital technician trainings, as long as the curriculum and audience focus is made clear. The type of technical training programs that Haiti Tec will use for their vocational courses, will be very different from the short duration programs that the Ministry of Health will want for their technicians.

Jude and Loby also both showed aptitude for teaching these types of programs and understand this audience very well. They have very different teaching skills and styles which could prove to be very beneficial and complementary.

Follow-up: It may be worthwhile in future trainings to have a dedicated translator instead of someone that is also acting as a co-instructor. It would also be useful for the instructors to meet one day in advance and conduct a mock training in order to go over the different teaching styles and review some basic teaching methodologies.

3. Create the core outline and curriculum for an ongoing battery/inverter/ generator technician training course: One of the goals of this training was to try out some new curriculum that could be replicated in future technician trainings. The majority of the class work went well and there are many ideas of how to make this a curriculum easier to use both by future local trainers and by the technicians themselves. Now that it has been taught once, the weekly schedule can be adjusted to reflect the amount of time actually needed in class and there are some changes that should be implemented into the curriculum.

Follow-up: Make all corrections to the existing curriculum from errors seen in this class. It is also recommended to create some more formalized class curriculum and exercises/quizzes that can be translated to Creole for the next training. The follow-up evaluation of the training indicated that not enough time was spent on equalization, and Tt will need to clarify expectations regarding this protocol in the future with the hospital technicians.

4. Strengthen technicians' skills: One success of this program was the enthusiastic participation of the hospital technicians during the battery and inverter training. Each day started with an individual quiz that was then discussed and reviewed on the previous day's lessons. The technicians were able to do basic navigation on the Outback MATE by the end of class, use their volt meters to read state of charge, and know what to do if the low battery alarm goes off. Each technician learned how to take monthly readings on the MATE for logging data, learned to equalize their battery bank, and clear and log an error on the inverter. Some technicians were quicker to comprehend the information than others, and all of them stated that they would need follow-up help implementing this information to their site. This training needs to be seen as just one of the steps to help the technicians understand their system and additional follow through will be needed.

Follow-up: Tt has planned a follow-up visit to each site to review and assist the technicians in doing next month's maintenance. This includes assistance in taking the monthly MATE data, helping to equalize the batteries, inspecting the battery's terminals for corrosion and application of the anti-corrosion spray, inspecting the batteries' water level, and reviewing the generator and MATE's daily logging sheets. A follow-up phone call in the next 3 weeks to answer any questions, and a follow-up site visit in the next 4-6 weeks while the information is still fresh, are recommended and planned. The person doing all the site visits should help the technician by talking them through any problems, but insist that the technician is the one actually "pushing the buttons" on the MATE to navigate and to use the curriculum guides that we created as reference.

Additionally, some of the technicians found the daily MATE logging sheets confusing for data collection. After some discussion a solution was identified, but there was not enough time to remake the annual logging booklets before the technicians left. Tt will make new sheets to distribute and review during the follow-up training.

5. Advanced training: Feedback from the participants included the desire to have more on-going training in the future. They expressed a desire to have more hands-on training with wiring an Outback system. They also wanted to have experience with swapping out fan and circuit boards on the Outback inverters, and on troubleshooting. Both of these experiences could either be done in a lab, or on a working system. Another area of interest was in having more training in solar electricity. There was also a desire from the participants to get a "Kill A Watt" meter (a meter that appliances can be plugged into in order to read their kW draw) that we used in class. This type of meter is used to show what loads are drawing in watts, volts, amps, and kWh. It allows a technician to quickly evaluate the energy consumption on new loads and to identify phantom loads.

Recommendation: A follow-up training in the fall with the same participants to both build on the topics learned in this session, and to gain further skills, is recommended. Each technician could bring in their logging sheets and part of the class would be answering any questions that the technicians saw in the first 6 months. Beyond the topics suggested above by the participants, a lesson on safe wiring practices, protecting wires with overcurrent devices, and general wiring, could be included. This lesson would be particularly relevant to the overall issues of providing better health care, because bad wiring practices at hospitals account for many of the power quality problems. This would also be an opportunity for the IHFI team to evaluate current maintenance and logging protocols seen in the field, and to present any revisions of methodologies to the hospital technicians.

Follow-up Inspection and Training

Introduction

In June of 2011, Tetra Tech representatives Jude Gaetan, Arturo Romero and Loby Gratia completed 11 training follow-up visits in Haiti, as recommended in item 4 above. The purpose of the visits was to interview the hospital electrical technicians from the March 2011 technician training, to inspect the battery/inverter power systems, and to provide a hands-on training review if required. Each hospital visit included a visual inspection of the system and the log book, an interview with the hospital technician, and a skills demonstration from the technician on

navigating the inverter's control panel to allow retrieval of information learned in the training. A questionnaire was developed to maintain consistent procedures and evaluations in all of the visits.

The results of the questionnaires are compiled in an Excel spreadsheet and attached in the summary table of Appendix E (technician and hospital names have been removed for public presentation, but IHFI will maintain internal records on technician and hospital performance). This table highlights the information that evaluates the extent of the retention of information from the March 2011 training workshop.

Of the original 16 hospitals/sites with electrical technicians who attended the training, 5 were not included in this report because of various reasons:

- Two hospitals do not currently have an operating battery/inverter power system (Jacmel is not yet installed; Belladere hospital was not operating)
- Two other hospitals (Pilate and Dame Marie) were visited by Tetra Tech for inspection of the battery/inverter system and contact with the technicians, but as these hospitals did not have a technician who attended the March training, the questionnaire results are not included in this report.
- The UGP power system was not included in the follow-up visit.

Follow-up visit highlights

- A visual inspection showed that all eleven hospital battery/inverter systems had battery terminals which were free of corrosion, with battery cables properly secured and the battery temperature sensor intact. Seven of the ten hospital power systems also had the tops of the batteries clean.
- Seven of the eleven hospital electrical technicians had been watering the batteries adequately and had proper levels in all of the cells at the time of the site inspection. Two of the hospital electrical technicians expressed difficulty in obtaining water from the administration. One of the hospitals was waiting for delivery of distilled water at the time of the site visit.
- The amount of distilled water used by the batteries in the two month period of April and May 2011 varied from 0-15 gallons between the different hospitals.
- Nine of the eleven hospitals reported that the system had not had any "Warnings", "Errors", or alarm signaling.
- Only two of the eleven hospital electrical technicians had seen a "Warning" signal on their inverter (high AC generator voltage), and one also had multiple "Error" signals (low battery voltage) on the inverter that shut the system down. This system also had had the alarm system sound many times because of low battery voltage, and the system was shut down at the time of the site visit. The technician demonstrated what to do in the case of an alarm, but because of generator problems, could not resume charging.
- Eight of the eleven sites had filled out the daily and monthly inverter logging sheets from the MATE since early April immediately after the training. The three other sites reported having problems getting access to either the inverter/battery room, or the logging notebooks. Tt spoke with the administration at all 3 sites to advocate the necessity of access for the technician.

- None of the technicians equalized their batteries in April or May. Seven of the eleven technicians requested more training on this subject. It is clear that the equalization was not sufficiently well covered in class.
- The highest performance scores among the different skills were seen when the technicians demonstrated retrieving the daily and monthly logging values from the MATE. This data correlates with the fact that the majority of the technicians has been doing the daily and monthly MATE logging and have maintained their proficiency in navigating the MATE for these values.
- The lowest performance scores on skills were seen when the technicians demonstrated how to equalize, navigate to the "Warnings" and "Errors" page, and clear an error by turning the inverter on and off. This data correlates with the fact that no equalization was performed on batteries in April and May, and that 9 hospitals did not have any warnings or errors occur in these months.
- Only 2 of the eleven hospitals filled out daily generator logs, and only 1 had filled in the monthly generator logging sheet. The most common reason stated as to why logging had not happened was that there is another technician that runs the generator at the hospital. One of the hospitals generators had a broken LCD display, another had their own internal logging method, and another had the generator room burn down, preventing logging.
- There were topics from the March 2011 training that the technicians wanted to review. Eight want to understand more about equalization, 3 want to understand how to get the last day data from the MATE, 3 want to understand how to clear an error or warning from the inverter if it occurs.
- All technicians requested additional topics in a future training. 9 want to learn more about installation procedures, 2 stated specifically how to repair an Outback, 4 generally request more information on system procedures, 1 specified design training, 1 specified training in design of a solar installation, 1 specified more training on the MATE.
- To try and correlate the technician's success with their background and training, the education and experience of each technician was summarized, along with a summary evaluation of their performance based on the follow-up visits and questionnaire. This analysis showed no direct correlation between years of experience and responsiveness to training, or between years of education and responsiveness. In fact, this result shows that most technicians have some formal education, and quite a few years of experience, but that their abilities are not what one would expect based on these years. This likely comes from lack of continuing education, insufficient opportunities to participate in installations done correctly, and lack of supervision and accountability, rather than a lack of capability. As a result, this training effort, and other efforts like it may offer a crucial opportunity for technicians to hone skills and recover pride in their work. Our experience in all interactions with technicians showed strong willingness to learn and clear responsiveness to instructions and procedures. Moreover, the field follow-up visits allowed the development of a stronger communication and connection with IHFI project staff, again encouraging the technicians' performance and increasing the possibility of long-term improvement of their skills and activities.

Conclusions and Recommendations

- The follow-up training and visits successfully accomplished IHFI goals by providing the hospital technicians with hands-on secondary training, addressing ongoing problems on site, informing our team of the real problems encountered by the hospital technicians, and helping to evaluate the March 2011 training.

- Some of the results of the questionnaire and interviews will help shape future trainings. The generator logging was not done at some of the hospitals because the technicians in the training were not the generator technicians. In the future, generator-specific classes will need to be held with those specific technicians assigned to generators. Higher level training for the medical administration and staff may also be beneficial to assure the hospital electrical technician is provided access to the batteries and inverter, as well as the right equipment, tools, notebooks, and distilled water.
- The skill performance scores showed that the technicians were able to retain the knowledge from the training for actions that they needed to do on a regular basis, such as daily and monthly logging for the MATE. The monthly MATE logging is a complicated series of steps that the 8 of the 11 technicians who were given access to the equipment performed correctly. Accessing the “Error” and “Warning” screens is equally difficult, but since 9 of the 11 hospital sites never saw this at their site during the post-training period, it was not a practiced skill beyond a review of the training. Since an “Error” will shut the system down, and could put the technician in a stressful position in the future if it happens during a hospital emergency, it is recommended to practice this again with the technicians during a future training. Three technicians stated that they wanted to review this information.
- Equalization was not addressed adequately in the class as was seen by the results of no technicians performing this in April and May. This concept and procedure should be addressed and practiced with the technicians in a future class. Eight technicians stated they wanted more practice at equalization.
- The technicians were also asked what information they would like to have in future trainings. Answers ranged from wanting more information on Outback installation, repair, solar installation, and general system procedures.
- The relationships and communications developed with the technicians in the course of the training and follow-up visits have served to strengthen the technicians’ skills and provide them with recognition and a sense of importance and participation. It will be crucial to build on this base through a number of activities, including: additional training; ongoing communications (not only site visits, but also telephone check-ins on a 3-4 month basis); and training for hospital administrators and directors on what technical services they can expect from the technicians, how to make them responsible and hold them accountable.
- Finally, the concept of logging data has been born out to be a useful focus for the technicians. In addition to providing useful data for the project and confirming proper operation of the systems, this activity brings the technicians closer to the equipment, helping them to obtain a better knowledge and respect for the technology, and strengthening their own skills. The IHFI staff will be looking to formalize data logging for different backup power systems in health facilities Haiti-wide.

Appendix A: List of Participating Institutions

Participant number	Title	Site	Department
1	Technician	Borgne*	**North**
2	Technician	Limbé*	
3**	Technician	Pilate*	
4	Technician	Justinien*	
5	Technician	Fort Liberté*	**Northeast**
6	Technician	Ouanaminthe*	
7	Technician	Port de Paix*	**Northwest**
8	Administrator	Beraca*	
9	Technician	Jérémie*	**Grand Anse**
10	Technician	Dame-Marie*	
11	Technician	Les Cayes*	**South**
12	Technician	Hinche*	**Central Plateau**
13	Technician	Belladère*	
14	Technician	HUEH*	**West**
15	Technician		
16	Technician		
17	Technician		
18		UGP*	
19			
20		MSPP DOSS	
21		Jacmel*	**Southeast**
22			

*sites where laboratory Outback systems have been installed
**left the training after the first day

Appendix B: Training Agenda

Lundi 28 mars
Entretien des batteries

8h-9h	Introductions. Message de bienvenue de l'UGP / MSPP et de l'USAID. Présentation du programme de la formation.
9h-12h	Les différents types de systèmes d'alimentation Le système le plus courant dans les hôpitaux **Batteries**: Anatomie : Révision des différents types de batteries qui existent et discussion sur les plaques, terminaux négatifs et positifs, électrolyte, batteries scellées et aérées. Cycles : Discussion sur les cycles et les limites de décharge. Durée de vie : Déterminer ce qui a un impact sur la durée de vie d'une batterie et l'importance de l'entretien pour que la batterie dure longtemps («equalize ») Mesures de précaution : Démonstration des mesures de sécurité à prendre lorsqu'on fait l'entretien des batteries. Entretien : Révision des procédures d'entretien pour les banques de batteries, y compris : niveaux de remplissage (eau), nettoyage des terminaux, ce qu'il faut vérifier régulièrement (senseur de température, corrosion, niveau d'eau), utilisation d'un anticorrosif sur les terminaux et inscrire les résultats de l'état de charge des batteries. Contrôle : Révision de comment utiliser de façon sûre un voltmètre et un hydromètre et pratique sur un système existant.
12h-13h	**Pause déjeuner**
13h-17h	Exercices pratiques Lab : Evaluer une banque de batteries existante pour son niveau de charge et effectuer l'entretien des batteries du système. Vieilles batteries : Comment prolonger la vie des batteries dans une vieille banque de batteries en groupant les batteries similaires. Documenter les activités d'entretien à faire régulièrement : Réviser les listes de contrôle de l'entretien et le rôle du technicien qui produira un rapport sur l'entretien. Charges : Importance de s'assurer que les charges d'origine sont respectées pour assurer le rendement maximum du système.

Mardi 29 mars
Charges et inverters

8h-8h30	Révision de la journée précédente. Répondre aux questions.
8h30-12h	Révision et analyse des charges des hôpitaux. Les techniciens feront un schéma de leur système et identifieront les charges sur les inverters contact et no-contact et quels sont les charges qui consomment le plus d'électricité. Comparaison entre l'électricité nécessaire pour les charges à alimenter et la capacité de la banque de batteries. Comprendre combien d'heures de la génératrice ou du réseau sont nécessaires pour recharger les batteries et l'importance de ne brancher sur le système que les charges pour lesquelles il a été conçu. Système d'alarme. Pourquoi l'alarme se déclenche-t-elle et que faire si la génératrice n'est pas en fonctionnement ? Inverters : Quel type d'inverter pour quelles charges. Discussion sur inverters/chargeurs. Identification des câbles et terminaux d'un inverter, Hub, Mate, senseur de température, lecture de la tension d'entrée et de sortie et polarité…
12h-13h	**Pause déjeuner**
13h-17h	Défaillances communes : orientation, environnement, débit d'air, rats, etc. Révision des diagrammes montrant le courant alternatif entrant provenant d'EDH, de la génératrice et des deux sources. Révision sur les inverters contact, no-contact et les inverters empilés l'un sur l'autre. Analyse des informations recueillies sur le fonctionnement des systèmes. Exercices pratiques sur comment remplir les registres de recueil des données (quotidien et mensuel). Discussion sur les données à recueillir, ce qu'elles signifient et pourquoi elles sont importantes (reflètent la santé du système). Récapitulatif des activités de contrôle (distribution des cahiers dans lesquels les données seront consignées).

Mercredi 30 mars
Inverter

8h-8h30	Révision de la journée précédente. Répondre aux questions.
8h30-12h	Savoir reconnaître la différence entre un message d'erreur et un avertissement. Comprendre ce que chaque message signifie, identifier le problème et y répondre comme il se doit afin de redémarrer le système. Exercices pratiques FX inverter/chargeur sur les « erreurs et avertissements » qui apparaissent sur l'écran du MATE.
12h-13h	**Pause déjeuner**
14-17h	Exercices sur la bonne tenue des documents dans lesquels seront consignées les données sur le fonctionnement du système Equilibrage des batteries à partir du MATE

Jeudi 31 mars
Utilisation et entretien des génératrices

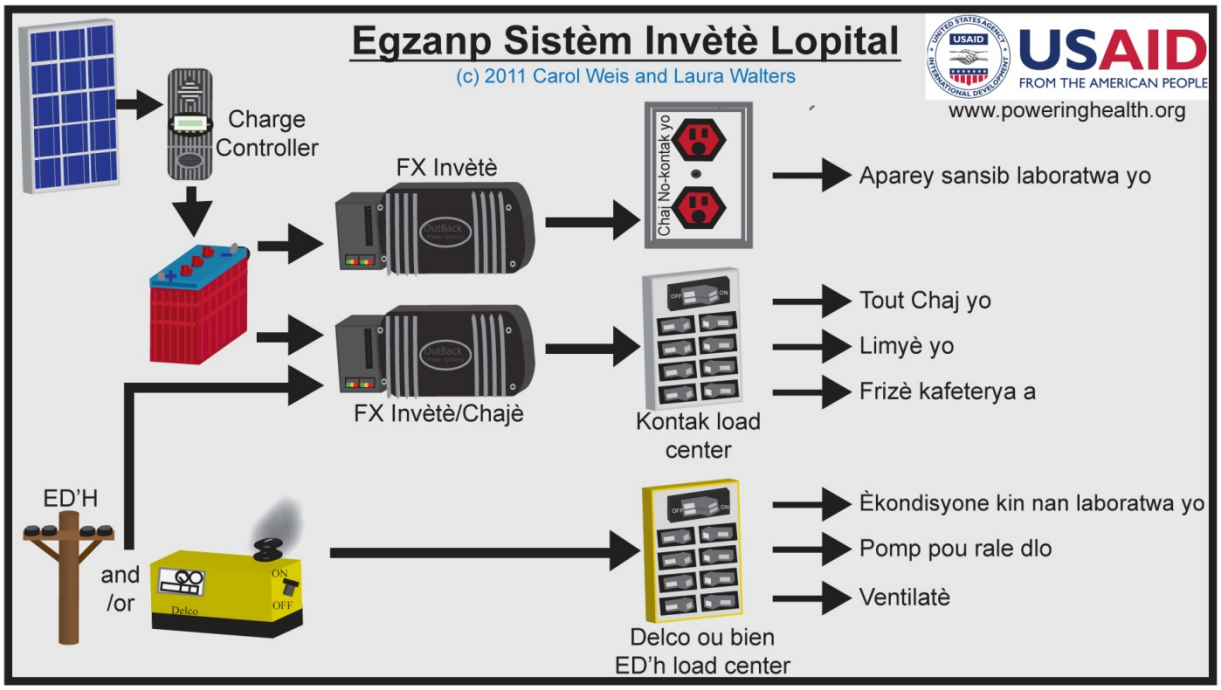
8h-8h30	Révision de la journée précédente. Répondre aux questions.
8h30-12h	Définition Description générale, (fig.-1) FIG-1 Différents circuits Alimentation en air ; Alimentation en essence (Diesel ou Gazoline) (fig.-2) ; Circuit de lubrification (fig.-4) ; Circuit de refroidissement (fig.-3) Vérification de la génératrice avant le démarrage Niveau d'huile ; Niveau du liquide de refroidissement ; Etat de la batterie ; Niveau de carburant Procédure de démarrage et d'arrêt Vérification des paramètres de fonctionnement Après le démarrage et la mise sous charge, vérification des paramètres (voltage de phase, ligne, fréquence, huile, voltage de la batteries…) Comment remplir les formulaires de rapport d'utilisation et d'entretien
12h-13h	**Pause déjeuner à la cafétéria**
14-17h	Importance de l'entretien Toutes les 250 heures : changer le filtre à essence ; le filtre à huile, l'huile et le filtre à air Problèmes rencontrés en général : batterie déchargée, combustible contaminé, débalancement des phases et surchauffe due à l'encrassement du radiateur Discussion générale

Appendix C: List of Training Materials Provided

The following documents were distributed to all the participants as handout material:

1) Power Point on System Configurations (English)
2) Example System & Alarm (Creole)
3) Example System & Alarm (English)
4) Battery Maintenance (Creole)
5) Example Technician Loads Sheet (English)
6) Example Technician System Size (English)
7) Daily Log Sheet (Creole)
8) Maintenance Summary (Creole)
9) Example Logging (English)
10) Technician Monthly Log (Creole)
11) Warnings and Errors (Creole)
12) Warning and Errors (English)
13) Generator Configurations (English)
14) Tool kit (included insulated wrenches, goggles, gloves, a wire brush, anticorrosion spray for the battery terminals, a hydrometer, and a volt meter)

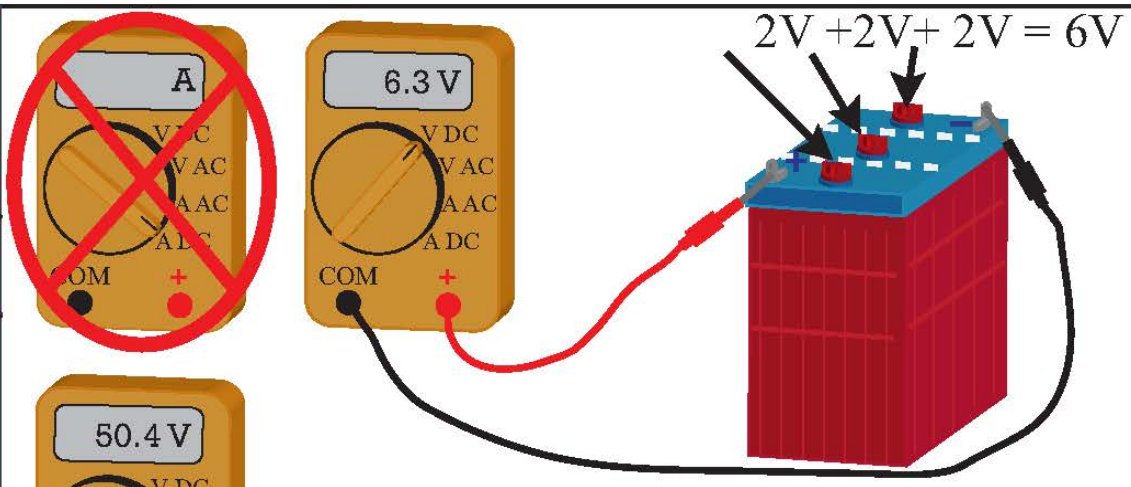
#2 - Example System & Alarm (Creole)

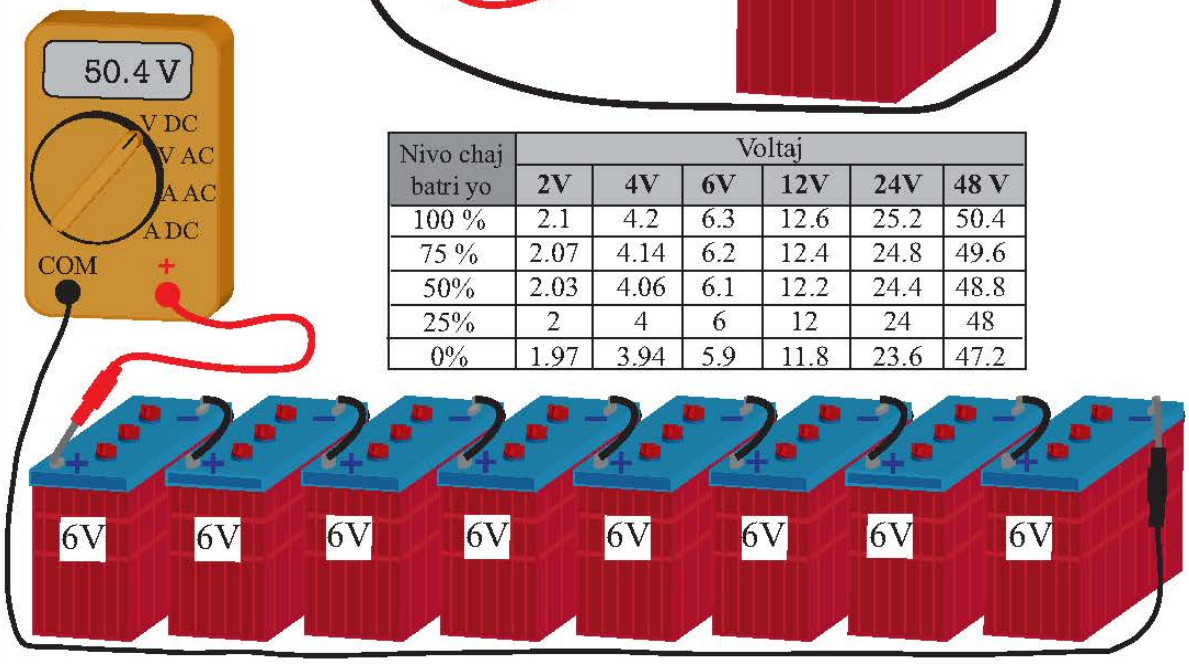


#4 - Battery Maintenance (Creole)

Entretyen Batri Yo

Fason pou nou teste voltaj batri yo

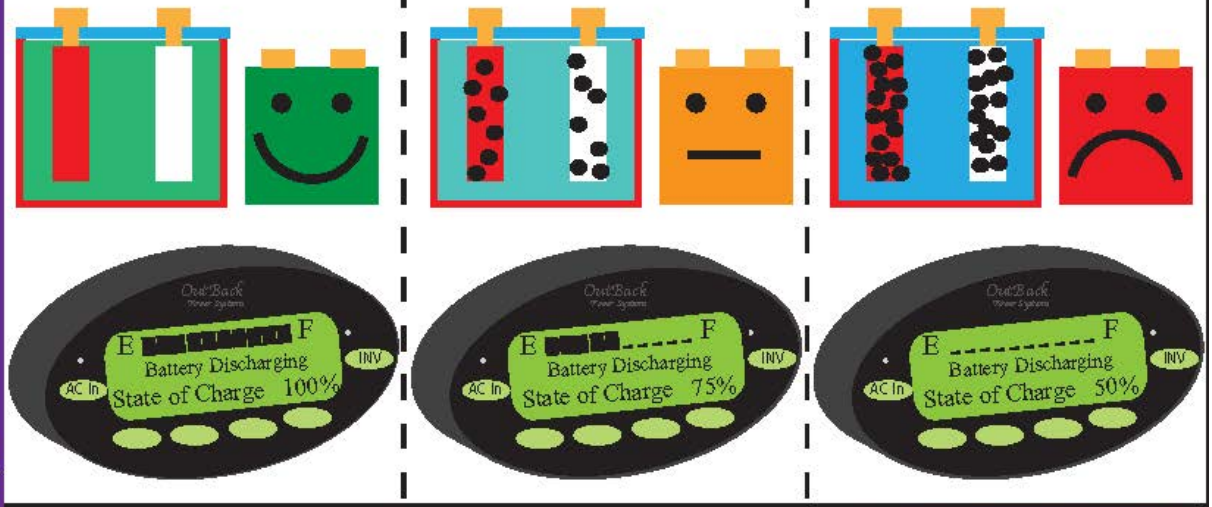


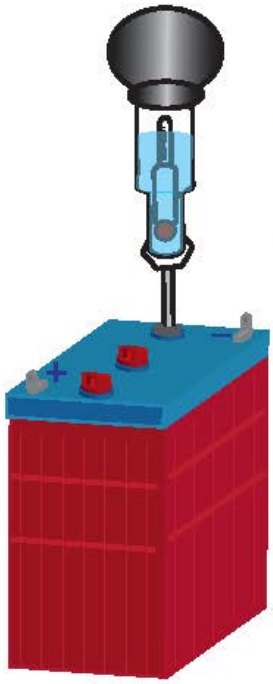


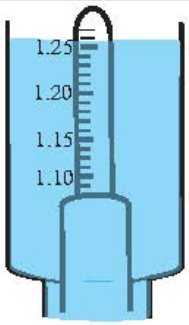
Nivo chaj batri yo	Voltaj					
	2V	**4V**	**6V**	**12V**	**24V**	**48 V**
100 %	2.1	4.2	6.3	12.6	25.2	50.4
75 %	2.07	4.14	6.2	12.4	24.8	49.6
50%	2.03	4.06	6.1	12.2	24.4	48.8
25%	2	4	6	12	24	48
0%	1.97	3.94	5.9	11.8	23.6	47.2

Fason pou retire vè de gri sou bòn batri yo

Nivo chaj batri yo

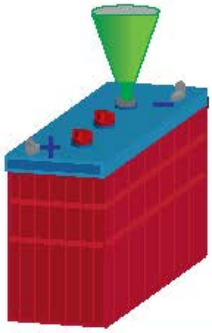


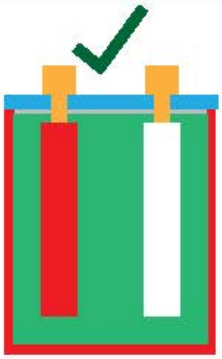


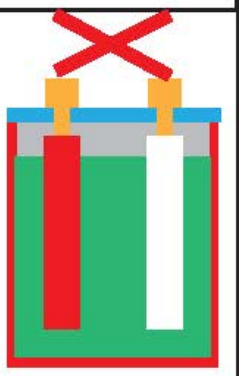


Nivo chaj batri yo	Nivo Acid
100 %	1.255-1.275
75 %	1.215-1.235
50%	1.200-1.180
25%	1.165-1.155
0%	1.130-1.110

Koman pou mete dlo nan bateri yo







#7 - Daily Log Sheet (Creole)

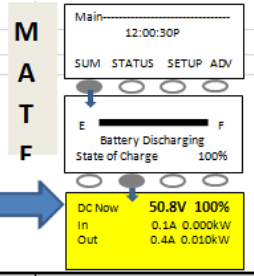
Not pou pran chak jou

POU RANPLI 2 FWA PA JOU: PREMYE FWA ANVAN YO DEMARE DELKO A
DEZYEM FWA: Avan labrim di swa
OU DWE RANPLI L SI OU TANDE KLAKSON NAN

Haiti Energy Team

Non Sant Sante a:

Non Teknisyen an:



DAT	Lè	Inisyal	Voltaj Batri yo	Eske Batri yo chaje	Este ou tande	Kisa ou fè			Gen limyè erè ki paret? Wi/No	Si Se Wi ki Erè?	Remak
						Pase Delko	Delko				
J/M/A			(MATE)	(MATE)	Klakson nan?	Wi ou No	Lè li derape	Lè li kampe			
			VDC	%			Start	Stop			
			VDC	%			Start	Stop			
			VDC	%			Start	Stop			
			VDC	%			Start	Stop			
			VDC	%			Start	Stop			
			VDC	%			Start	Stop			
			VDC	%			Start	Stop			
			VDC	%			Start	Stop			
			VDC	%			Start	Stop			
			VDC	%			Start	Stop			
			VDC	%			Start	Stop			
			VDC	%			Start	Stop			
			VDC	%			Start	Stop			
			VDC	%			Start	Stop			
			VDC	%			Start	Stop			
			VDC	%			Start	Stop			

#8 - Maintenance Summary (Creole)

Technician Duties

Rapò chak jou:

Ranpli Fèy la 2 fwa chak jou:
Ranpli l' lè nou fèk start dèlko a nan maten, ak lè nou pral etèn li nan apremidi ..
Fòk nou note tou ki aksyon ki pran aprè alam fin pati.
Pran nòt de tout erè ak avètisman lè yo parèt

Rapò chak mwa:

Tcheke Batri yo:
Asire ou ke tèt yo pwòp epi sèk.
Tcheke nivo Acid la.
Ajoute dlo distile si yo manke.Men pa debòde.
Ekri kantite lit dlo ou itilize pou ranpli batri yo

Panno solè:

Enspekte panno yo chak semèn.
Netwaye panno solè yo, pou retire pousyè sou yo.
Asire pa gen anyen lonbraj ki kouvri panno yo.

Klakson:

Klakson lan ak limye a ap active a 47.2V.
Klakson ka etèn pandan 6 zè, lè nou active timer ki nan kabinè AC flex la.
Yon fwa alam nan deklannche, li pa pral fèmen jiskaske chaj batri yo rive a 53V, atravè chaje. Chaje sa a kapab panno solèy yo oswa avek yon dèlko.

Equalizasyon Batri:

Tanzantan sistèm lan beswen fè egalizasyon. Se moun ki gen kontra antretyen kap gen pou fèl. Lè sa a Dèlko a ap bezwen Start, aprè sa batri yo ap bezwen fin rampli ak dol distile lè egalizasyon an fini.

Egalizasyon an ta dwe fè yon fwa chak mwa, si SOC pa rive a 100% chak semèn. Si SOC rive a 100% chak semèn, Equalizasyon an ka fèt nan entèval 6 mwa.

Teknisyen yo dwe prezan pandan chaj Egalizasyon. Sistèm pa dwe poukont li pandan egalizasyon an ap fèt.

#10 - Technician Monthly Log (Creole)

Not pou pran chak Mwa

Dwe konplete chak mwa

Haiti Energy Team

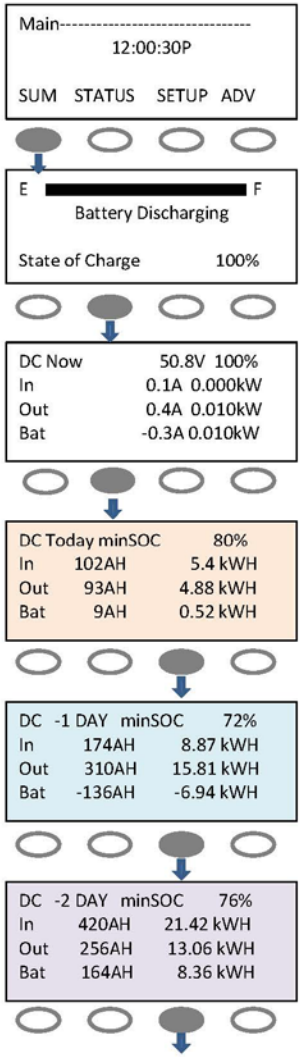
Non Sant Sante a:

Non Teknisyen an:

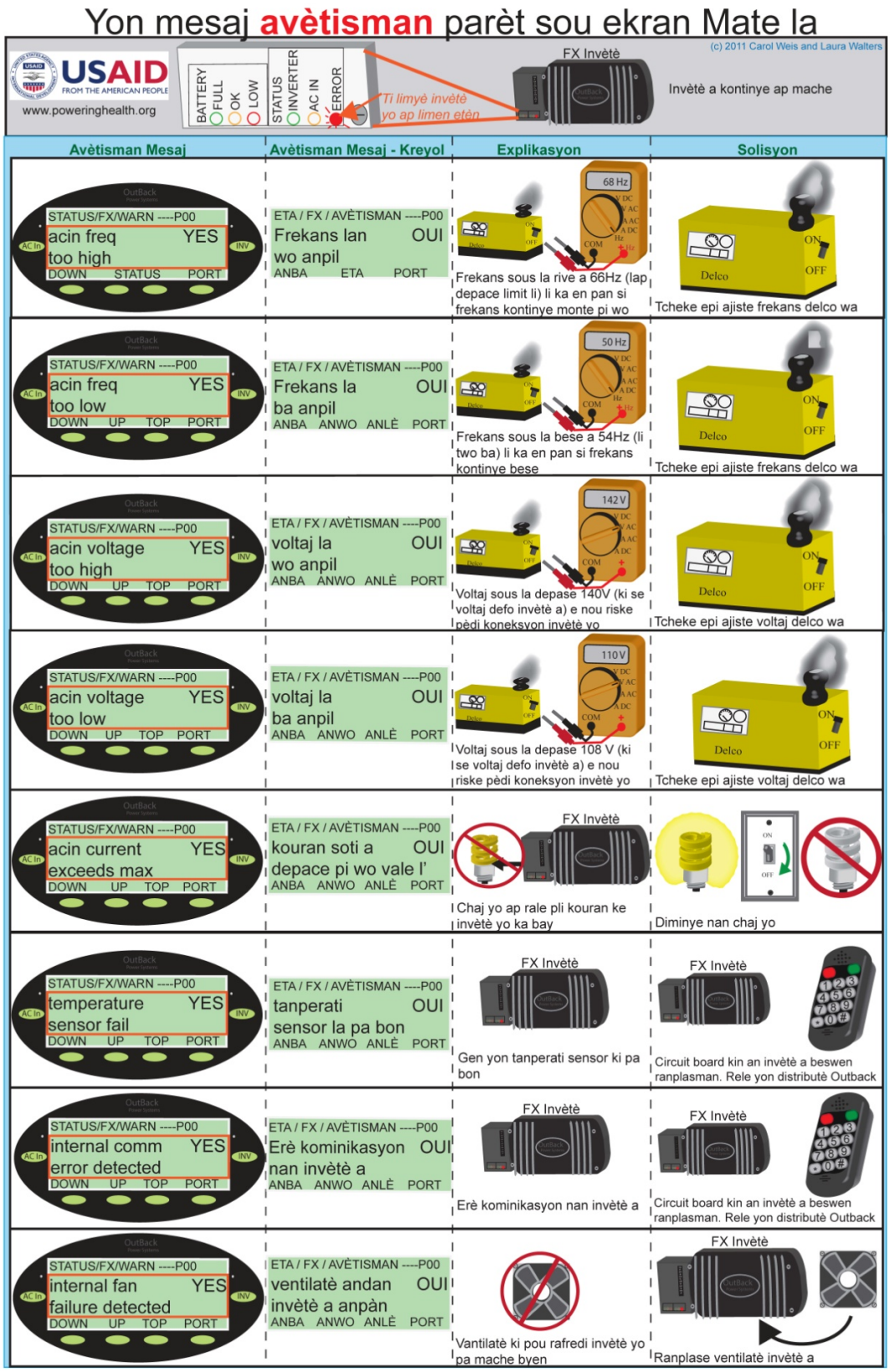
Flex Net DC Monitor - OUTBACK POWER MATE

	DAT	Min SOC %	Amphours (AH) In	Amphours (AH) Out	Amphours (AH) Bat	kWH In	kWH Out	kWH Bat	Remak
28/2/11									
27/2/11									
26/2/11									
25/2/11									
24/2/11									
23/2/11									
22/2/11									
21/2/11									
20/2/11									
19/2/11									
18/2/11									
17/2/11									
16/2/11									
15/2/11									
14/2/11									
13/2/11									
12/02/11									
11/02/11									
10/02/11									
09/02/11									
08/02/11									
07/02/11									
06/02/11									
05/02/11									
04/02/11									
03/02/11									
02/02/11									
01/02/11									

Initialize once this is complete this once per month			
Egalize	Tcheke dlo nan batri yo	Ki kantite lit dlo ou te mete?	Netwaye tèt batri yo ak tèminal yo



#11 - Warnings and Errors (Creole)



Yon erè parèt sou ekran Mate la

www.poweringhealth.org

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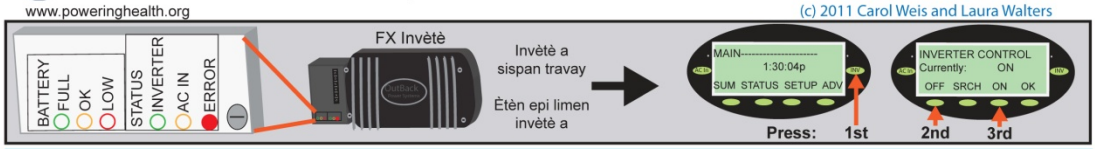

Erè Mesaj	Erè Mesaj - Kreyol	Explikasyon	Solisyon
STATUS/FX/ERROR ----P00 low ac output voltage YES DOWN STATUS PORT	ETA / FX / ERÈ ----------P00 voltaj la ba nan soti sous la OUI ANBA ETA PORT	FX Invètè Invètè pa ka bay ase voltaj pou chaj la	Diminye sou chaj yo
STATUS/FX/ERROR ----P00 stacking error detected YES DOWN UP TOP PORT	ETA / FX / ERÈ ----------P00 erè pwogramasyon kouplaj OUI ANBA ANWO ANLÈ PORT	Pwoblèm kominikasyon nan pami invètè yo	1. Pwogramasyon Mate la 2. Tcheke HUB ak kab yo wè si pa gen erè
STATUS/FX/ERROR ----P00 inverter overtemp YES DOWN UP TOP PORT	ETA / FX / ERÈ ----------P00 invètè chofe OUI ANBA ANWO ANLÈ PORT	FX Invètè Invètè depase maksimòm tanperati yo ka travay	1. Diminye sou chaj yo 2. Invètè yo manke ayere
STATUS/FX/ERROR ----P00 low battery voltage YES DOWN UP TOP PORT	ETA / FX / ERÈ ----------P00 voltaj batri yo ba OUI ANBA ANWO ANLÈ PORT	FX Invètè Voltaj batri yo anba "Low battery cut-out voltage" setpoint.	1. Diminye sou chaj yo 2. Chaje batri yo ak kouran delco a
STATUS/FX/ERROR ----P00 high battery voltage YES DOWN UP TOP PORT	ETA / FX / ERÈ ----------P00 voltaj batri yo wo OUI ANBA ANWO ANLÈ PORT	Voltaj batri a monte pi wo ke voltaj maksimòm lan pandan 10S	Tcheke Charge Controller ki pou system sole a avek lot sous yo
STATUS/FX/ERROR ----P00 ac output shorted YES DOWN UP TOP PORT	ETA / FX / ERÈ ----------P00 soti kouran an koupe OUI ANBA ANWO ANLÈ PORT	FX Invètè Invètè yo depace kapasite maksimòm, yo etèn	1. Diminye sou chaj yo 2. Tcheke fil kouran yo, pou wè si pa gen kousikwi
STATUS/FX/ERROR ----P00 ac output backfeed YES DOWN UP TOP PORT	ETA / FX / ERÈ ----------P00 soti kouran an jwen ak rantre kouran an OUI ANBA ANWO ANLÈ PORT	FX Invètè Kouran soti a Kouran antre a Yo konekte yon lot sous nan soti invètè yo	FX Invètè Kouran soti a Kouran antre a Tcheke fil kouran yo

Appendix D: Evaluation of the Training by the Participants

Legend	
2	Not good
3	Good
4	Very good
5	Excellent

	INSTRUCTORS					
#	**Armand**	**Carol**	**Christopher**	**Jude**	**Loby**	**Lesly**
1	5	5	5	5	5	5
2	5	5	5	5	5	5
3	3	5	4	5	4	5
4	5	5	5	5	5	5
5	5	5	5	5	5	5
6	5	4	4	4	4	3
7	4	5	5	5	5	5
8	5	5	5	5	5	5
9	5	5	5	5	5	5
10	3	5	5	5	4	5
11	5	5	5	5	5	5
12	4	4	5	5	4	5
13	5	5	5	5	5	5
14	3	4		4	4	4
15	5	5	5	5	5	5
16	5	5	5	5	5	5
17	3	5	3	3	5	3
18	3	5	4	4	4	4
19	3	4	4	4	3	3
20	3	5	5	5	4	4
Average	4.2	4.8	4.7	4.7	4.6	4.6

	LOGISTICS					
#	**Transport**	**Hotel**	**Food**	**Classroom**	**Documents**	**Tools**
1	5	3	3	3	4	4
2	4	5	4	5	5	5
3	3	2	2	4	5	4
4	5	5	5	5	5	5
5	5	4	4	4	5	5
6	4	4	3	5	5	5
7	4	4	3	4	4	4
8	5	5	4	5	5	5
9	5		4.5	5	5	5
10	5	5	5	5	5	5
11	5	4	4	4	5	5
12	2		3	4	4	4
13	2		4	4	5	5
14			3	3	4	2
15	2		4	4	5	
16	3		3	5	5	5
17	3		2	3	3	4
18			3	3	5	5
19	2	3	3	4	4	5
20	4	3	3	4	5	5
Average	3.8	3.9	3.5	4.2	4.7	4.6

Subjects that interested you most	All subjects	Inverter	Battery	Generator
	5	10	4	4

Subjects that did not interest you	None	Inverter	Battery	Generator
	13		1	3

If we organize another training, which subject should be covered again?	MATE	Inverter	Battery	Generator
	1	12	0	1

Documents you will review	All	Inverter	Monitoring logs	Maintenance
	10	2	3	3

Appendix E: Follow Up Inspection Report

Technician #	1	2	3	4	5	6	7	8	9	10	11
Visual inspection of system											
Are the tops of the batteries clean?	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	No
Are the batteries terminals free from corrosion?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Are the battery cables securely fastened on terminals?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Does each battery cell have an adequate amount of water?	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	No
If the answer is no to the above question, how many cells needed water?	___	____	All of them	____	____	All of them	____	____	____	___	All
Do any battery cells have lead plates exposed above the water level? If so, how many cells were like that?	___	____	21	____	____	8 cells	____	____	____	___	Yes, All
Is the battery temperature sensor intact?	Yes	Yes	Yes (though it is not well attached to the battery)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Was the system operational during your inspection?	Yes	Yes	No, the battery voltage was too low	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were there any errors or alarms on during your visit?	No	No	Yes	No	No	No	No	No	No	No	No

Technician	1	2	3	4	5	6	7	8	9	10	11
Evaluation of completed logging sheets											
Have the GENERATOR daily logging sheets been completed since April 1st? If not, what dates were completed.											
	No	No	No	No	Yes, Since April 7, 2011	Yes	No	No	No	No	No
If the answer is NO to the above question, explain why the logs were not done											
	Another technician is in charge of the generator	Another technician is in charge of the generator	Generator not functioning, and administrator has the notebook, and another technician runs the generator	Technician says he did not understand how to fill the logs out	N/A	N/A	They log in their own paperwork	Another technician is in charge of the generator	Another technician is in charge of the generator	LCD is broken on generator	Do not use generator much
Have the MATE daily logging sheets been completed since April 1st? If not, what dates were completed?											
	Yes	Yes	No	No	Yes, Since April 7, 2011	Yes	Yes, since April 22, 2011	Yes	Yes	No	Yes
If the answer is NO to the above question, explain why the logs were not done											
	N/A	N/A	Notebook not available, the administrator has it	No access to the lab room where inverter system was	N/A	N/A	N/A	N/A	N/A	Does not have keys to inverter system room	N/A
How many ERRORS have been registered on the MATE daily logging sheets since April 1? Which ERRORS occurred?											

	No error	No error	There is no logging, but technician says there has been low battery voltage error	No error	No error	No error	No error	No error	No error	No error	No error
How many times did the Klaxon turn on since April 1st?											
	Never	N/A	Many times - nobody knows	Never	Never	Never	Never	Never	Never	Never	Never
Does the logging record the generator being run after the Klaxon signals?											
	N/A	N/A	There is no logging	N/A	N/A	N/A	N/A	N/A	N/A	N/A	na
Was the April 1st and May 1st monthly GENERATOR logging sheet fully completed?											
	No	No	No, Notebook not available, administrator has it	No	No (generator room burned down)	Yes	No	No	No	No	No
Was the April 1st and May 1st monthly MATE logging sheet fully completed?											
	Yes	Yes	No, Notebook not available, administrator has it	No	Yes	Yes	Yes	Yes	Yes	No	Yes
How many liters of water were added in April?											
	8 gallons	12 gallons	15 gallons	2 gallons	3 gallons	12 gallons	2 gallons	5 gallons	1 gallons	Not registered	No water has been added
How many liters of water were added in May?											
	6 gallons	12 gallons	Nothing	2 gallons	3 gallons	12 gallons	3 gallons	3 gallons	2 gallons	Not registered	No water has been added
Did the technician do an equalization charge on the battery April 1?											
	No	No	No	No	No	No	No	No	No	No	No

Did the technician do an equalization charge on the battery May 1?											
	No	No	No	No	No	No	No	No	No	No	No

Technician	1	2	3	4	5	6	7	8	9	10	11
Demonstration of technician's proficiency of navigating the MATE	This is the second hands-on training with the MATE. During this time, the technician should be ENCOURAGED to use their training material to navigate the MATE. If the technician is having problems with navigating the MATE, Tetra tech will use the curriculum diagrams to aide technician.										
	Please rate how the technician's proficiency 1)Could perform task on his own without notes 2)Could perform task on his own with training material to follow 3) could not perform the task but could after a demonstration from Tetra tech 4) Could not perform the task even after demonstration 5) Would not comply with the exercise										
Technician to demonstrate how to locate information for daily logs	1	1	4	3	2	1	1	1	3	3	1
Technician to demonstrate how to locate information for monthly logs (Day -1, Day-2, etc)	1	1	4	3	2	1	1	1	3	3	1
Technician to demonstrate how to equalize the battery by navigating the MATE	1	3	4	3	3	3	3	3	3	3	1
Technician to demonstrate how to navigate the MATE and locate the Warnings page	1	1	4	3	3	1	3	1	3	3	3
Technician to demonstrate how to navigate the MATE and locate the Errors page	1	1	4	3	3	1	3	1	3	3	3
Technician to demonstrate how to clear an error (by turning the MATE Inverter Off and On buttons)	1	1	4	3	3	1	3	3	3	3	1

U.S. Agency for International Development
1300 Pennsylvania Avenue, NW
Washington, DC 20523
Tel: (202) 712-0000
Fax: (202) 216-3524
www.usaid.gov