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Prepared for
U.S. DEPARTMENT OF ENERGY
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SUMMARY

The NASA Lewis Research Center has concluded a project to develop and field test photovoltaic-powered refrigerator/freezers for vaccine storage in remote areas of developing countries. As a conclusion to this project, questionnaires were sent to the in-country administrators for each test site probing user acceptance of the systems and attitudes regarding procurement of additional systems. Responses indicate that the systems had a positive effect on the local communities, that they made a positive impression on the local health authorities, and that system cost and scarcity of funds are the major barriers to procurements of additional systems.

INTRODUCTION

Since 1979 the NASA Lewis Research Center has been engaged in a project to develop and field test photovoltaic-powered refrigerator/freezer systems for vaccine storage in rural (electricityless) areas of developing countries. That project was undertaken at the request of the U.S. Centers for Disease Control (CDC) and was later included in the U.S. Department of Energy (DOE)-funded Stand-Alone Photovoltaic Systems project and in the Agency for International Development (AID)-funded Development and Support Program, both managed by the Lewis Research Center.

The field test phase of the project began in 1981 and was nominally concluded in June 1985. Twenty-nine photovoltaic-powered vaccine storage refrigerator/freezer systems were installed in 24 developing countries. Varying amounts of performance data have been received from 21 of the systems. Project and system descriptions, results from analyses of data, system and component reliability information, and technical recommendations regarding system design and operation were reported earlier (ref. 1).

At the conclusion of the field test phase of the project (at least 1 year following installation of all systems), questionnaires were sent to the in-country U.S. project managers and to the national ministerial project managers. The questionnaires probed user opinion and evaluation of the system and the project. The responses from those questionnaires, comments on the responses, and an analysis of the results are reported herein.

BACKGROUND

Photovoltaic-powered vaccine refrigerator/freezer systems are designed to serve the far end of the vaccine cold chain--the rural health center not served with electricity. The systems provided under this project offered the capability to store vaccines for extended periods of time in health centers often

previously served only by outreach. That capability provided part of the means for implementing full-scale local immunization programs and outreach from each health center.

System installation in rural health centers was in many, if not most, cases a perturbation in the affairs of those centers and an additional administrative burden for the Ministries of Health and the cooperating U.S. agency. To fully utilize the systems, the ministries had to provide adequate amounts of vaccines and the personnel and means to administer the vaccines.

The systems also constituted the introduction of a new energy technology and the requirement to cope with and evaluate the appropriateness of that technology. This burdened health center staffs with system data recording and transmittal and the need to understand how to use the novel refrigerator system so as not to endanger their vaccine supply. It also burdened national level health service staff and cooperating U.S. agencies with the need to transmit data, to maintain liaison with NASA, and to provide technical and operational support for the systems.

Finally, there was the need to determine how these systems were perceived to fill the need for refrigerated vaccine storage in rural health centers.

The factual data (ref. 1) indicated that the systems had performed well. Data from reporting sites indicated that the systems had been in operation 84 percent of the time and that they maintained the World Health Organization (WHO)-recommended vaccine storage temperature range of 0 to 8 °C for 80 percent of the time. But to fully evaluate this project and the technology, NASA, CDC and WHO needed answers to myriad questions regarding how the systems were used and how the users perceived systems operation; hence the questionnaire.

Questionnaires were sent to the in-county AID, CDC, or WHO project managers and to the national ministerial project managers. The questionnaires probed user opinion of the system, use of the system, plans for additional systems, evaluation of the perceived system performance, and project management. The responses from those questionnaires, comments on the responses, and an analysis of the results are reported herein.

QUESTIONNAIRE

A field test activity the size and scope of this project generates a thirst for both performance data (the information that comes from meters and problem/failure reports) and information relating to how the system is used and how its performance is perceived by the users.

To obtain information on system use and user opinion, NASA Lewis, with help from CDC and WHO, assembled two slightly different but rather lengthy questionnaires.

Each questionnaire contained approximately 72 questions covering such subjects as number of site visits by health officials, amounts and types of vaccines stored in the refrigerator, population and area size administered from the system site, community response, perceptions on system strong and weak points, problems, reliability, need for and willingness to procure additional systems, user and technician training, need for additional electrical appliances at the

site, and comments regarding various aspects of the project. A sample copy of the questionnaire sent to AID, CDC, or WHO offices is shown in appendix A. Answering the questionnaire required some effort and research, and the author is grateful to those who did take the time to respond.

ANALYSIS AND SUMMARY OF USER EVALUATION RESPONSES

Table I lists all of the systems sites and shows the system supplier for each site (Solar Power Corp. (SPC) or Solavolt International (SVI)).

Table II lists those sites to which the questionnaires were sent (by country and site name) and those sites for which completed questionnaires were received.

Appendix B is as faithful a copy of replies as is possible given various scripts and translations. In some instances a respondent's comments were edited for clarity. Verbatim responses were incorporated wherever possible as a courtesy to the respondent and as an accurate indication of the respondent's thoughts. The symbol N/R indicates no response, and N/A indicates not applicable.

When reviewing the actual responses in appendix B and the analysis and summary of responses in this section of the report, the reader should be aware that for two sites (Chiota, Zimbabwe, and Al Aried, Jordan) separate responses were received from two different organizations. Certain questions can only be properly evalauated on the basis of one reply per site. The analysis of responses to other questions can accommodate multiple responses for a single site. The reader should also be aware that the words "respondents" and "site," or "country," differentiate between types of questions. Likewise the type of question affects the total numbers of valid responses for different questions.

The following is a reiteration of each question in the AID/CDC/WHO version of the questionnaire and a summary of the replies with comments on the nature of the reply where needed. The questionnaire sent to ministerial personnel differed only in certain questions directed to AID and CDC/WHO offices.

1.0 Have you had an opportunity to follow the progress of the photovoltaic (PV)-powered refrigerator/freezer (R/F) system field test at your site?

Twenty respondents replied that they had followed the progress of the project, and two respondents replied that they had not.

Approximately how many times did you or your staff visit the site since the system was installed?

Two respondents replied that they had never visited the site. One of these respondents (AID/Ivory Coast) also had not followed the progress of the project. Of the other respondents, visit frequency ranged from once over the period of the project to every week from September 1982 to March 1985. Most respondents visited the site often enough to gain a reasonable understanding of how the system was functioning and being accepted.

2.0 Have National level representatives from the MOH Immunization Program followed the field test? If no, why not?

Of 22 respondents, two did not reply to the question; one was not specific; and two did not visit the sites, one because the project was considered outside of the MOH immunization program and the other because of transportation difficulty (Kuluduffushi in the Maldive Islands is difficult to access).

3.0 Does the MOH have an established program for vaccine preservation in rural (electricityless) areas? If yes, please describe the program, type of equipment used for vaccine storage and approximate annual cost per site:

Of the 17 countries that responsed, 11 or 12 countries (depending on how Peru's reply to the second part of this question is interpreted) have established programs for vaccine preservation in electricityless areas, 2 countries have not, and 3 countries did not answer the question.

The types of equipment and method of vaccine delivery vary, but generally the respondents use kerosene-fueled refrigerators. Jordan does outreach from centers where electricity is available, and Mali often uses privately owned refrigerators.

Reported annual costs vary. Gambia claimed $1050/year, Guatemala claimed $150/year, Zimbabwe reported $150 (RHC)/year for kerosene alone, and Jordan reported $1500/year. The higher costs are probably more accurate and take into account maintenance, fuel, replacement parts, and depreciation of the R/F. But probably none of the respondents considered the cost of lost vaccine resulting from R/F outage due to fuel shortages and/or maintenance problems.

4.0 Have vaccines been routinely stored in the PV-powered R/F? If no, why not?

Of the 20 sites represented, vaccine is routinely stored at 17 sites and reportedly not routinely stored at 3 sites. Within the context of these trial systems, "routinely" should be interpreted as "when the system (R/F) was functioning." Several of the sites (ref. 1, fig. 15 and table III) had nonoperational periods. One system site, Cibungbulong, Indonesia, stored vaccines at the site for a time, presumably until the system stopped functioning (ref. 1). Guyana and the Maldives did not routinely store vaccines because of operational problems with the R/F's (ref. 1; for Guyana, table VII, comment 4; for Maldives, table VIII, comment 6). However, once the problem was corrected in Guyana, vaccines apparently have been routinely stored there.

The Dominican Republic responded "Yes" but then reported that "vaccines are brought in from refrigerated sources hours before each campaign."

4.1 If yes, approximately what percentage of the time?

Sixteen sites responded to this question. Fifteen sites gave answers with percentages ranging from 60 to 100 percent. Two of these sites qualified their response with "while R/F was functioning." Thailand responded "1 week." Because of data and correspondence and a personal knowledge of the people at

the site and the situation there, the author believes that this reply is incorrect and that vaccines are being stored there 100 percent of the time.

With the acknowledgment that vaccines were not stored during periods of equipment problems, vaccines have been stored at 17 sites somewhat less than 95 percent of the time. This indicates a reassuringly high R/F usage.

4.2 Approximately how often are vaccines delivered to the PV-powered R/F sites?

Four sites did not respond to this question. The others responded as follows:

Quarterly	3
Monthly	9
Biweekly	1
Weekly	4

4.3 Please indicate, by type of vaccine, approximately how many vaccinations are administered per week at the PV-powered R/F site:

Type	Sites responding	Vaccinations/Week	
		Average	Range
DPT	15	43	7 to 107
Polio	15	40	6 to 100
Measles	14	22	0 to 100
BCG	14	21	3 to 50
TT	15	13	5 to 25
MR	1	0	0
Yellow Fever	3	8	13 to 20
Anti-Rabies	2	15[a]	- - - - - -
DT	1	20	- - - - - -

[a]One respondent replied "every six months" without indicating how many doses.

5.0 Does the PV-powered R/F site have an outreach program?

Fourteen sites do, three do not, two did not reply, and Zimbabwe maintains an outreach from a local hospital because there is too small a staff at Chiota (the R/F site) to support an outreach program.

5.1 If yes, approximately how large an area is administered?

Six sites did not respond to this question. Five either had not responded previously (question 5.0) or had indicated no outreach program. Of the 14 responding sites, areas ranged from 3.2 to 500 km^2. The Guyana site services an indeterminately large area (appendix B), the local Zimbabwe hospital serves an area of 1000 km^2, and the Peru site serves an area of unknown size.

5.2 Approximately how large a population is administered?

Five sites did not respond, and one respondent did not know the number of people served. Of the 14 other respondents, population served ranged from 2000 (Las Tablas, Dominican Republic) to 200 000 (Zaranou, Ivory Coast).

5.3 Approximately how many cold packs are frozen each week?

Seven respondents did not answer this question. Three of these (Guyana, and the two Gambia sites) did not respond to the question, although all reported outreach programs. Of the other 12 sites, 11 reported freezing an average of 7 cold packs/week with specific numbers ranging from 2 to 12/week. One site reported freezing "1 pack of 12 doses," which is probably a misinterpretation of the question.

6.0 Has the PV-powered R/F system at your site allowed immunization services to be offered on a routine basis?

Yes	18
No	1
N/R	1

6.1 If yes, has immunization coverage increased?

Seventeen sites responded that immunization coverage had increased, and two sites (Maldives and India) did not respond. Zaire indicated that the PV-powered R/F only increased the efficiency of the existing program. Guatemala reported that immunization had increased considerably. Indonesia reported an increase because polio and measles vaccines were available. Haiti reported "just a little" increase because of problems with transportation, motivation, and medical personnel, and because of an uninformed community.

6.2 If no, please explain why immunization has not been offered on a routine basis:

The Maldives attributes no increase in immunization to problems with the system. However, the preexistence of electricity on the island, and thus a refrigerator, probably precluded any increase in immunizations.

6.3 As a consequence of offering immunization services routinely, has the community consulted on or demanded other health services?

Yes	12
No	4
N/R	2
Not known	2

The positive responses are interesting and are repeated here for the convenience of the reader:

(1) Las Tablas, Dominican Republic: "There has been a two way demand - mothers of children coming in for immunizations may have requested other health services or may have come in for routine health services and requested immunization. The community is pleased with the service offered by the clinic."

(2) Anse-A-Veau, Haiti: "People will be informed about other possibilities of the health center. Through immunization services there will be better contact between population and better psychological accessibility."

(3) Tierra Blanca, Guatemala: "All the primary health care services."

(4) Gunjur and Kaur, Gambia: "Yes, as part of the EPI [Extended Program on Immunization]/MOH integrated program."

(5) Zaranou, Ivory Coast: "This unit has brought new respect to the health authorities. People come to the center to see it."

(6) Chiota, Zimbabwe: "Yes, people in remote villages have asked for immunization services in their areas."

(7) Pucara, Peru: "Yes, since they know about this service, they ask about birth control, growth development; their knowledge has increased."

(8) Tambon Tha Thong: "Yes, the community wants to use solar cells to generate electric light during delivery by night."

(9) Guaimaca, Honduras: "Yes, because of increased vaccine availability, a desire for well-baby clinics has been stimulated."

(10) Al Aried, Jordan: "Yes, the community is demanding establishing a hospital in the area."

(11) Ouelessebougou, Mali: "Yes, the administration of nioaquine and other kinds of vaccinations."

To present a balanced view, the negative responses are also repeated here. These are more perplexing than interesting.

(1) Cibungbulong, Indonesia: "No, demands are only made through a complex village organization. We have not heard of any such demand."

(2) Batujaya, Indonesia: "A complex village system assists residents in health services. Any demands come through this system."

(3) Schepmoed, Guyana: "The community has had 'medical presence' in the form of a dispenser, commonly referred to as 'Doc.' The community has always looked to 'Doc' for all kinds of medical care."

(4) Niofouin, Ivory Coast: "No, the population is extremely pleased with the unit, but the information requested is understandable."

7.0 How did the local community receive (or perceive) the installation and/or use of the system?

7.1 Accepted without comment or problems: 19 (1 N/R)

7.2 Problem(s) accepting (please explain): 0

7.3 Do not know: 0

Again, the positive responses are interesting and give some insight into the villagers' reaction to such a system and so are repeated here for the convenience of the reader:

(1) Las Tables, Dominican Republic: "Yes, local officials are very enthused."

(2) Schepmoed, Guyana: "Yes, comments and queries were made about its functioning. The community seemed anxious that immunization services be available on a routine basis."

(3) Niofouin, Ivory Coast: "Yes, they declared a holiday and danced with joy."

(4) Chiota, Zimbabwe: "Enthusiastic that something was being done for their benefit."

(5) Pucara, Peru: "Yes, accepted it and they feel proud that in their town there is a solar energy refrigerator. They admire the technology and the way it generates electricity and there is trust in the vaccine."

(6) Guaimaca, Honduras: "There were no problems, but it is viewed as a novelty and has been visited by teachers, students and various local residents."

8.0 Please indicate what you view as the system's strong or weak points. Answer Strong or Weak and please explain:

8.1 Photovoltaic power system:

8.1.1 PV modules, structure and cabling:

All sites indicated the PV structure and cabling modules as strong points, with several sites adding comments such as "no problems" and "trouble free."

8.1.2 PV system controls:

Strong	15
Weak	2
N/R	5

The responses to this question by Guatemala and Thailand were obviously in regard to instrumentation and so have been moved to question 8.1.4 by the author. Guatemala and Thailand are thus shown as N/R here.

8.1.3 Batteries:

Twelve sites (14 respondents) reported favorably on batteries. Seven sites responded that the batteries are a weak point. Pucara, Peru so responded, but the data indicates no problem with the batteries there. Two sites (India and the Maldive Islands) commented on short battery life. This would have been the result of overuse and/or undersizing of the PV array because of inexact

insolation data (no one's fault). One respondent commented (justifiably) on the difficulty of accessing the batteries.

8.1.4 PV system instrumentation:

Eight respondents reported the PV system instrumentation as a strong point, 10 cited it as a weak point, 2 did not understand the question, and 2 did not reply. Negative comments on PV system instrumentation were justified, since the instrumentation with the Solar Power Corp. systems was a major problem (ref. 1). However, problems with the PV system instrumentation did not affect system operation.

8.1.5 Thermograph:

Eleven respondents (corresponding to 11 sites) reported that the thermo graph was a strong point. Ten respondents (corresponding to nine sites) reported that the thermograph was a weak point. One site did not respond. Comments regarding its weakness included: "often malfunctioned," "difficult for health staff to understand," "problem with clock mechanism," and "out of calibration."

One characteristic of the thermograph clock mechanism bears mentioning. The clocks are spring motor driven. Unfortunately, the design of the spring motor is such that it is almost impossible to sense (from winding force required) when the mechanism is nearing the fully wound condition. It is, therefore, very easy to inadvertently wind the clock too tightly. When that happens, the spring will not unwind and the clock drive mechanism will not operate. To correct this problem, the spring has to be slightly unwound by gently turning the winding key in the opposite direction for a few minutes. This potential problem and its remedy was explained to all users and technicians during installation. Four to six of those reporting the thermograph to be a weak point may have experienced this type of problem.

8.2 Refrigerator/freezer:

8.2.1 Design:

Nineteen respondents (corresponding to 18 sites) reported the design of the R/F to be a strong point. One site did not respond, and one respondent reported the design to be a weak point, citing specifically the door latch. This was a problem with the Marvel R/F, where in several instances screws securing the door latch to the refrigerator box pulled out of the box.

Some of those responding positively to the R/F design nevertheless commented on various aspects of the design. One respondent (Guyana) thought the overall system was too large to transport to remote locations. Another commented on wasted space and the need for shelves. NASA Lewis and the CDC recognized the need for stacking shelves but were unable to provide them for these systems. Another respondent commented on what may have been a lid hinge attachment problem. Others reinforced their positive evaluations with various comments.

8.2.2 Size, too small or too large:

The following table best summarizes the responses (22 responses for 19 sites) to this question:

Strong (unqualified)	6
Strong (qualified)	5
Weak (unqualified)	0
Weak (qualified)	6
N/R	2
Other	3

Those who qualified their "strong" size rating did so on the following bases: R/F too large (Indonesia), R/F too small for a regional or district storage and too large for a health center (Haiti), freezer too small (Mali), and R/F "adequate" (Guatemala).

Those who qualified their "weak" size rating did so on the following bases: R/F too small (Ivory Coast), freezer too small (Gambia and Thailand), and R/F too large (Guyana). Peru and Zaire, without rating the size, indicated that it was too large.

The overwhelming majority of responses indicated a strong preference for the size of these R/F's, with most indicating a preference for a somewhat larger freezer section. Interestingly though, those who indicated that the freezer is too small do not freeze even 2 kg of water each day.

A review of the answers to question 5 (outreach activities) indicates that for those sites (both Gambia sites, Thailand, and Mali) stating that freezer volume is too small, outreach areas and populations range from 3.2 km^2 with a population of 16 727 to an 18-km-radius geographic area with a population of 35 000. These same 4 sites reported the following numbers of ice packs frozen per week: Gambia, no responses; Thailand, 7; and Mali, 2. The refrigerator/freezer systems are all designed to make 2.1 kg (six 350-ml ice packs) of ice every 24 hr. Thus, the comment that freezer compartments are too small appears somewhat unjustified considering reported usage.

Although the Gambia sites administer the greatest number of inoculations weekly (of the reporting sites), they are resupplied monthly. Thus, none of the vaccines actually has to be stored in a frozen state.

8.2.3 Frost/ice removal:

Twelve respondents replied that frost/ice removal was a strong point, five replied it was a weak point, and five did not reply. Thailand reported that they always have to remove frost; they are very conscientious and the climate there is very humid. This question would better have been phrased "ease of frost/ice removal." Presumably, the respondents answered in that regard.

8.3 Ability to store non-EPI medications and/or vaccines (e.g., rabies and veterinary vaccines):

Fourteen of the respondents indicated that the ability to store non-EPI items was a strong point, but none (with the possible exception of Mali) indicated they were so using the R/F. Gambia reported for both sites that there would not be enough room. Three sites did not respond, two respondents had no opinion, and one specifically stated that no other use was being made of the R/F, without addressing the merit of potential use.

8.4 System cost: please explain any other strong or weak points you may have observed.

Unfortunately, in editing the questionnaire an oversight here resulted in, if not a confusing question, at least one covering two separate issues. Nonetheless, the respondents voiced interesting opinions and/or observations.

The single comment receiving most response was high cost (six respondents) Four respondents did not reply. The other responses generally addressed problems, some of which bear comment.

The Ivory Coast commented on lack of sufficient training, "no spares and insufficient tools." In-depth training was not possible during installation, and this lack of training is an acknowledged shortcoming of the project. However, critical spare parts and sufficient tools to replace those parts were left with each system. Peru commented on the problems with instruments (a valid comment). Morocco commented on the problem with the Solar Power Corp./ Adler-Barbour power cable plug (ref. 1, table VII, comment 4) and difficulty of battery access. Haiti and Honduras commented on problems with the inner refrigerator and freezer compartment covers, and Mali believes their array and batter capacity should be larger.

8.5 What would you do to improve the system?

This question returned a host of suggestions/comments. The reader is referred to appendix B for details. Similar comments received from more than one respondent were system cost (too high), less and/or better quality instrumentation, less expensive and longer lifetime batteries, improved battery access, a larger PV array, and better venting for the condenser. Many of the suggestions (in addition to those listed above) identified through the course of the field test phase of the project added to the overall worth of the project and presumably will be incorporated in future systems by manufacturers.

9.0 How does your Mission view the MOH's reaction to PV-powered vaccine R/F systems? Are problems real or perceived?

In general, ministers of health were pleased to enthusiastic about the systems. Guyana sees the extension of health service to other remote areas occurring as the result of PV systems (in a broader context than just vaccine preservation). There is concern over the high cost of the systems in two countries and over the cost and lack of spare batteries in Peru. Only the Maldives responded negatively to this question, indicating the MOH was not pleased because of problems with the system (ref. 1, table VIII, comment 6).

10.0 Are the people who were trained in R/F system operation and use by the installation team still at the health post?

Yes	11
No	8
N/R	1

The number of "Yes" replies is based on the author's assigning a "No" to each of the Gambia "Yes" replies on the basis of Gambia replies to other parts of this question.

If not, were the replacements trained in R/F operation and use?

Yes	4
No	4
N/R	1

This tabulation reflects only the six sites which indicated that the originally trained operator was no longer at the site.

If yes, who trained them?

The four sites that indicated the replacements had been trained responded as follows:

(1) Maldive Islands: by member of National EPI staff

(2) Dominican Republic: by Regional Engineer of MOH

(3) Gambia (both sites): by the predecessor, but that such training was inadequate because the person replaced did not have time to train his replacement (thus the author's conclusion that the original operators were no longer at the site)

Peru and Thailand answered this question although answers to the first part of this question indicated that the original operator was still at the site. Mali indicated replacement training by NASA engineer James Martz, but Martz did not return to Mali after the system was installed.

If no, why were they not trained?

For the four "no" replies to the second part of this question (i.e., replacements not trained), two sites (Indonesia) indicated "trial [period] has ended" and reported no overlap of duty periods which would have allowed the predecessor to train the encumbent, and Haiti indicated that they had a problem paying someone to do the training.

11.0 Please summarize operating problems with the system under the following categories:

11.1 Instrumentation problems which <u>did not</u> affect system operation:

Five sites reported problems with amp-hour meters, and five sites reported problems with thermographs. Actually, more than five sites had amp-hour meter and thermograph problems (ref. 1, table X). Only two sites reported insolometer problems, but practically all of the insolometers had problems. One site recognized the problem with separate nonrechargeable instrument batteries, two

reported problems with staffers understanding the instrumentation, and two had problems with the high-temperature alarm. Responses from Gambia are confusing on this issue.

11.2 Equipment problems which did affect system operation:

There was a variety of answers to this question, some of which need explanation.

Five sites reported that there were no problems affecting system operation, and four sites did not respond to this question. Comments on the other responses are as follows:

(1) India reported "erratic operation of the temperature controller due to low voltage." This is not technically correct. The Adler/Barbour R/F employs a mechanical thermostat which operates independently of system voltage. What may be referred to here is the high refrigerator temperature alarm, which operates from a separate dry cell battery and which operates erratically as that battery becomes discharged but which does not affect system operation. India also reported a need to clean the PV array frequently. The building on which the array is located is near a dirt road which probably causes dust accumulation on the array. Cleaning, however, is considered one of the two normal maintenance functions (the other being defrosting the evaporator in the freezer compartment).

(2) The Maldives reported a freon leak. The R/F arrived at the site with a low freon charge, the apparent result of a factory error and insufficient quality control (ref. 1, table VIII, comment 6).

(3) Guyana reported problems with the alarm, compressor, and thermostat card. This was not the case. The problem was with the array power cable connector (ref. 1, table VII, comment 4).

(4) Gambia/Kaur reported leaking batteries and low states-of-charge. This was the first indication of this problem.

(5) Ivory Coast/Zaranou reported one broken solar panel (module). Solar Power Corp. was required to provide one spare PV module with each system and elected to mount and wire the spare module on the array and thus have an on-line spare. Thus, the broken PV module at Zaranou merely reduced that PV array to its design size (peak watt output), and the loss of the module should not have affected system operation.

(6) Ivory Coast/Niofouin reported that a consultant (a NASA Lewis engineer) was sent to diagnose "the problem," which was a failed condenser fan. A replacement fan and installation instructions were sent to the site after the engineer's return to NASA. The electronic control module for the compressor was returned to Lewis for testing (it was functional) and was then returned to the site with the new fan assembly.

(7) Peru and Morocco both reported a problem with the power cable connector. It was the first indication of this problem from either location. The loss of array power as a result of this problem could have caused the batteries to discharge one or more times. This may be why Peru, in this questionnaire, often commented on the need for replacement batteries.

(8) Thailand's comments here more appropriately apply to question 8.5 and have been so incorporated.

(9) Honduras reported problems with the thermostat circuit board and with a continuously operating condenser fan. These problems resulted from a low-rated power transistor on the thermostat card and fan high-starting current. The systems supplier (Solavolt) made modifications to correct this problem on all Marvel R/F units in the field under this program.

(10) Mali reported problems with fuses, blockage of the fan, the compressor electronic control module, and "battery weakness (stored energy)." The problems with the fuses actually were due to corrosion in the fuse holder. Whatever was blocking the condenser fan was removed by a local technician. The system did experience a failure of one of the two system voltage regulators. The statement about battery weakness stems from several instances of discharged batteries. The cause for the discharge is not clear. It may have been a result of the faulty voltage regulator, R/F overuse (too much ice making), an undersized array, or a combination of all of the above.

11.3 Operator practices which affected system operation:

Five sites reported no operator practices which affected system operation, and eight sites did not respond to the question. Of the five sites enumerating problems, Indonesia reported a lack of tools, spare parts, and operator skills necessary to maintain and operate the system. Again, tools and critical spare parts were supplied to each site, and operators and technicians were trained during installation. Peru commented that the system operates automatically, but that the operator did not take data as instructed. The Ivory Coast/Niofouin site reported that they believe the "current problem" (without saying what that problem is) is due to operator error. From the available records, during the time the questionnaire was being completed, the R/F was out of operation awaiting the replacement condenser fan from the U.S.

11.4 Other, or combinations of above:

Five sites indicated that there were no other problems, and the other sites did not respond.

12.0 Please list problems which the following personnel corrected:

12.1 Operator personnel:

Six sites responded "none," and ten sites did not respond. Of the others, Gambia/Kaur responded that the operator corrected a continuously sounding high-temperature alarm for the refrigerator compartment, the Ivory Coast/Niofouin operator replaced burned-out fuses, the Zimbabwe operator adjusted the covers of the freezer-to-refrigerator air circulation holes to achieve proper temperature in the refrigerator compartment, and the Mali operator cleaned the PV modules.

12.2 MOH personnel:

Ten sites did not respond to the question, and five sites responded that the MOH personnel had not corrected any problems. Of the others, MOH personnel

had performed minor repairs (changing fuses, adjusting compartment temperatures, removing the thermograph for repairs, and repairing a thermostat electronics card).

12.3 Mission personnel:

Eleven sites did not respond to this question, and eight sites indicated that mission personnel had corrected no problems. For one site, mission personnel shut off the R/F to allow the batteries to be recharged by the PV array.

12.4 Other, or combinations of above:

Twelve sites did not respond to this question, and two sites responded "none." For the other sites, a Solar Power Corp. (SPC) technician visited Guyana, an SPC in-country subcontractor visited the Indonesian sites, a non-MOH person replaced a fuse in Zimbabwe, a local jeweler fixed a thermograph chart drive in Guatemala, and someone attempted to repair the thermograph in Jordan.

13.0 How is system reliability viewed by AID and the MOH in regard to vaccine storage and icemaking?

13.1 Vaccine storage:

	MOH	AID/CDC
Very good	14	7
Good	5	2
Fair	0	0
Poor	0	0
N/R	3	13

13.2 Icemaking:

	MOH	AID/CDC
Very good	13	7
Good	2	0
Fair	3	2
Poor	0	0
N/R	4	13

14.0 How many health posts in your country are without electricity?

India	More than 1000
Indonesia	4000
Maldive Islands	Not available
Dominican Republic	Unknown[a]

[a]While many sites have electricity, power is only available a few hours a day.

14.0 - Continued.

Haiti	155[b]
Guyana	Approx. 60 to 80
Guatemala	240
Gambia	25
Ivory Coast	150
Zimbabwe	N/R
Peru	Many
Morocco	N/R
Zaire	N/R
Thailand	(c)
Honduras	4[d]
Jordan	2[d]
Mali	8[d]

[b]Without full time electricity.

[c]Question misunderstood.

[d]An error in the way the question was worded in the questionnaires sent to Solavolt systems sites produced responses regarding only local areas or districts.

14.1 How many of these health posts could use PV-powered R/F systems?

India	Most
Indonesia	3500 to 4000
Maldive Islands	All
Dominican Republic	Not available
Haiti	10
Guyana	Approx. all
Guatemala	211
Gambia	25
Ivory Coast	150
Zimbabwe	N/R
Peru	Many
Morocco	N/R
Zaire	N/R
Thailand	1[a]
Honduras	4[a]
Jordan	2[a]
Mali	8[a]

[a]An error in the way the question was worded in the questionnaires sent to Solavolt systems sites produced responses regarding only local areas or districts.

15.0 Does the MOH have funds to procure PV-powered vaccine R/F systems?

	No	N/R
MOH	13	4
AID/CDC	10	7

The Guatemala MOH responded that it would have funds to procure systems if the prices were lower.

16.0 Would your Mission (AID or CDC/WHO) endorse procurement of and/or order additional systems? If yes, how many? Over what period of time? If no, why not? If no because of cost (present systems cost about $5000 each) at what cost would additional procurement be considered?

The responses to this question were even; that is, six respondents would endorse procurement of PV-powered RF systems, six would not, one claimed a need for further analysis, and four did not reply. Of those endorsing purchase, only two would actually buy these systems. The overwhelming reason given for not procuring systems is high system cost. The price range that would apparently stimulate procurement is $1000 to $1500/system. This price doubtless has some relation in the minds of the respondents to the price of kerosene-fueled refrigerators. Unfortunately, there appears little chance that a complete PV-powered R/F system could be sold free-on-board (FOB) to the using country for $1500.

There were some comments regarding reliability of PV-powered vaccine R/F systems. Data from the systems in this project (which cover a broad spectrum of the developing world) show that the refrigerator compartments of the systems for which data is available were within the required 0 to 8 °C temperature range 80 percent of the time during the trial periods. It would be very interesting to review similarly documented performance from kerosene refrigerators in identical locations. It is probable that no one knows the temperature maintenance reliability of kerosene refrigerators in comparable situations. Table III lists responses to question 16 by country.

17.0 Would the MOH order additional systems?
If yes, how many? Over what period of time?
If no, why not? If no because of cost (assuming systems cost $5000 each), at what cost would procurements be considered?

Four respondents indicated that they would order additional systems, nine indicated that they would not, one responded "maybe," and three did not respond. Of those four respondents indicating that they would order systems, Guyana would order for all electricity deficient health centers, Peru did not know how many, and Jordan indicated 20 systems. Again cost and reliability were cited as barriers by those who opposed purchase, although the upper cost limit was somewhat higher than in the responses to question 16. Table IV lists responses to question 17 by country.

18.0 Would your Mission or the MOH be more receptive to ordering these systems if a manufacturer would train a technical cadre and/or provide a central store of spares in the country?

	Yes	No	N/R
Training	12	3	2
Maintain spares	12	2	3

If yes, what spares do you believe should be stocked?

Judging from the responses to this question, the issue of training and spares would have a major impact on systems procurement, although these issues rarely surfaced in the answers to the previous two questions. Respondents indicated that the following spares should be stocked: PV modules (despite only one documented PV module failure and that by apparent vandalism), cables, batteries, voltage regulators, fuses, instruments, diodes, compressor electronic control module, inner R/F compartment doors, R/F door seal, and glass thermometers (none were supplied with the systems). Curiously, none suggested sparing a complete refrigeration system or a complete refrigerator/freezer per se. This could be interpreted as an indication of the perceived reliability of the R/F itself (although the compressor electronic control module is part of the R/F).

19.0 Are there needs for additional electrical services at rural health posts?

Yes	14
No	0
N/R	3

If yes, what type?

	Yes	No	N/R
Area lighting	15	1	1
Exam lights	12	2	3
Sterilizer	15	0	2
Two-way radio	8	4	5
Other	3	0	14

This question elicited a vigorous response in favor of the need for additional electrical services at rural health posts. In the "Other" category, three respondents expressed a need for pumped water, and one additionally expressed a need for television. Clearly this points to a wider electricity need base for rural clinics which, when taken within the overall context of a rural clinic, makes PV power for vaccine R/F's more justifiable and cost-effective.

If no, why not?

The one respondent (Ivory Coast) stated no need for a two-way radio because of an excellent telephone system.

20.0 Would the inclusion of additional electrical services with the PV-powered vaccine R/F system make the systems more attractive even though these services would increase system cost?

Yes	11
No	4
N/R	2

It is unfortunate that this question did not contain a second part soliciting information on how much additional expense would be acceptable, especially given the responses to questions 16, 17, and 19.

21.0 What comments does your Mission and/or the MOH have regarding:

21.1 How the field test project was managed:

In retrospect this question should have been specific in regard to which management organization was being evaluated. The interpretation of this question thus led to a variety of answers, some of which, taken out of the respondents' context, are not clearly understandable:

(1) India and Gambia responded "good." Haiti responded "bad," but that evaluation was directed at how the Department of Public Health carried out its responsibilities for paying the system operator and acquiring data.

(2) The Maldive Islands responded "not well enough."

(3) Indonesia responded "rather poorly" and cited inadequate communication and unsatisfactory performance by the Solar Power Corp.'s subcontractor in Indonesia.

(4) The Dominican Republic cited frequent changes of local personnel.

(5) Guyana was "disappointed" and cited lack of in-country technical expertise and a need for additional contractor (system supplier) visits to help solve the problem (loose power cable plug) that caused a prolonged outage.

(6) Guatemala responded "good" and indicated that management could have been better if the EPI division had managed the project.

(7) The Ivory Coast indicated insufficient supervision by the central EPI, no assistance from US/AID, lack of CDC presence when the systems arrived on site, and insufficient or inappropriate English language contact with NASA.

(8) Zimbabwe indicated that the project was fairly well managed, but that they could have used an additional visit from the contractor (SPC) and/or NASA.

21.2 System performance:

India	Good
Indonesia	Generally good, except for instrumentation (both sites)
Maldives	Poor
Dominican Republic	Very good
Haiti	Excellent
Guyana	Seemingly OK
Guatemala	Good
Gambia	Good

21.2 - Continued.

Ivory Coast	Excellent when operating
Zimbabwe	Excellent and good (two respondents)
Peru	More electricity than needed
Morocco	N/R
Zaire	N/R
Thailand	Satisfactory
Honduras	Very pleased
Jordan	Good
Mali	No response

The replies to this question were generally positive. Peru's response, "thought more electricity generated than needed," is interesting given the numerous comments in their questionnaire reply relating to the need for spare batteries.

21.3 System design:

India	Good but expensive
Indonesia	Very good
Maldives	Good, but expensive
Dominican Republic	Very good
Haiti	Good
Guyana	Good
Guatemala	Good
Gambia	Good
Ivory Coast	Excellent
Zimbabwe	Excellent and good (two responses)
Peru	Adequate
Morocco	N/R
Zaire	Think overly complex
Thailand	Satisfactory
Haiti	Good but improvable
Jordan	OK
Mali	Good

21.4 User training:

Six countries responded that training was good, four countries responded that training was fair, one country responded that it was highly inadequate, and another responded that it was grossly inadequate. Indonesia reported that the training materials were not designed to be comprehended by workers at the village level. Zimbabwe replied that training was not as good as it should have been and was too hurried.

Two other sites (Dominican Republic and Guyana) indicated that the persons trained by the installation team left the site after one year. Nothing further was said about training of replacements, except that the nurse at the Dominican Republic site saw no point in recording data.

21.5 System manuals:

One country responded that the system manuals were very good, three countries responded that they were good, and one country responded "OK." Other comments included the following: need improvement; OK for technicians, but not clear for others; need technical interpretation, layman afraid of touching apparatus; easily understood, good translation, useful above all for the large diagrams for correcting errors (Solavolt manuals); has to have electrical connection documents and electronic circuits of all (parts of) the system; and clear for the operator but contains nothing on how to fix them (R/F system and/or components).

Three countries commented on translations of the manuals. The Ivory Coast claimed the manuals were useless because they were all in English, and Guatemala claimed the manuals were good, but that they needed a Spanish translation. The contractor for those sites (Solar Power Corp.) was supposed to have sent both English and local language (French and Spanish, respectively) copies to all sites. Honduras, a Solavolt system site, reported good translation into Spanish. Mali, also a Solavolt system site, expressed a need for a French translation. When the Solavolt systems manuals were distributed (by Lewis), Mali was sent both French and English copies.

It should be noted that Solar Power Corp., and Solavolt each wrote their own manuals and that certain deficiencies noted by Lewis in the earlier Solar Power Corp. manuals were corrected in the Solavolt manuals. All systems providers, however, have come to recognize the importance of good manuals and the deficiencies in their manuals and are continuously making improvements.

21.6 Operational support:

There was one unqualified "good," one unqualified "fair," one unqualified "bad," and two sites did not respond. All of the other sites had comments, some of which merit some comment and/or explanation.

India commented that spares "like special batteries" were not available locally. In fact, the batteries used in these systems are not available in India because of import regulations.

Cibungbulong, Indonesia commented that communications with NASA were inadequate, that there were no spares in the MOH, and that an Indonesian firm subcontracted by Solar Power Corp. to perform system repairs was only semi-cooperative.

First, in regard to communications with NASA, "inadequate" is difficult to quantify. There were numerous exchanges of letters and telexes, and all requests for information were handled promptly. In regard to "no spares at the MOH," all system spares were always left at the site with the system. Finally, the Indonesian subcontractor hired by Solar Power Corp. was apparently only prepared to perform repairs to the refrigeration system and not to the instrumentation subsystem. There apparently were also communications problems between Solar Power Corp. and their subcontractor.

The reason for Haite (Anse A-Veau) responding "bad" to the question is apparently (from separate correspondence) because MOH did not adequately provi for a trained person to record and transmit data.

Gambia cited lack of spare parts for the thermographs ("thermograph recor ing pens, spare instrumentation batteries, and inadequate spare parts"). In fact, spare recording pens, the only spare needed for the thermographs, were provided. Spare dry cell instrumentation batteries were not supplied with the Solar Power Corp. systems (they were not needed for the Solavolt systems) because they would probably have been used for other purposes and also because they would have been partially discharged from storage at the time of need.

The Ivory Coast (Zaranou and Niofouin) stated that operational support was nonexistent, that the response was slow, and that personnel could not per form. It is unclear what organization was being referred to here. NASA pro vided support through telexed directions for problem diagnosis, a site visit by a NASA engineer during installation of the Menee system, and replacement parts with installation instructions following that visit. The respondent may have been referring to MOH personnel.

Thailand reported that operational support was not very good, but there is nothing in the correspondence record that substantiates that response.

Jordan replied that "no support has been received after the P.V.R. was installed." Data indicated that the system had functioned properly except tha there was shipping damage to the thermograph, which disabled one thermograph channel, and later the other two channels on the thermograph were reported "out-of-order." Solavolt revisited this site in July 1986 and found the com pressor electronic control module failed and the spare control module dis assembled and damaged. All system problems were corrected at that visit.

Mali reported "no support to the operator." The Mali system experienced a number of problems, and there was a great deal of correspondence and several telephone calls to resolve the problem. Therefore, it is difficult to under stand the meaning of their reply to this question.

21.7 Other:

Ten respondents (12 sites) did not reply, and the other five had various comments which generally reiterated earlier comments.

22.0 Has anyone on your staff conducted any life-cycle cost compa isons of PV-powered vaccine R/F systems and alternative vaccine storage methods (Yes, No)? If "Yes", what were the other storage methods and what were your conclusions?

Question 22 was only included in the questionnaire sent to Solavolt Inter national system users. All responded that no one had conducted such analyses, and it is reasonable to assume that neither has anyone associated with the Solar Power Corp. systems.

Properly done, comparative (PV-powered versus kerosene-fueled R/F) life-cycle costing is a very site-specific calculation because, to be accurate, it

must include all site-specific variables; for example, cost of delivered kerosene, reliability of kerosene supply, maintenance costs, and cost of vaccines lost because of lack of fuel or lack of proper maintenance of kerosene refrigerators. A recent cost comparison of kerosene-fueled and PV-powered refrigerators shows the direct cost per dose to be lower for PV-powered systems costing as much as $3424 than for kerosene. Clearly the economic bias against PV-powered refrigerators stems from lack of proper analyses and/or information.

Since the ultimate measure of system reliability is the ratio of successfully administered vaccine doses to the number of doses delivered to a site, it would behoove ministers of health and donor agencies to review their positions on PV-powered vaccine R/F systems in that regard. Since the true cost of administered vaccines includes all of the overhead associated with delivering a successful inoculation, it would similarly behoove ministers of health and donor agencies to compare the total EPI cost per successfully delivered dose of vaccine over the lifetime of a PV-powered system with that for a kerosene-fueled R/F.

An important fact that is probably overlooked by ministries of heath and donor agency planners is that PV-powered systems have a high capital cost and almost no operation and maintenance costs, whereas kerosene-fueled R/F's have low capital cost and high operation and maintenance costs, and problems with fuel supply and quality, spare-parts availability, and the carrying out of the maintenance function.

SUMMARY OF RESULTS

Questionnaires probing user acceptance of photovoltaic-powered vaccine storage refrigerators were sent to the administrative agencies overseeing field tests of the NASA Lewis photovoltaic-powered vaccine refrigerator systems. Questionnaires were sent for each of the 29 systems. Replies were received from 17 countries representing 20 systems.

Responses indicate that almost all sites were routinely storing vaccines in the refrigerators, that most sites had outreach immunization programs, and that populations served from each site ranged from 2000 to 200 000 people. Most sites reported that immunizations had increased since systems installations and that the local communities are now requesting additional health services.

User and technician training was cited by many respondents as an aspect requiring further attention. Also, there was an expressed need for better manuals.

Although most respondents rated system reliability for vaccine storage and ice making as very good, there was still apprehension about refrigerator (not photovoltaic system) reliability. In regard to refrigerator and freezer compartment volumes, most respondents indicated that the freezer sections are too small.

A series of questions aimed at identifying market size and/or marketing barriers revealed that (1) market potential varies widely by country, ranging from 25 to 3500 systems, (2) respondents were about evenly divided on endorsing

the purchase of photovoltaic-powered vaccine refrigerator systems but with a majority declining to actually purchase systems, and (3) cost is the major barrier, with an acceptable cost being about $1500 (U.S.) per system. There was no indication that any respondent had done life-cycle cost comparisons of photovoltaic-powered and kerosene-fueled refrigerators.

Most respondents indicated that there would be an increased interest in purchasing these systems if there were better provisions for user and technician training and better in-country spare parts availability. And finally, there was a strong expression of need for additional electrical services at rural health centers and an indication that the provision of those services (mostly lighting) would increase system attractiveness, even at an increase in system cost.

In conclusion, the responses indicate that the systems had a positive impact on the local communities, made a positive impression on local health authorities and would find a ready market if procuring authorities better understood the life-cycle costs of photovoltaic-powered and kerosene-fueled vaccine refrigerators.

APPENDIX A - PHOTOVOLTAIC-POWERED VACCINE REFRIGERATOR/FREEZER USER EVALUATION QUESTIONNAIRE

1. Have you had an opportunity to follow the progress of the photovoltaic (PV)-powered refrigerator/freezer (R/F) system field test at Pucara, Peru?
   Yes ___ No ___

   Approximately how many times did you or your staff visit the site since the system was installed? _____

2. Have National level representatives from the MOH Immunization Program followed the field test?

   Yes ___ No ___ If no, why not? _____

3. Does the MOH have an established program for vaccine preservation in rural (electricityless) areas? Yes ___ No ___

   If yes, please describe the program, type of equipment used for vaccine storage and approximate annual cost per site: _____

4. Have vaccines been routinely stored in the PV-powered R/F? Yes ___ No ___

   If no, why not? _____

   If yes,

   4.1 Approximately what percentage of the time? _____

   4.2 Approximately how often are vaccines delivered to Pucara?

   _____

4.3 Please indicate, by type of vaccine, approximately how many vaccinations are administered per week at Pucara.

		Vaccinations/Week
4.3.1	DPT	_____
4.3.2	Polio	_____
4.3.3	Measles	_____
4.3.4	BCG	_____
4.3.5	TT	_____
4.3.6	MR	_____
4.3.7	Others (please list)	
	_____	_____

5. Does Pucara have an outreach program? Yes ___ No ___

If yes,

5.1 Approximately how large an area is administered? _____

5.2 Approximately how large a population is administered? _____

5.3 Approximately how many cold packs are frozen each week? _____

6. Has the PV-powered R/F system at Pucara allowed immunization services to be offered on a routine basis? Yes ___ No ___

6.1 If yes, has immunization coverage increased? _____

6.2 If no, please explain why immunization has not been offered on a routine basis: _____

As a consequence of offering immunization services routinely, has the community consulted on or demanded other health services?

6.3 Yes ___ Please explain _____

6.4 No ___ Please explain _____

7. How did the local community receive (or perceive) the installation and/or use of the system?

7.1 Accepted without comment or problems ___

7.2 Problems(s) Accepting ___ Please explain _____

7.3 Do not know ___

8. Please indicate what you view as the system's strong or weak points?

	STRONG	WEAK	Please Explain
8.1 Photovoltaic power system:			
8.1.1 PV modules structure and cabling	___	___	_____
8.1.2 PV system controls	___	___	_____
8.1.3 Batteries	___	___	_____
8.1.4 PV system instrumentation	___	___	_____
8.1.5 Thermograph	___	___	_____

	STRONG	WEAK	Please Explain
8.2 Refrigerator/Freezer:			
8.2.1 Design	___	___	_____
8.2.2 Size	___	___	(Too Small ___) (Too Large ___)
8.2.3 Frost/ice removal	___	___	_____

8.3 Ability to store non-EPI medications and/or vaccines (e.g., rabies and veterinary vaccines): ___ ___ _____

8.4 System cost:
Please explain any other strong or weak points you may have observed. _____

8.5 What would you do to improve the system? _____

9. How do you view MOH's reaction to PV-powered vaccine R/F systems? Are problems real or perceived? _____

10. Are the people who were trained in R/F system operation and use by the installation team still at the health post? Yes ___ No ___

If not, were the replacements trained in R/F operation and use?
Yes ___ No ___

If yes, who trained them? _____

If no, why were they not trained? _____

1. Please summarize operating problems with the system under the following categories:

11.1 Instrumentation problems which did not affect system operation.

_____

11.2 Equipment problems which did affect system operation. _____

_____

11.3 Operator practices which affected system operation. _____

_____

11.4 Other, or combinations of above. _____

12. Please list system problems which the following personnel corrected:

12.1 Operator personnel _____

12.2 MOH personnel _____

12.3 Other, or combinations of above _____

13. How is system reliability viewed by you in regard to:

13.1 Vaccine storage: Very Good ___ Good ___ Fair ___ Poor ___

13.2 Ice making: Very Good ___ Good ___ Fair ___ Poor ___

14. How many health posts in Peru are without electricity? _____

14.1 How many of these health posts could use PV-powered R/F systems?

_____

15. Does the MOH have funds to procure PV-powered vaccine R/F systems?

Yes ___ No ___

If yes, how much? _____

16. Would you endorse the procurement of and/or order additional systems?
Endorse: Yes ___ No ___ Order: Yes ___ No ___
If yes, how many? _____
Over what period of time? _____
If no, why not? _____
If no because of cost (present systems cost about $5000 each) at what cost would additional procurement be considered? _____

17. Would the MOH order additional systems? Yes ___ No ___

If yes, how many? _____

Over what period of time? _____

If no, why not? _____

_____

If no because of cost (assuming systems cost $5000 each), at what cost would procurements be considered? _____

18. Would you or the MOH be more receptive to ordering these systems if a manufacturer would train a technical cadre and/or provide a central store of spares in the country?

Training: Yes ___ No ___

Maintain spares: Yes ___ No ___

If yes, what spares do you believe should be stocked? _____

19. Are there needs for additional electrical services at rural health posts?
Yes ___ No ___

		Yes	No
If yes, what type?	Area lighting	___	___
	Exam lights	___	___
	Sterilizer	___	___
	2-way radio	___	___
	Other	_____	

If no, why not? _____

20. Would the inclusion of additional electrical services with the PV-powered vaccine R/F system make the systems more attractive even though these services would increase system cost? Yes ___ No ___

21. What comments do you and/or the MOH have regarding:

21.1 How the field test project was managed: _____

21.2 System performance: _____

21.3 System design: _____

21.4 User training: _____

21.5 System manuals: _____

21.6 Operational support: _____

21.7 Other: _____

APPENDIX B - QUESTIONNAIRE RESPONSES

India, Indonesia, and Maldive Islands

Questions 1.0 to 5.1	India Bhoorboral	Indonesia Cibungbulong	Indonesia Batujaya	Maldive Islands Kuluduffushi
1.0 Have you had an opportunity to follow the progress of the photovoltaic (PV)-powered refrigerator/freezer?	YES	YES	YES	YES
Approximately how many times did you or your staff visit the site since the system was installed?	6	7	7	5
2.0 Have National level representatives from the MOH Immunization Program followed the field test?	YES	YES	YES	NO, difficult transport and communications; the refrigerator had leakage of refrigerant since beginning and arrangements for repairs by manufacturer were delayed
3.0 Does the MOH have an established program for vaccine preservation in rural (electricityless) areas?	NO	YES	YES	YES
If yes, please describe the program, type of equipment used for vaccine storage and annual cost per site:	N/A	They use a variety of kerosene refrigerators; electricity is becoming more available at health centers	They use a variety of kerosene refrigerators; electricity is becoming more available at health centers	Kerosene refrigerators and also cold boxes replenished with ice; cost estimates not available
4.0 Have vaccines been routinely stored in the PV-powered R/F?	YES	NO	YES	NO
If no, why not?	N/A	Vaccines were stored there until one year ago; since then, no vaccines have been stored there	N/A	R/F did not function well since beginning
If yes,				
4.1 Approximately what percent of the time?	90 percent	N/R	100 percent	N/A
4.2 Approximately how often are vaccines delivered?	Monthly	Once each month	Once each month	Not known
4.3 Please indicate, by type of vaccine, approximately how many vaccinations are administered per week:				
4.3.1 DPT	N/R	50	50	Information not known
4.3.2 Polio		50	50	
4.3.3 Measles		20	20	
4.3.4 BCG		50	50	
4.3.5 TT		20	20	
4.3.6 MR		N/R	N/R	
4.3.7 Others		N/R	N/R	
5.0 Does your site have an outreach program?	N/R	YES	YES	NO
If yes,				
5.1 Approximately how large an area is administered?	N/R	10 km^2	10 km^2	N/A

Questions 5.2 to 8.1.4	India Bhoorboral	Indonesia Cibungbulong	Indonesia Batujaya	Maldive Islands Kuluduffushi
5.2 Approximately how large a population is administered?	100 000	40 000	40 000	N/A
5.3 Approximately how many cold packs are frozen each week?	N/R	5	5	N/A
6.0 Has the PV-powered R/F system allowed immunization services to be offered on a routine basis?	YES	YES, until one year ago	YES	NO
6.1 If yes, has immunizatization coverage increased?	YES	YES, because polio and measles vaccines were introduced	YES, because they were allowed to provide measles vaccines with the solar refrigerator	N/R
6.2 If no, please explain why immunization has not been offered on a routine basis:	N/A	N/A	N/A	Lack of storage facilities due to breakdown of PV unit
As a consequence of offering immunization services routinely, has the community consulted on or demanded other health services?				
6.3 Yes, please explain	Not Known	N/A	N/A	Not known
6.4 No, please explain	N/A	NO, demands are only made through a complex village organization; we have not heard of any such demand	NO, a complex village system exists where residents can assist in development and opportunities for receiving health services; any demands come through this system; we have heard of none	N/A
7.0 How did the local community receive (or perceive) the installation and/or use of the system?				
7.1 Accepted without comment or problems	YES	YES	YES	YES
7.2 Problem(s) accepting, please explain	N/A	N/A	N/A	N/A
7.3 Do not know	N/A	N/A	N/A	N/A
8.0 Please indicate what you view as the system's strong or weak points; STRONG/WEAK, please explain				
8.1 Photovoltaic power system:				
8.1.1 PV modules structure and cabling	STRONG	STRONG	STRONG	STRONG
8.1.2 PV system controls	STRONG	WEAK, many breakdowns; frustrating to maintain and repair	WEAK, many breakdowns; frustrating to maintain and repair	STRONG
8.1.3 Batteries	STRONG, battery life of 3 years not long enough	WEAK, batteries were checked after 1 year and were weak	WEAK batteries after 1 year	WEAK, after 1 year all batteries were checked with voltmeter and were weak
8.1.4 PV system instrumentation	WEAK, problems with ampere meter and temperature controller	WEAK, many breakdowns	WEAK, many, many breakdowns	WEAK, ampere hour meters and warning system uses separate batteries, which may need frequent changes and are not easily available

Questions 8.1.5 to 11.1	India Bhourboral	Indonesia Cibungbulong	Indonesia Batujaya	Maldive Islands Kuluduffushi
8.1.5 Thermograph	STRONG	WEAK, often malfunctioned and difficult for health staff to understand	WEAK, often malfunctioned and difficult for health staff to understand	STRONG
8.2 Refrigerator/freezer:				
8.2.1 Design	STRONG	STRONG	STRONG	STRONG
8.2.2 Size, too small or too large	STRONG	STRONG, too large	STRONG, too large	STRONG
8.2.3 Frost/ice removal	STRONG	WEAK	WEAK	STRONG
8.3 Ability to store non-EPI medications and/or vaccines (e.g., rabies and veterinary vaccines):	STRONG	STRONG, was not used for this purpose	STRONG, was not used for this purpose	STRONG
8.4 System cost: Please explain any other strong or weak points you may have observed	1) Very high system cost, 2) Very high replacement battery cost	N/R	N/R	1) Overall system is expensive, 2) batteries replacement cost is high, 3) temperature control device on thermostatic bimetal control principle is good, but its reliability and durability is questionable
8.5 What would you do to improve the system?	Use of cheap, long life batteries	Should be smaller, cheaper and with few instruments; there should be an easier program for maintenance	Should be smaller, cheaper and with few instruments; there should be an easier program for maintenance	1) Cheaper and longer life batteries should be employed, 2) instrumentation should be simple and should not employ other types of batteries
9.0 How do you view MOH's reaction to PV-powered vaccine R/F systems? Are problems real or perceived?	Real problems; 1) high cost of the system, 2) high cost of battery replacement	Real problems; appraisal of solar units realistic	Problems are very real and appraisal of solar units realistic	Not good due to inoperation of equipment
10.0 Are the people who were trained in R/F system operation and use by the installation team still at the health post?	YES	NO	NO	NO
If not, were the replacements trained in R/F operation and use?	N/A	NO	NO	YES
If yes, who trained them?	Manufacturer/ manuals	N/A	N/A	National EPI staff
If no, why were they not trained?	N/A	Trial period has ended	Trial period has ended	N/A
11.0 Please summarize operating problems with the system under the following categories:				
11.1 Instrumentation problems which did not affect system operation	1) Ampere hour meters defective, 2) separate batteries for AH-meters and controllers get discharged very soon	Difficult to understand for local health staff; frequently broken; difficult to maintain and repair	Difficult to understand for local health staff; frequently broken; difficult to maintain and repair	Energy meters defective

Questions 11.2 to 16.3	India Bhoorboral	Indonesia Cibungbulong	Indonesia Batujaya	Maldive Islands Kuluduffushi
11.2 Equipment problems which did affect system operation	1) Erratic operation of temperature controller due to low voltage; 2) frequent clearing of panels in summer months	N/R	N/R	Refrigerant leakage
11.3 Operator practices which affected system operation	N/R	Lacked spare parts, tools and background (skills) necessary to maintain and operate	Lacked spare parts, tools and background (skill) necessary to maintain and operate	N/R
11.4 Other, or combinations of above	N/R	N/R	N/R	N/R
12.0 Please list system problems which the following personnel corrected:				
12.1 Operator personnel	N/R	None	None	N/R
12.2 MOH personnel	N/R	Changed fuses, tested batteries	Changed fuses, tested batteries	N/R
12.3 Mission personnel	None	None	None	N/R
12.4 Other, or combinations of above	N/R	P.T. Jeunesse, (private company) repaired instruments	P.T. Jeunesse, (private company) repaired instruments	N/R
13.0 How is system reliability viewed by you in regard to:				
13.1 Vaccine storage				
MOH	N/R	Very Good	Very Good	N/R
AID or WHO	Good	Very Good	Very Good	Good
13.2 Icemaking				
MOH	N/R	Very good	Very good	N/R
AID or WHO	Fair	Very good	Very good	Good
14.0 How many health posts in your country are without electricity?	More than 1000	4000	4000	Not available
14.1 How many of these health posts could use PV-powered R/F systems?	Most	3500	3500	All, if cost of units come down
15.0 Do you (AID or WHO) and/or the MOH have funds to procure PV-powered vaccine R/F systems?				
AID or WHO	N/R	NO	NO	N/R
MOH	NO	NO	NO	NO
16.0 Would you endorse the procurement of and/or order additional systems?				
Endorse	NO	NO	NO	NO
Order	N/R	NO	NO	N/R
16.1 If yes, how many?	N/R	N/A	N/A	N/R
16.2 Over what period of time?	N/R	N/A	N/A	N/R
16.3 If no, why not?	High cost	Too many problems in operation and too expensive	Too many problems in operation and too expensive	1) Too expensive, 2) battery replacement cost is high, 3) reliability is yet to be proved

Questions 16.4 to 21.1	India Bhoorboral	Indonesia Cibungbulong	Indonesia Batujaya	Maldive Islands Kuluduffushi
16.4 If no because of cost (present systems cost about $5000 each) at what cost would additional procurement be considered?	$1500	Unknown	Unknown	$1500
17.0 Would the MOH order additional systems?	NO	NO	NO	NO
If yes, how many?	N/A	N/A	N/A	N/A
Over what period of time?	N/A	N/A	N/A	N/A
If no, why not?	High cost	Too many problems in operation and too expensive	Too many problems in operation and too expensive	Costly and unreliable
If no because of cost (assuming systems cost $5000 each), at what cost would procurements be considered?	$1500	Unknown	Unknown	$1500
18.0 Would you or the MOH be more receptive to ordering these systems if a manufacturer would train a technical cadre and/or provide a central store of spares in the country?				
Training	YES	YES	YES	YES
Maintain spares	YES	YES	YES	YES
If yes, what spares do you believe should be stocked?	N/R	All parts for wiring, batteries, instruments and control system (regulator, diodes, etc.)	All parts for wiring, batteries, instruments and control system regulator, diodes, etc.)	N/R
19.0 Are there needs for additional electrical services at rural heal h posts?	YES	YES	YES	YES
If yes, what type?				
Area lighting	YES	YES	YES	YES
Exam lights	NO	YES	YES	NO
Sterilizer	YES	YES	YES	YES
Two-way radio	NO	N/R	N/R	YES
Other	N/R	N/R	N/R	N/R
If no, why not?	N/A	N/A	N/A	N/A
20.0 Would the inclusion of additional electrical services with the PV-powered vaccine R/F system make the systems more attractive even though these services would increase system cost?	YES	YES	YES	YES
21.0 What comments do you and/or the MOH have regarding				
21.1 How the field test project was managed:	GOOD	Rather poorly; communication was inadequate; Solar Power authorized a private company to store spare parts and make repairs and their performance was less than satisfactory	Same comments as for Cibungbulong	Not well enough

Questions 21.2 to 21.7	India Bhoorboral	Indonesia Cibungbulong	Indonesia Batujaya	Maldive Islands Kuluduffushi
21.2 System performance:	GOOD	Generally good, except for instrumentation	Generally good, except for instrumentation	POOR
21.3 System design:	GOOD, but expensive	VERY GOOD	VERY GOOD	GOOD, but expensive
21.4 User training:	GOOD	Initial training insufficient; no materials really designed for comprehension of workers at village level in Indonesia	Same comments as for Cibungbulong	FAIR
21.5 System manuals:	Need improvements	For technical expert at MOH, the manuals were sufficient; for others these manuals were not clear	Same comments as for Cibungbulong	Needs improvement
21.6 Operational support:	Spares like special batteries not easily available locally	Very poor support; communication inadequate between Indonesia and NASA; No spare parts in MOH; all repair work implemented through private company that was only semicooperative	Same comments as for Cibungbulong	FAIR
21.7 Other:	N/R	N/R	N/R	N/R

Dominican Republic, Haiti, Guyana, and Guatemala

Questions 1.0 to 4.2	Dominican Republic Las Tablas	Haiti Anse-A-Veau	Guyana Schepmoed	Guatemala Tierra Blanca
1.0 Have you had an opportunity to follow the progress of the photovoltaic (PV)-powered refrigerator/freezer?	YES	YES	YES	YES
Approximately how many times did you or your staff visit the site since the system was installed?	10	3 times a year	10	Once a month
2.0 Have National level representatives from the MOH Immunization Program followed the field test?	YES	YES	YES	NO, because it was considered an independent project of MOH Immunization Program
3.0 Does the MOH have an established program for vaccine preservation in rural (electricityless) areas?	YES	YES	NO	YES
If yes, please describe the program, type of equipment used for vaccine storage and annual cost per site:	There are some gas refrigerators, but maintenance and spare parts have been a major problem; cost estimates are not available, except for the refrigerator (U.S. $270 - 6 years ago); major immunization programs are carried out on a national campaign basis using vaccine carriers and vaccines brought in from refrigerated sources before each campaign	Planification for complete immunization of 100 of children under one year old in the area of the health center; we use refrigerator Electrolux RCW42Eg, gas, butane and electricity; cost per site is $52 per year	N/A	MOH uses kerosene powered refrigerators in electricityless areas as part of its national cold chain system; MOH develops two vaccination campaigns a year at national level; the operation cost per kerosene powered refrigerator is approximately $150
4.0 Have vaccines been routinely stored in the PV-powered R/F?	YES	YES	NO	YES
If no, why not?	N/A	N/A	For the first 16 months of the field test, the R/F did not function satisfactorily; it has only been within the last 6 months that effective service from the R/F has encouraged storage of vaccines	N/A
If yes,				
4.1 Approximately what percentage of the time?	80 percent	Full time	N/R	N/R
4.2 Approximately how often are vaccines delivered?	Monthly	Every month	N/R	Every 3 months

Questions 4.3 to 6.4	Dominican Republic Las Tablas	Haiti Anse-A-Veau	Guyana Schepmoed	Guatemala Tierra Blanca
4.3 Please indicate, by type of vaccine, approximately how many vaccinations are administered per week?				
4.3.1 DPT	N/R	7	25	34
4.3.2 Polio	N/R	6	25	34
4.3.3 Measles	N/R	0	N/R	13
4.3.4 BCG	N/R	3	25	10
4.3.5 TT	12	6	25	5
4.3.6 MR	N/R	N/R	N/R	N/R
4.3.7 Others	N/R	N/R	N/A	N/R
5.0 Does your site have an outreach program?	YES	NO	YES	YES
5.1 If yes, approximately how large an area is administered?	15 km^2	N/A	80 miles up the Berbice River, 35 miles up Canje River, 12 miles of the East Bank Community	12 km^2
5.2 Approximately how large a population is administered?	2112	N/A	3000	3267 inhabitants
5.3 Approximately how many cold packs are frozen each week?	1 pack of 12 doses	4	N/R	10
6.0 Has the PV-powered R/F system allowed immunization services to to be offered on a routine basis?	YES	YES	YES	YES
6.1 If yes, has immunization coverage increased?	YES	YES, but just a little this year (1984)	YES, previously the infrequent visit of a public health nurse from the Central Hosp. was the only immunization service	YES, it has increased considerably
6.2 If no, please explain why immunization has not been offered on a routine basis: As a consequence of offering immunization services routinely, has the community consulted on or demanded other health services?	N/A	Problem of locomotion, problem of motivation of medical personnel, problem of informing the community	N/A	N/A
6.3 Yes, please explain	There has been a two way demand: mothers of children coming in for immunizations may have requested other health services or may have come in for routine health services and requested immunization; the community is pleased with the service offered by the clinic	People will be informed about other possibilities of the health center; through immunization services there will be better contact with population and better psychological accessibility	N/A	All the primary health care services
6.4 No, please explain	N/A	N/A	The community has had "medical presence" in the form of a dispenser, commonly referred to as "Doc," whom they always looked to for all kinds of medical care	N/A

Questions 7.0 to 8.2.3	Dominican Republic Las Tablas	Haiti Anse-A-Veau	Guyana Schepmoed	Guatemala Tierra Blanca
7.0 How did the local community receive (or perceive) the installation and/or use of the system?				
7.1 Accepted without comment or problems	YES, local officials very enthused	N/R	Comments and queries were made about its functioning; the community seemed anxious that immunization services be available on routine basis	YES
7.2 Problem(s) accepting, please explain	N/A	N/A	None	N/A
7.3 Do not know	N/A	YES	N/A	N/A
8.0 Please indicate what you view as the system's strong or weak points; STRONG/WEAK, please explain				
8.1 Photovoltaic power system:				
8.1.1 PV modules structure and cabling	STRONG	STRONG	STRONG, no problems experienced	STRONG, good functioning
8.1.2 PV system controls	STRONG	N/R	STRONG	WEAK, only 3 failed: freezer temperature, ambient temperature, insolation temperature
8.1.3 Batteries	STRONG	STRONG, all night long and during rainy season there is always enough charge to keep the vaccines cool	STRONG, maintenance free except for cleaning of battery lugs; very useful when user is off site for long periods	STRONG
8.1.4 PV system instrumentation	WEAK	STRONG, it still functions	WEAK, currently out of operation, reason(s) unknown	STRONG
8.1.5 Thermograph	STRONG	STRONG, 3 months after delivery the thermograph failed	STRONG, no problems other than that the blue (refrigerator) indicator worn out	WEAK, ambient temperature, freezer temperature
8.2 Refrigerator/freezer:				
8.2.1 Design	STRONG	STRONG, without good maintenance it is still in good condition	STRONG, the sizes of the internal compartments are adequate and need to have the six batteries is understood, but the overall size of the R/F in addition to the panels may be prohibitively large to transport to remote locations	STRONG, it is good
8.2.2 Size, too small or too large	STRONG	STRONG, too small; too large for a health center and too small for regional or district storage	WEAK, too large	STRONG, adequate
8.2.3 Frost/ice removal	STRONG	We did not ask for information	STRONG, no problems	STRONG, normal

Questions 8.3 to 11.3	Dominican Republic Las Tablas	Haiti Anse-A-Veau	Guyana Schepmoed	Guatemala Tierra Blanca
8.3 Ability to store non-EPI medications and/or vaccines (e.g., rabies and veterinary vaccines):	STRONG	STRONG, it is a question of better use	No opinion, not tested	STRONG, its capacity is good
8.4 System cost: Please explain any other strong or weak points you may have observed	It is too expensive for the Dominican Republic	The black rubber under the glass cover seems not so hard and so strong for tropical countries	None	Definitely its cost is so expensive
8.5 What would you do to improve the system?	N/R	Should establish easy rules for good maintenance	Attempt to make it more easily transportable	Reduce its complexity and cost
9.0 How do you view MOH's reaction to PV-powered vaccine R/F systems? Are the problems real or perceived?	Mission views the PV system as very positive effort; there are areas within the country where a much larger system could be used	N/R	MOH reaction has been very positive to use of PV technology, MOH sees future of health development in relatively inaccessible areas arising from application of photovoltaics; mission is, of course, pleased at this reaction	Its reaction is enthusiastic, but sorry about the high cost; the problems are real
10.0 Are the people who were trained in R/F system operation and use by the installation team still at the health post?	NO	NO	NO	YES
If not, were the replacements trained in R/F operation and use?	YES	NO	NO	N/A
If yes, who trained them?	Regional Engineer of the MOH	N/A	N/A	N/A
If no, why were they not trained?	N/A	Problem of retribution	No overlap between personnel due to abrupt departures by incumbents; mission and other local personnel could only give guidance from limited knowledge	N/A
11.0 Please summarize operating problems with the system under the following categories:				
11.1 Instrumentation problems which did not affect the system operation	The alarm system is very sensitive to changes in temperature	N/R	Currently non-functioning panel (meter) showing array and load ampere-hours	There were problems with the ambient temperature, freezer temperature and refrigerator temperature meters
11.2 Equipment problems which did affect system operation	None	N/R	Problems between alarm, compressor and thermostat for about a year kept the R/F out of effective use	None
11.3 Operator practices which affected system operation	None	N/R	It is possible that operators have been guilty in the past of opening the R/F too frequently, thus retarding the cooling down process	None

Questions 11.4 to 16.2	Dominican Republic Las Tablas	Haiti Anse-A-Veau	Guyana Schepmoed	Guatemala Tierra Blanca
11.4 Other, or combinations of above	N/R	N/R	None	None
12.0 Please list system problems which the following personnel corrected:				
12.1 Operator personnel	N/R	N/R	None	None
12.2 MOH personnel	Regional Engineer	N/R	None	None
12.3 Mission personnel	N/R	N/R	None	None
12.4 Other, or combinations of above	N/R	N/R	In March 1983, the Solar Power engineer returned to sort out malfunction in R/F; the regulator was diagnosed as faulty and was changed; two local engineers trained in PV installation at the Waramari site assisted mission in identifying the alarm, thermostat, compressor problems and correcting (?)it	The clock mechanism on the refrigerator thermograph was repaired by "La Perla", a private jeweler's shop located in Guatemala City
13.0 How is system reliability viewed by you in regard to				
13.1 Vaccine storage				
MOH	Very Good	Very Good	Very Good	Very Good
AID or WHO	Very Good	N/R	Very Good	Very Good
13.2 Icemaking				
MOH	Very Good	Very good	Very Good	Very Good
AID or WHO	Very Good	N/R	Very Good	Very Good
14.0 How many health posts in your country are without electricity?	Unknown; while many facilities have electricity, power is available only a few hours a day	Full time: 155	Approx. 60 to 80	240
14.1 How many of these health posts could use PV-powered R/F systems?	Not available	10	All	211
15.0 Do you (AID or WHO) and/or the MOH have funds to procure PV-powered R/F systems?				
AID or WHO	NO	N/R	NO	NO
MOH	NO(unknown)	NO	NO	NO, but maybe yes if it is possible to obtain a better price
16.0 Would you endorse the procurement of and/or order additional systems?				
Endorse	Needs further	YES	YES	NO
Order	analysis	N/A	YES (if project funding available)	NO
16.1 If yes, how many?	Needs further analysis	10	Up to 30, probably more	N/A
16.2 Over what period of time?	Needs further analysis	As soon as possible	1 year	N/A

Questions 16.3 to 20.0	Dominican Republic Las Tablas	Haiti Anse-A-Veau	Guyana Schepmoed	Guatemala Tierra Blanca
16.3 If no, why not?	Country is undergoing very serious economic problems, including devaluation of its currency	It is a question of funds	N/A	The current fiscal budget does not include funds for this purpose. MOH is using kerosene powered refrigerators which cost between $600 to $1200
16.4 If no because of cost (present systems cost about $500 each) at what cost would additional procurement be considered?	Does not know	N/R	N/A	No more than $1200 per unit
17.0 Would the MOH order additional systems?	N/R	NO	YES and NO both. Yes if foreign exhange were available	Maybe
If yes, how many?	N/R	N/A	For all electricity-deficient health centers	N/R
Over what period of time?	N/R	N/A	3 to 5 years	N/R
If no, why not?	N/R	It is a question of funds	Lack of foreign exchange	N/R
If no because of cost, (assuming systems cost $5000 each), at what cost would procurements be considered?	N/R	$1000, if possible	N/R	No more than $1200 per unit
18.0 Would you or the MOH be more receptive to ordering these systems if a manufacturer would train a technical cadre and/or provide a central store of spares in the country?				
Training	N/R	YES	YES	YES
Maintain spares	N/R	YES	YES	YES
If yes, what spares do you believe should be stocked?	N/R	Battery, glass cover, rubber band-seal, electric cable, glass thermometer	Owing to our limited experience, we cannot detail this	Photovoltaic cells, controls, instruments and other parts specially designed for this system
19.0 Are there needs for additional electrical services at rural health posts?	YES	N/R	YES	YES
If yes, what type?				
Area lighting	YES	NO	YES	YES
Exam lights	YES	YES	YES	YES
Sterilizer	YES	YES	YES	YES
Two-way radio	NO	NO	YES	N/R
Other	N/R	N/R	Water pump	N/R
If no, why not?	N/A	N/R	N/A	N/A
20.0 Would the inclusion of additional electrical services with the PV-powered vaccine R/F system make the systems more attractive even though these services sould increase system cost?	YES	YES	YES	NO

Questions 21.0 to 21.7	Dominican Republic Las Tablas	Haiti Anse-A-Veau	Guyana Schepmoed	Guatemala Tierra Blanca
21.0 What comments do you and/or the MOH have regarding				
21.1 How the field test project was managed:	The information was not collected in a very scientific way; there was constant change in local officials involved with the project	BAD (Comment is directed at Dept. of Public Health and Population regarding definition of health worker responsibilities all of which contributed to lack of data)	In view of mission's lack of technical expertise in this area, a greater "presence" in the country in the form of visits by the technical experts perhaps on a six or nine month basis should have been scheduled; we are disappointed that no one was dispatched to examine/repair the R/F despite its malfunctioning for a year after the Solar Power engineer's visit	GOOD, however could be better if MOH Epidemiology Division managed the project
21.2 System performance:	VERY GOOD	EXCELLENT	Seemingly OK; we have no information that the system did not perform well; the problems all appeared to be with the R/F unit	GOOD
21.3 System design:	VERY GOOD	GOOD	GOOD	GOOD
21.4 User training:	The first doctor that was trained left Tablas and the next one did not have too much knowledge of the system; the auxiliary nurse does not have high level education and does not see the necessity of collecting information in a scientific manner	GOOD	Presumed OK; the user trained at site left 1 year later; unable to evaluate since R/F was inoperational for most of that period	GOOD
21.5 System manuals:	VERY GOOD	No Comment	Need technical interpretation; "Laymen" in Guyana are afraid of touching electrical apparatus	GOOD, but preferable in Spanish
21.6 Operational support:	Any time help is needed, NASA sent a person to solve the problem	BAD, see comment to reply to question 21.1	N/R	GOOD
21.7 Other:	N/R	No Comment	N/R	Suggest local procurement and manufacture of some parts to reduce cost

Gambia and Ivory Coast

Questions 1.0 to 5.0	Gambia Gunjur	Gambia Kaur	Ivory Coast Zaranou	Ivory Coast Niofouin
1.0 Have you had an opportunity to follow the progress of the photovoltaic (PV)-powered refrigerator/freezer?	YES	YES	NO	NO
1.1 Approximately how many times did you or your staff visit the site since the system was installed?	4	None	Once	None
2.0 Have National level representatives from the MOH Immunization Program followed the field test?	YES	YES	YES	YES
3.0 Does the MOH have an established program for vaccine preservation in rural (electricityless) areas?	YES	YES	YES	YES
3.1 If yes, please describe the program, type of equipment used for vaccine storage and annual cost per site:	Kerosene refrigerators are used; approximate annual cost per site is $1050	Kerosene refrigerators are used; approximate annual cost per site is $1050	Each health sector has a refrigerator-freezer, plus portable vaccine carriers; these are generally kerosene refrigerators, except on louba, where they are gas; each has a budget; figures available at the central level	Same comments as for Zaranou
4.0 Have vaccines been routinely stored in the PV-powered R/F?	YES	YES	YES	YES
If no, why not?	N/A	N/A	N/A	But the R/F has been nonfunctional for some time
If yes,				
4.1. Approximately what percentage of the time?	100 percent	100 percent	100 percent	100 percent while functioning
4.2. Approximately how often are vaccines delivered?	Monthly	Monthly	Weekly	Monthly
4.3 Please indicate, by type of vaccine, approximately how many vaccinations are administered per week				
4.3.1 DPT	460	280	55	45
4.3.2 Polio	324	234	55	45
4.3.3 Measles	71	60	40	30
4.3.4 BCG	84	111	7	3
4.3.5 TT	54	35	13	5
4.3.6 MR	N/R	N/R	N/R	N/R
4.3.7 Others (Yellow Fever)	75	58	N/R	N/R
5.0 Does your site have an outreach program?	YES	YES	YES	NO

Questions 5.1 to 8.1.3	Gambia Gunjur	Gambia Kaur	Ivory Coast Zaranou	Ivory Coast Niofouin
If yes,				
5.1 Approximately how large an area is administered?	45 km^2	3.168 km^2	N/R	N/A
5.2 Approximately how large a population is administered?	17 191 (1982)	16 727	200 000	N/A
5.3 Approximately how many cold packs are frozen each week?	N/R	N/R	10	N/A
6.0 Has the PV-powered R/F system allowed immunization services to be offered on a routine basis?	YES	YES	YES	YES
6.1 If yes, has immunization coverage increased?	YES, on a national average, it has increased	YES, on a national average, it has increased	YES	YES
6.2 If no, please explain why immunization has not been offered on a routine basis	N/A	N/A	N/A	N/A
As a consequence of offering immunization services routinely, has the community consulted on or demanded other health services?				
6.3 Yes, please explain	YES, as part of the EPI/MOH integrated program	YES, as part of the EPI/MOH integrated program	This unit has brought new respect to the health authorities. People come to the center to see it	N/A
6.4 No, please explain	N/A	N/A	N/A	NO, the population is extremely pleased with the unit, but the information requested is understandable
7.0 How did the local community receive (or perceive) the installation and/or use of the system?				
7.1 Accepted without comment or problems	YES	YES	YES	YES, they declared a holiday and danced with joy
7.2 Problem(s) accepting, please explain	N/A	N/A	N/A	N/A
7.3 Do not know	N/A	N/A	N/A	N/A
8.0 Please indicate what you view as the system's strong or weak points; STRONG/WEAK, please explain				
8.1 Photovoltaic power system:				
8.1.1 PV modules structure and cabling	STRONG	STRONG	STRONG, no problems	STRONG, no problems
8.1.2 PV system controls	STRONG	STRONG	STRONG	STRONG
8.1.3 Batteries	STRONG	WEAK, leaking and lowly charged 12 V batteries	STRONG	STRONG

Questions 8.1.4 to 11.1	Gambia Gunjur	Gambia Kaur	Ivory Coast Zaranou	Ivory Coast Niofouin
8.1.4 PV system instrumentation:	WEAK, support structure alignment is heavy, not handy	WEAK, support structure alignment is heavy, not handy	Not clear what this means	Not clear what this means
8.1.5 Thermograph	STRONG	STRONG	STRONG	STRONG
8.2 Refrigerator/freezer:				
8.2.1 Design	STRONG	STRONG	STRONG	STRONG
8.2.2 Size, too small or too large	WEAK, too small, specifically the freezer	WEAK, too small, specifically the freezer	WEAK, too small	WEAK, too small
8.2.3 Frost/ice removal	N/R	STRONG	STRONG	STRONG
8.3 Ability to store non-EPI medications and/or vaccines (e.g., rabies and veterinary vaccines):	WEAK, there isn't enough storage room	WEAK, there isn't enough storage room in the unit	STRONG	STRONG
8.4 System cost: Please explain any other strong or weak points you may have observed	Very expensive	Very expensive	Seems OK; not enough training for local technicians, no spare parts and insufficient tools for local repair	Seems OK; not enough training for local technicians, no spare parts and insufficient tools for local repair
8.5 What would you do to improve the system?	Increase size of freezer, surport structures should be handy and batteries to be rechargeable (refers to instrument batteries)	Increase size of freezer, support structures should be handy and batteries to be rechargeable (refers to instrument batteries)	Assure indepth training of local personnel to allow minor repairs following the experimental phase	Assure indepth training of local personnel to allow minor repairs following experimental phase
9.0 How do you view MOH's reaction to PV-powered vaccine R/F systems. Are the problems real or perceived?	Highly welcomed the system; some of the problems are real as mentioned under Section 8	Highly welcomed the system; some of the problems are real as mentioned under Section 8	N/R	Problems are real
10.0 Are the people who were trained in R/F system operation and use by the installation team still at the health post?	YES	YES	YES	YES
If not, were the replacements trained in R/F operation and use?	YES	YES	N/A	N/A
If yes, who trained them?	The predecessor; the training was inadequate	The predecessor; the training was inadequate	NASA trained the person for 6 hr	NASA trained the person for 6 hr
If no, why were they not trained?	The person replaced did not have enough time to train his replacement	The person replaced did not have enough time to train his replacement	N/A	N/A
11.0 Please summarize operating problems with the system under the following categories:				
11.1 Instrumentation problems which did not affect the system operation	Support structure alignment and size of freezer	Support structure alignment and size of freezer	None	None

Questions 11.2 to 15.0	Gambia Gunjur	Gambia Kaur	Ivory Coast Zaranou	Ivory Coast Niefouin
11.2 Equipment problems which did affect system operation	N/R	Leaking batteries and their state of low charges	One solar panel broken	I am not sure; a consultant was sent to diagnose the problem; he did not repair the the unit, which is still non-functioning
11.3 Operator practices which affected system operation	Regular monitoring of temperature	N/R	N/R	It is felt that the current problem is due to operator error
11.4 Other, or combinations of above	N/R	N/R	N/R	N/R
12.0 Please list system problems which the following personnel corrected:				
12.1 Operator personnel	N/R	Continuous alarming (March 1983 and July, 1984)	N/R	Replaced burned out fuses
12.2 MOH personnel	N/R	N/R	N/R	None
12.3 Mission personnel	N/R	Charged the batteries by putting off the compressor (load current)and letting the array current charge batteries	N/R	N/R
12.4 Other, or combinations of above	N/R	N/R	N/R	N/R
13.0 How is system reliability viewed by you in regard to:				
13.1 Vaccine storage				
MOH	Good	Good	Very good	Very good
AID or WHO	N/R	N/R	N/R	N/R
13.2 Icemaking				
MOH	Good	Good	Very good	Very good
AID or WHO	N/R	N/R	N/R	N/R
14.0 How many health posts in your country are without electricity?	25	25	150	150
14.1 How many of these health posts could use PV-powered R/F systems?	25	25	50	50
15.0 Do you (AID or WHO) and/or the MOH have funds to procure PV-powered vaccine R/F systems?				
AID or WHO	NO	NO	NO	NO
MOH	NO	NO	N/R	N/R

Questions 16.0 to 20.0	Gambia Gunjur	Gambia Kaur	Ivory Coast Zaranou	Ivory Coast Niofouin
16.0 Would you endorse the procurement of and/or order additional systems?				
Endorse	YES	YES	NO	NO
Order	NO	NO	N/R	N/R
16.1 If yes, how many?	N/R	N/R	N/R	N/R
16.2 Over what period of time?	N/R	N/R	N/R	N/R
16.3 If no, why not?	System cost very expensive	System cost very expensive	Cost and inadequate training of maintenance personnel	Cost and inadequate training of maintenance personnel
16.4 If no because of cost (present systems cost about 5000 dollar) at what cost would additional procurement be considered?	N/R	N/R	$1500	$1500
17.0 Would the MOH order additional systems?	NO	NO	NO	NO
If yes, how many?	N/A	N/A	N/A	N/A
Over what period of time?	N/A	N/A	N/A	N/A
If no, why not?	System cost [is] expensive	Unit cost is very expensive	Cost	Cost
If no because of cost (assuming systems cost $5000 each), at what cost would procurements be considered be?	N/R	N/R	$3000, difficult to determine without asking the minister	$3000, difficult to determine without asking the minister
18.0 Would you or the MOH be more receptive to ordering these systems if a manufacturer would train a technical cadre and/or provide a central store of spares in the country?				
Training	NO	NO	YES	YES
Maintain spares	NO	NO	YES	YES
If yes, what spares do you believe should be stocked?	N/A	N/A	Unfamiliar with technical specifications	Unfamiliar with technical specifications
19.0 Are there needs for additional electrical services at rural health posts?	YES	YES	N/R	N/R
If yes, what type?				
Area lighting	YES	YES	YES	YES
Exam lights	YES	YES	YES	YES
Sterilizer	YES	YES	YES	YES
Two-way radio	YES	YES	NO	NO
Other	N/R	N/R	N/R	N/R
If no, why not?	N/A	N/A	Excellent telephone system	Excellent telephone system
20.0 Would the inclusion of additional electrical services with the PV-powered vaccine R/F system make the system more attractive even though these services would increase system cost?	YES	YES	YES	YES

Questions 21.0 to 21.7	Gambia Gunjur	Gambia Kaur	Ivory Coast Zaranou	Ivory Coast Niofouin
21.0 What comments do you and/or the MOH have regarding				
21.1 How the field test project was managed:	GOOD	GOOD	Insufficient supervision by central EPI; no help from US/AID; no CDC personnel at Ivory Coast when refrigerator arrived; insufficient or unappropriate (English) contact with NASA	Insufficient supervision by central EPI; no help from US/AID; no CDC personnel at Ivory Coast when refrigerator arrived; insufficient or inappropriate (English) contact with NASA
21.2 System performance:	GOOD	GOOD	System does not perform; when it did, it was excellent	System does not perform; when it did, it was excellent
21.3 System design:	GOOD	GOOD	EXCELLENT	EXCELLENT
21.4 User training:	Highly inadequate	Highly inadequate	Grossly inadequate	Grossly inadequate
21.5 System manuals:	Helpful	Helpful	Useless; all in English	Useless; all in English
21.6 Operational support:	GOOD, except no spares for thermographs, recording pens, 1.35-, 6-, and 9-V batteries; inadequate spares where provided	GOOD, except no spares for thermographs, recording pens, 1.35-, 6- and 9-V batteries; inadequate spares where provided	Was nonexistent; slow response; personnel could not perform	Was nonexistent; slow response; personnel could not perform
21.7 Other:	N/R	N/R	N/R	N/R

Zimbabwe, Peru, Morocco, and Zaire

Questions 1.0 to 4.3.7	Zimbabwe Chiota-Dr. Sang (Ministry of Health-Provincial)	Zimbabwe Chiota-Mr. Mzezewa (Ministry of Energy)	Peru Pucara	Morocco Bouaboute	Zaire[a] Kionzo
1.0 Have you had an opportunity to follow the progress of the photovoltaic (PV)-powered refrigerator/freezer?	YES	YES	YES	YES	YES
1.1 Approximately how many times did you or your staff visit the site since the system was installed?	20 times	7 times	Every week (9/82)	Once a month during one year	N/S
2.0 Have National level representatives from the MOH Immunization Program followed the field test?	YES	N/R	YES	N/R	N/S
3.0 Does the MOH have an established program for vaccine preservation in rural (electricity-less) areas?	YES	N/R	YES	N/R	N/S
3.1 If yes, please describe the program, type of equipment used for vaccine storage and annual cost per site:	Kerosene refrigerators at most rural Health Centers, visited monthly by staff from central level to restock with vaccines; outreach clinics held monthly by staff from rural health center; approximate annual cost per site is (RHC) $150 (kerosene only)	N/R	Does not know whether MOH has an established program	N/R	Kerosene-fueled R/F previously used at site
4.0 Have vaccines been routinely stored in the PV-powered R/F?	YES	N/R	YES	YES	YES
If no, why not?	N/A	N/R	N/A	N/A	N/A
If yes,					
1.1 Approximately what percentage of the time?	100 percent	N/R	80 percent	60 to 100 percent	Until R/F experienced a problem about 1-1/2 years after installation
4.2 Approximately how often are vaccines delivered?	Weekly	N/R	Every 3 months	Weekly	N/S
4.3 Please indicate, by type of vaccine, approximately how many vaccinations are administered per week:					
4.3.1 DPT	10	N/R	12	N/R	N/S
4.3.2 Polio	10	N/R	12	N/R	N/S
4.3.3 Measles	8	N/R	8	N/R	N/S
4.3.4 BCG	10	N/R	8	N/R	N/S
4.3.5 TT	20	N/R	6	N/R	N/S
4.3.6 MR	N/R	N/R	N/R	. . .	N/S
4.3.7 Others	N/R	N/R	Anti-Rabies, every 6 months	N/R	N/S

[a] A narrative report was received. The author has extracted information from that report to complete a questionnaire for the benefit of this report. The response N/S indicates not stated.

Questions 5.0 to 6.4	Zimbabwe Chiota-Dr. Sang (Ministry of Health-Provincial)	Zimbabwe Chiota-Mr. Mzezewa (Ministry of Energy)	Peru Pucara	Morocco Bouaboute	Zaire[a] Kionzo
5.0 Does your site have an outreach program?	YES, run by mobile clinic from Marouden Hospital because too few staff at Chiota Rural Hospital	N/R	YES	N/R	YES
If yes,					
5.1 Approximately how large an area is administered?	1000 km^2	N/R	Do not know	N/R	Surrounding villages
5.2 Approximately how large a population is administered?	50 000	N/R	Do not know	N/R	N/S
5.3 Approximately how many cold packs are frozen each week?	6	N/R	9	N/R	N/S
6.0 Has the PV-powered R/F system allowed immunization services to be offered on a routine basis?	YES	N/R	YES	N/R	YES
6.1 If yes, has immunization coverage increased?	YES	N/R	YES, it has increased	N/R	NO, only allowed existing program to be offered
6.2 If no, please explain why immunization has not been offered on a routine basis:	N/A	N/R	N/A	N/R	N/A
As a consequence of offering immunization services routinely, has the community consulted on or demanded other health services?					
6.3 Yes, please explain	YES, people in remote villages have asked for immunization services in their areas	N/R	YES, since they know about this service, they ask about birth control, growth development; their knowledge has increased	N/R	N/S
6.4 No, please explain	N/A	N/R	N/A	N/R	N/S

[a]A narrative report was received. The author has extracted information from that report to complete a questionnaire for the benefit of this report. The response N/S indicates not stated.

Questions 7.0 to 8.2.3	Zimbabwe Chiota-Dr. Sar (Ministry of Health-Provincial)	Zimbabwe Chiota-Mr. Mzezewa (Ministry of Energy)	Peru Pucara	Morocco Bouaboute	Zaire[a] Kionzo
7.0 How did the local community receive (or perceive) the installation and/or use of the system?					
7.1 Accepted without comments or problems	Enthusiastic that something was being done for their benefit	N/R	People accepted it and they feel proud that in their town there is a solar energy refrigerator; they admire the technology and the way it generates electricity and there is trust in the vaccine	Accepted without comment or problems	YES
7.2 Problem(s) accepting, please explain	N/A	N/R	N/A	N/A	N/A
7.3 Do not know	N/A	N/R	N/A	N/A	N/A
8.0 Please indicate what you view as the system's strong or weak points; STRONG/WEAK, please explain					
8.1 Photovoltaic power system:					
8.1.1 PV modules structure and cabling	STRONG, trouble free	STRONG, no problems have been experienced so far with these components	STRONG	STRONG, the region is very windy and there was no problem with PV modules structures and connections	N/S
8.1.2 PV system controls	STRONG	STRONG, no problems	STRONG	STRONG, no defects	N/S
8.1.3 Batteries	STRONG, trouble-free service	STRONG, no problems	WEAK, disappointed; we have asked for spares before	STRONG, even the system works with 5 batteries, it's going well	N/S
8.1.4 PV system instrumentation	STRONG	N/R	STRONG	WEAK, not accurate	N/S
8.1.5 Thermograph	WEAK, stopped working 2 months after installation	WEAK, broke down several times; the fridge thermograph had to be replaced by a thermometer; ambient thermograph not working; several breakdowns	STRONG, blue and red pens refills are required	WEAK, many problems especially with the clock systems; all of the thermographs are out of work now	N/S
8.2 Refrigerator/freezer:					
8.2.1 Design	STRONG, compact	STRONG, desired temperatures attained	STRONG, for its use and mode is adequate	STRONG, good insulation and good design	thinks overly complex
8.2.2 Size, too small or too large	STRONG	N/R	too large	N/R	too large
8.2.3 Frost/ice removal	STRONG, easy to do	N/R	N/R	WEAK	N/S

[a]A narrative report was received. The author has extracted information from that report to complete a questionnaire for the benefit of this report. The response N/S indicates not stated.

Questions 8.3 to 10.0	Zimbabwe Chiota-Dr. Sang (Ministry of Health-Provincial)	Zimbabwe Chiota-Mr. Mzezewa (Ministry of Energy)	Peru Pucara	Morocco Bouaboute	Zaire[a] Kionzo
8.3 Ability to store non-EPI medications and/or vaccines (e.g., rabies and veterinary vaccines):	Only EPI vaccines stored	N/R	STRONG, for the necessary space there is enough room	N/R	N/S
8.4 System cost: Please explain any other strong or weak points you may have observed.	Strong point is not having to rely on Panaffins fuel; it runs itself and has cost nothing	N/R	The insolometer: with the rain water it has oxidized and it is not working	The batteries installation: difficult to test the batteries without disconnecting them; the plug of the refrigerator is defective; it causes the cut of current	N/S
8.5 What would you do to improve the system?	More reliable thermograph	Data acquisition system should be more robust and reliable to enable collection of data for meaningful system evaluation	Protect it with a fence so strangers cannot mishandle it; our center is not fenced in entirely	Modify the type of plug; modify the design of the batteries installation; for example, have them installed in a row slide movable back and off on wheels; modify the thermographs (install other more reliable thermographs	N/S
9.0 How do you view MOH's reaction to PV-powered vaccine R/F systems? Are the problems real or perceived?	Problems of repairs are real	N/R	There is some concern about its functioning, though it looks like its maintenance (batteries) are expensive and it looks bad because there are no spare batteries	N/R	N/S
10.0 Are the people who were trained in R/F system operation and use by the installation team still at the health post?	YES	YES	YES	N/R	YES
If not, were the replacements trained in R/F operation and use?	N/A	N/A	N/A	N/R	N/A
If yes, who trained them?	N/A	N/A	The chief doctor	N/R	N/A
If no, why were they not trained?	N/A	N/A	N/A	N/R	N/A

[a]A narrative report was received. The author has extracted information from that report to complete a questionnaire for the benefit of this report. The response N/S indicates not stated.

Questions 11.0 to 12.4	Zimbabwe Chiota-Dr. Sang (Ministry of Health-Provincial)	Zimbabwe Chiota-Mr. Mzezewa (Ministry of Energy)	Peru Pucara	Morocco Bouaboute	Zaire[a] Kionzo
11.0 Please summarize operating problems with the system under the following categories:					
11.1 Instrumentation problems which did not affect system operation	Thermograph failure; blown fuse resulted in continuous alarm; had to be repaired; the ambient temperature recorder ceased to function shortly after it was started	Thermograph, solarimeter not working	We did not find any	Problems with thermographs	N/S
11.2 Equipment problems which did affect system operation	None	None	The cable that feeds the refrigerator disconnect did not work, but you can connect it again and it works	The refrigerator power plug	1) Apparent loss of refrigerant resulted in system shutdown; 2) later problem with compressor electronic module or system voltage regulator resulted in system being out of service
11.3 Operator practices which affected system operation	Other refrigerator thermometers were placed in the freezer to record temperatures	N/R	Its operation is automatic, the operator fails by not taking the reading at the opportune time	N/R	N/S
11.4 Other, or combinations of above	None	N/R	N/R	N/R	N/S
12.0 Please list system problems which the following personnel corrected:					
12.1 Operator personnel	Covered (air transfer) holes as directed when temperature fell too low	N/R	N/R	N/R	N/S
12.2 MOH personnel	Collected the ambient temperature recorder and gave it to MIED for repair/replacement; it was never repaired/replaced	N/R	None	Adjusted the freezer temperature and refrigerator tempeature; changed the regulator and alarm batteries; changed the fuse	N/S
12.3 Mission personnel	None	N/R	N/R	N/R	N/S
12.4 Other, or combinations of above	Ministry of [unreadable] sent people to place fuse at instigation of MOH	N/R	N/R	N/R	Local refrigeration technican replaced alleged lost refrigerant

[a]A narrative report was received. The author has extracted information from that report to complete a questionnaire for the benefit of this report. The response N/S indicates not stated.

Questions 13.0 to 17.0	Zimbabwe Chiota-Dr. Sang (Ministry of Health-Provincial)	Zimbabwe Chiota-Mr. Mzezewa (Ministry of Energy)	Peru Pucara	Morocco Bouaboute	Zaire[a] Kionzo
13.0 How is system reliability viewed by you in regard to:					
13.1 Vaccine storage					
MOH	Very Good	N/R	Very Good	N/R	N/S
AID or WHO	N/R	N/R	N/R	N/R	---
13.2 Icemaking					
MOH	Very Good	N/R	Very Good	N/R	N/S
AID or WHO	N/R	N/R	N/R	N/R	---
14.0 How many health posts in your country are without electricity?	N/R	N/R	Many	N/R	N/S
14.1 How many of these health posts could use PV-powered R/F systems?	N/R	N/R	Many	N/R	N/S
15.0 Do you (AID or WHO) and/or the MOH have funds to procure PV-powered vaccine R/F systems?					
AID or WHO	N/R	N/R	NO, we do not know	N/R	N/S
MOH	NO	N/R	N/R	N/R	---
16.0 Would your Mission endorse the procurement of and/or order additional systems?					
Endorse	N/R	N/R	YES	N/R	Unclear response
Order	N/R	N/R	YES	N/R	N/S
16.1 If yes, how many?	N/R	N/R	According to the sanitary centers	N/R	N/S
16.2 Over what period of time?	N/R	N/R	Immediately	N/R	N/S
16.3 If no, why not?	N/R	N/R	Its cost is too high for our economy	N/R	N/S
16.4 If no because of cost (present systems cost about $5000 each) at what cost would additional procurement be considered?	N/R	N/R	$4000	N/R	N/S
17.0 Would the MOH order additional systems?	NO	N/R	YES	N/R	N/S
If yes, how many?	N/A	N/R	Do not know	N/R	N/S
Over what period of time?	N/A	N/R	After 6 months	N/R	N/S
If no, what not?	Lack of funds	N/R	N/A	N/R	N/S
If no because of cost (assuming systems cost $5000 each), at what cost would procurements be considered?	Possibly $2000	N/R	$4000	N/R	N/S

[a]A narrative report was received. The author has extracted information from that report to complete a questionnaire for the benefit of this report. The response N/S indicates not stated.

Questions 18.0 to 21.5	Zimbabwe Chiota-Dr. Sang (Ministry of Health-Provincial)	Zimbabwe Chiota-Mr. Mzezewa (Ministry of Energy)	Peru Pucara	Morocco Bouaboute	Zaire[a] Kionzo
18.0 Would your mission or the MOH be more receptive to ordering these systems if a manufacturer would train a technical cadre and/or provide a central store of spares in the country?					
Training	YES	N/R	YES	N/R	YES[b]
Maintain spares	YES	N/R	YES	N/R	YES[b]
If yes, what spares do you believe should be stocked?	Fuses and possibly batteries	N/R	110-A hr batteries	N/R	N/S
19.0 Are there needs for additional electrical services at rural health posts?	YES	YES	YES	N/R	YES
If yes, what type?					
Area lighting	N/R	YES	YES	N/R	YES
Exam lights	YES	YES	N/R	N/R	YES
Sterilizer	YES	YES	YES	N/R	YES
Two-way radio	YES	N/R	N/R	N/R	YES
Other	N/R	Water pumping from wells/bore holes	N/R	N/R	N/S
If no, why not?	N/A	N/A	N/A	N/R	N/A
20.0 Would the inclusion of additional electrical services with the PV-powered vaccine R/F system make the systems more attractive even though these services would increase the cost?	NO	YES	YES	N/R	Apparently, as there are at least nine other systems in Zaire which also have lights
21.0 What comments do you and/or the MOH have regarding					
21.1 How the field test project was managed:	MOH-fairly well managed, but I believe an extra visit from NASA/ Lewis or Solar Power Corp. personnel would have been welcomed	N/R	With a good leading time	N/R	N/S
21.2 System performance:	MOH considers this to have been excellent	GOOD	We thought there was more electricity generated than needed	N/R	N/S
21.3 System design:	MOH considers this to be excellent	GOOD	For our center, it is adequate	N/R	N/S
21.4 User training:	MOH-I believe this was not as good as as it should have been	Rather too hurried	There was good training for the chief doctor and his deputy	N/R	N/S
21.5 System manuals:	MOH-GOOD	OK	They are very clear for the operator, but they do not say anything about how to fix them	N/R	N/S

[a] A narrative report was received. The author has extracted information from that report to complete a questionnaire for the benefit of this report. The response N/S indicates not stated.

[b] Author's interpretation of remarks.

Questions 21.6 to 21.7	Zimbabwe Chiota-Dr. Sang (Ministry of Health-Provincial)	Zimbabwe Chiota-Mr. Mzezewa (Ministry of Energy)	Peru Pucara	Morocco Bouaboute	Zaire[a] Kionzo
21.6 Operational support:	MOH-POOR	N/R	We did not have any	N/R	Claimed poor communication between AID mission and NASA
21.7 Other:	This is a remarkably efficient R/F and the only major problem was a blown fuse, which would have been repaired within hours but was not fixed for to the "trained" persons lack of training	N/R	The questionnaire was adequate, but above our heads in some areas	N/R	N/S

[a]A narrative report was received. The author has extracted information from that report to complete a questionnaire for the benefit of this report. The response N/S indicates not stated.

Thailand, Honduras, Jordan, and Mali

Questions 1.0 to 4.3.7	Thailand Tambon Tha Thong	Honduras Guaimaca	Jordan-AID Al Aried	Jordan-MOH Al Aried	Mali Ouelessebougou
1.0 Have you had an opportunity to follow the progress of the photovoltaic (PV)-powered refrigerator/freezer?	YES	YES	YES	YES	YES
1.1 Approximately how many times did you or your staff visit the site since the system was installed?	Once	One time	US/AID-twice MOH-15	More than 12 times	20
2.0 Have National level representatives from the MOH Immunization Program followed the field test?	YES	YES	YES	YES	YES
3.0 Does the MOH have an established program for vaccine preservation in rural (electricityless) areas?	YES	N/R	YES	YES	YES
3.1 If yes, please describe the program, type of equipment used for vaccine storage and annual cost per site:	Refrigerators at provincial and district levels and most of subdistrict health center; cold boxes are used when immunization is out at village level	They utilize kerosene powered refrigerators, 5 to 12 cu. ft, mostly Electrolux; each refrigerator costs approximately $400	MOH stores vaccine in centers where electricity is available; a vaccination team takes the vaccine in cold storage boxes and visits clinics periodically for vaccination purposes; approximate cost per site is $1500 annually	We have for all areas in Jordan an established EPI since 1978; in all areas in Jordan we have electricity, and so we have here good electrical cold chain system	BCG vaccination program - 1 session per month; use of petrol refrigerators belonging to private individuals (when possible) - quite variable, often without cost to the MOH
4.0 Have vaccines been routinely stored in the PV-powered R/F?	YES	YES	YES	YES	YES
If no, why not?	N/A	N/A	N/A	N/A	N/A
If yes,					
4.1 Approximately what percentage of the time?	One week	100 percent	100 percent	100 percent	100 percent
4.2 Approximately how often are vaccines delivered?	Every week	Monthly	Once every 2 weeks, depending on need	Monthly	Once quarterly
4.3 Please indicate, by type of vaccine, approximately how many vaccinations are administered per week:					
4.3.1 DPT	20	100	15	20	50
4.3.2 Polio	20	100	15	20	50
4.3.3 Measles	10	20	5	10	100
4.3.4 BCG	20	40	N/R	N/R	20
4.3.5 TT	20	15	10	12	N/R
4.3.6 MR	N/R	0	N/R	N/R	N/R
4.3.7 Others	20 - DT	N/R	N/R	N/R	15 - Anti-rabies 20 - Yellow fever

Questions 5.0 to 7.1	Thailand Tambon Tha Thong	Honduras Guaimaca	Jordan-AID Al Aried	Jordan-MOH Al Aried	Mali Ouelessebougou
5.0 Does your site have an outreach program?	YES	YES	YES	YES	YES
If yes,					
5.1 Approximately how large an area is administered?	3200 acres	500 km^2	7 villages	200 km^2	8-km radius
5.2 Approximately how large a population is administered?	5019	10 769	6000	2000	35 000
5.3 Approximately how many cold packs are frozen each week?	7 packs/week	12	4	N/R	2
6.0 Has the PV-powered R/F system allowed immunization services to be offered on on a routine basis?	YES	YES	YES	YES	YES
6.1 If yes, has immunization coverage increased?	YES, it has increased	YES, because more vaccine can be stored with increased reliability	YES	YES	YES
6.2 If no, please explain why immunization has not been offered on a routine basis:	N/A	N/A	N/A	N/A	N/A
As a consequence of offering immunization services routinely, has the community consulted on or demanded other health services?					
6.3 Yes, please explain	YES, the community wants to use solar cell to generate electric light during delivery by night	YES, because of increased vaccine availability, a desire for well baby clinics has been stimulated	YES, the community is demanding establishing a hospital in the area	N/A	YES, administration of nioaquine and other kinds of vaccinations
6.4 No, please explain	N/A	N/A	N/A	NO	N/A
7.0 How did the local community receive (or perceive) the installation and/or use of the system.					
7.1 Accepted without comments or problems	YES	There were no problems, but it is viewed as a novelty and has been visited by teachers, students and various local residents	YES	YES	YES

Questions 7.2 to 8.3	Thailand Iambon Tha Thong	Honduras Guaimaca	Jordan-AID Al Aried	Jordan-MOH Al Aried	Mali Ouelessebougou
7.2 Problem(s) accepting, please explain	N/A	N/A	N/A	N/A	N/A
7.3 Do not know	N/A	N/A	N/A	N/A	N/A
8.0 Please indicate what you view as the system's strong or weak points; STRONG/WEAK, please explain					
8.1 Photovoltaic power system:					
8.1.1 PV modules structure and cabling	STRONG	STRONG, cable is protected, the PV screens are waterproof and very hard	STRONG	STRONG	STRONG, improve connections between panel and refrigerator (the connecting support is very fragile)
8.1.2 PV system controls	N/R	N/R	STRONG	STRONG	WEAK
8.1.3 Batteries	WEAK, batteries ought to be added	STRONG, no maintenance necessary, but the compartment is so small that any kind of action with batteries is difficult	STRONG	STRONG	WEAK, installation battery capacity weak for periods with ambient temperatures of 35 to 45 °C
8.1.4 PV system instrumentation	WEAK, array ampere current no ran, but have already changed	STRONG, readings are exact, but instrument controls are hard to get to, making them hard to read	STRONG	STRONG	STRONG, but often the integrators are blocked; these must be improved
8.1.5 Thermograph	WEAK, graph indicated temperature higher than the fact	WEAK, the thermograph did not rotate completely	WEAK, has been out of order since installed	WEAK	STRONG, very good - never any problems
8.2 Refrigerator/freezer:					
8.2.1 Design	WEAK, door holder damages	STRONG, easy storage, but a lot of wasted space; it needs an additional shelf	STRONG	GOOD	STRONG, improve connecting supports with very resistent material
8.2.2 Size, too small or too large	WEAK, too small freezer	STRONG	STRONG	Normal, adequate	STRONG, freezer too small
8.2.3 Frost/ice removal	WEAK, frost/ice must always be removed	STRONG	WEAK	STRONG	STRONG
8.3 Ability to store non-EPI medications and/or vaccines (e.g., rabies and veterinary vaccines):	STRONG, there is enough space for storing non-EPI medications in refrigerator	Not using it for this purpose	STRONG	GOOD	STRONG, products for veterinary use

Questions 8.4 to 11.1	Thailand Tambon Tha Thong	Honduras Guaimaca	Jordan-AID Al Aried	Jordan-MOH Al Aried	Mali Ouelessebougou
8.4 Please explain any other strong or weak points you may have observed.	Charger does not work properly	The black screens (inner compartment covers) which cover the refrigerator when it is opened rest on very weak supports which have broken	None	N/R	The system deserves to have many more panels and batteries for use in hot countries (ambient temperatures from 40 to 50 °C)
8.5 What would you do to improve the system?	Solar module ought to be at least 7 modules to increase capacity of assimilating photoenergy	1) Increase the battery storage space to make access to them easier, 2) strengthen the supports for the compartment covers; 3) additional variable level shelves to take advantages to space, and 4) improve location of instrument controls	None	Better observation for thermograph	Add panels and batteries, enlarge the battery spaces, improve the quality of the electronic circuits and avoid too many electronic circuits and too many wires
9.0 How do you view MOH's reaction to PV-powered vaccine R/F systems? Are the problems real or perceived?	MOH is satisfied with the system; problems are real	Problems are real, but MOH has been very pleased with the system	Good and well accepted	N/R	N/A[a]
10.0 Are the people who were trained in R/F system operation and use by the installation team still at the health post?	YES	YES	YES	YES	YES
If not, were the replacements trained in R/F operation and use?	N/A	N/A	N/A	N/A	N/A
If yes, who trained them?	Mr. Somchai Turiyagom, who works maintenance at engineering center III	N/A	N/A	N/A	Jim Martz, (NASA) Albousseini Issa Maiga (LESO)
If no, why were they not trained?	N/A	N/A	N/A	N/A	N/A
11.0 Please summarize operating problems with the system under the following categories:					
11.1 Instrumentation problems did not affect system operation.	2 times on "number indicator" are not in the same line, difficult to read	Defects in the thermograph card	The automatic thermograph has been out of order since installed	Thermograph indicator charts are out of charge soon after installation of the refrigerator	The integrators frequently blocked

[a]The questionnaire reported here was the MOH version, which did not contain this question.

Questions 11.2 to 15.0	Thailand Tambon Tha Thong	Honduras Guaimaca	Jordan-AID Al Aried	Jordan-MOH Al Aried	Mali Ouelessebougou
11.2 Equipment problems which did affect system operation	Batteries ought to be outside the refrigerator; it is easier to maintain; condensing unit should be more properly ventilated	Defects in the thermostat; condensor fan works continuously	None	NO	Fuses, temporary blockage of ventilator, electronic module on compressor and battery weakness (stored energy)
11.3 Operator practices which affected system operation	There is no problem	None	None	NO	N/R
11.4 Other, or combinations of above	N/R	None	None	N/R	N/R
12.0 Please list system problems which the following personnel corrected:					
12.1 Operator personnel	N/R	None	None	None	Cleaning of modules
12.2 MOH personnel	N/R	Defects in the thermostat card	None	None	N/R
12.3 Mission personnel	No time to see the system work on a routine basis	None	None	N/R	N/R
12.4 Other, or combinations of above	N/R	None	None	Thermograph without effect	N/R
13.0 How is system reliability viewed by you in regard to:					
13.1 Vaccine storage					
MOH	Good	Very Good	Very Good	Very Good	Very Good
AID or WHO	Good	Very Good	Very Good	N/R	N/R
13.2 Ic ing					
MOH	Fair	Very Good	Very Good	N/R	Very Good
AID or WHO	Fair	Very Good	Very Good	N/R	N/R
14.0 How many health posts in your country are without electricity?	One[b], there is only one health center in this district	4[b]	2[b]	N/R[b]	8
14.1 How many of these health posts could use PV-powered R/F systems?	1[b]	4[b]	2[b]	None[b]	8
15.0 Do you (AID or WHO) and/or the MOH have funds to procure PV-powered vaccine R/F systems?					
AID or WHO	NO	NO, not currently but has invested over $250 000 in cold chain equipment	NO	N/R	N/R
MOH	NO	NO	NO	N/R	NO

[b]An error in the way the question was worded in the questionnaire sent to Solavolt system sites produced answers regarding only the local area or district.

Questions 16.0 to 18.0	Thailand Tambon Tha Thong	Honduras Guaimaca	Jordan-AID Al Aried	Jordan-MOH Al Aried	Mali Ouelessebougou
16.0 Would your Mission endorse the procurement of and/or order additional systems?					
Endorse	NO	YES	YES	N/A[a]	N/A[a]
Order	NO	N/R	N/R	N/A[a]	N/A[a]
16.1 If yes, how many?	N/A	Depends on MOH needs; perhaps 200	2	N/A[a]	N/A[a]
16.2 Over what period of time?	N/A	N/R	Next year	N/A[a]	N/A[a]
16.3 If no, why not?	It is AID's policy not to support equipment purchase on a large scale	N/R	N/R	N/A[a]	N/A[a]
16.4 If no because of cost (present systems cost about $5000 each) at what cost would additional procurement be considered?	N/R	N/R	N/R	N/A[a]	N/A[a]
17.0 Would the MOH order additional systems?	NO	YES, with donor funding	NO	YES	NO
If yes, how many?	N/A	N/R	N/A	20	N/A
Over what period of time?	N/A	N/R	N/A	Over 1 year	N/A
If no, why not?	They do not see it as cost-effective; rural areas (at sub-district level) will all be electrified in the next few years; electric refrigeration is more acceptable	N/R	Jordan is carrying out a rural electrification program which will cover the whole Kingdom shortly	N/R	Financial problems
If no because of cost (assuming systems cost $5000 each), at what cost would procurements be considered?	N/R	N/R	N/R	N/R	$1000
18.0 Would your mission or the MOH be more receptive to ordering these systems if a manufacturer would train a technical cadre and/or provide a central store of spares in the country?					
Training	NO	YES	NO	N/R	YES
Maintain spares	N/R	YES	NO	N/R	YES
If yes, what spares do you believe should be stocked?	N/R	N/R	N/A	N/R	Fuses, electronic compressor modules, battery regulators, batteris, panels

[a]The questionnaire reported here was the MOH version, which did not contain this question.

Questions 19.0 to 21.5	Thailand Tambon Tha Thong	Honduras Guaimaca	Jordan-AID Al Aried	Jordan-MOH Al Aried	Mali Ouelessebougou
19.0 Are there needs for additional electrical services at rural health posts?	YES	YES	YES	YES	YES
If yes, what type?					
Area lighting	YES	YES	YES	YES	YES
Exam lights	YES	YES	YES	YES	YES
Sterilizer	YES	YES	YES	YES	YES
Two-way radio	YES	YES	YES	N/R	YES
Other	IV and water-pump	N/R	N/R	N/R	N/R
If no, why not?	N/A	N/A	N/A	N/A	N/A
20.0 Would the inclusion of additional electrical services with the PV-powered vaccine R/F system make the systems more attractive even though these services would increase the cost?	NO	NO	NO	NO	N/R
21.0 What comments do you and/or the MOH have regarding the following items? Please be specific and detailed.					
21.1 How the field test project was managed:	N/R	N/R	N/R	By physician	The fridge was given by NASA and the maintenance was done by LESO through AID (RE)
21.2 System performance:	Satisfactory	MOH and mission very pleased with system performance	The system is good and serves its purpose	N/R	We have to find a solution to the problem of hot season, principally to add a panel and a battery
22.3 System design:	Satisfactory	Design is good, but could be improved by incorporating the recommendations made previously	OK	N/R	GOOD, we have to work on the imperviousness of the system (avoid heat transfer during the hot season), the door has to be maintained when the user put something in
21.4 User training:	GOOD	Considered to be adequate	OK	N/R	Was well done; the man in charge was sometimes very busy, so he forgot or missed some data
21.5 System manuals:	GOOD	Easily understood, good translation, useful above all for the logical system employed for correcting errors	OK	N/R	VERY POOR, has to be in French, and has to have the electrical connector documents and possibly the electronic circuits of all the system

Questions 21.6 to 22.0	Thailand Tambon Tha Thong	Honduras Guaimaca	Jordan-AID Al Aried	Jordan-MOH Al Aried	Mali Ouelessebougou
21.6 Operational support:	Not very good	Satisfactory, but would have preferred direct communication rather than going through the mission, mission concurs	No support has been received after the P.V.R. was installed	N/R	No support to the operator
21.7 Other:	N/R	MOH is concerned about obtaining spare parts of the system, if they should need them	Mission and MOH would like to have the thermograph repaired; at present, thermometers are put into each compartment of PV-powered vaccine R/F and reading is taken once every day; the thermograph gives the change in temperature for a whole day	N/R	The fridge seemed to be OK, a few arrangements have to be done and a lot of spares have to be delivered, like fuses, electronic module, compressor controller
22.0 Has anyone on your staff conducted any life-cycle cost comparisons of PV-powered vaccine R/F systems and alternative vaccine storage methods?	NO	NO	NO	NO	NO
If yes, what were the other storage methods and what were your conclusions?	N/R	N/R	N/R	N/R	N/R

REFERENCE

1. Ratajczak, A.F.: Photovoltaic-Powered Vaccine Refrigerator-Freezer Systems Field Test Results. (DOE/NASA/20485-18) NASA TM-86972-Rev, 1985.

TABLE I. - NASA LEWIS PV-POWERED VACCINE REFRIGERATOR FIELD-TEST SUMMARY

Latin America/Caribbean	Africa	Near East	Asia
(CDC) Peru Pucara [a]248/[b]525 14 Oct. 82 SPC/AB	(CDC) Gambia 1. Kaur 320/630 2. Gunjur 320/630 27 Jan. 83 SPC/AB		(CDC) Maldives Kuludutfushi 284/630 6 May 82 SPC/AB
(CDC) Columbia Bocas Del Palo 284/630 11 Sep. 82 SPC/AB	(CDC) Ivory Coast 1. Niofouin 355/630 2. Zaranou 355/630 5 Feb. 83 SPC/AB		(CDC) India Bhoorbaral 355/630 19 Oct. 81 SPC/AB
(AID) Dominican Republic Las Tablas 284/[b]525 28 Aug. 82 SPC/AB	(AID) Ivory Coast Menee 280/315 25 Feb. 84 SVI/PP	(AID) Jordan Al Aried 160/420 28 June 84 SVI/M	(AID) Indonesia 1. Cibung bulang 320/630 2. Batujaya 320/630 16 Apr. 82 SPC/AB
(AID) Guatemala Tierra Blanca 248/630 7 Oct. 82 SPC/AB	(AID) Burkina Faso Orodara 200/315 21 Feb. 84 SVI/PP	(AID) Tunisia 1. Es-Smirat (Siliana) 240/315 2. Bir Amama 240/420 1. 3 Feb. 84 1. SVI/PP 2. 6 Feb. 84 2. SVI/M	(AID) Thailand Tambon Tha Thong 200/420 2 Nov. 83 SVI/M
(AID) Honduras Guaimaca 200/420 12 Jan. 84 SVI/M	(AID) Liberia Suehn 390/630 12 Oct. 84 SPC/AB	(AID) Morocco Bouaboute 355/[b]525 28 Oct. 83 SPC/AB	
(AID) Haiti Anse-A-Veau 284/630 2 Sep. 82 SPC/AB	(AID) Zaire Kionzo 355/[b]525 11 Feb. 83 SPC/AB		
(AID) Guyana Schepmoed 284/630 30 Sep. 82 SPC/AB	(AID) Zimbabwe Chiota 284/630 15 Feb. 83 SPC/AB		
(AID) Ecuador Comuna Cobos 284/630 23 Sep. 82 SPC/AB	(AID) Mali Ouelessebougou 200/315 14 FEb. 84 SVI/PP		
(AID) St. Vincent & the Grenadines 1. New Sandy Bay 200/420 2. Canouan 160/315 1. 18 Jan. 84 1. SVI/M 2. 25 Jan. 84 2. SVI/PP			

LEGEND:

AID U.S. Agency for International Development
CDC U.S. Centers for Disease Control
AB Adler-Barbour
M Marvel
PP Polar Products
SPC Solar Power Corp.
SVI Solavolt International

a Array peak watts (Wp)/battery ampere-hours (A-hr)
b One battery damaged or lost in transit

Modules	Batteries
SPC: LG12-351, 35.5 Wp	SPC: Delco 2000, 105 A-hr
SVI: MSP43E40, 40 Wp	SVI: Delco 2000, 105 A-hr

TABLE II. - QUESTIONNAIRE DISTRIBUTION AND RESPONSE SYSTEM

[Total sites queried, 29; total sites replying, 20; total questionnaires sent, 46; total replies, 22.]

Location	AID, CDC/WHO		MOH	
	Sent	Received	Sent	Received
Solar Power Corp. systems				
India	•	•		
Indonesia/Cibungbulong	•	•		
Indonesia/Batujaya	•	•		
Maldive Islands	•	•		
Dominican Republic	•	•	•	
Haiti	•		•	•
Guyana	•	•	•	
Guatemala	•		•	•
Gambia/Gunjur	•	•		
Gambia/Kaur	•	•		
Ivory Coast/Zaranou	•	•		
Ivory Coast/Niofouin	•	•		
Zimbabwe	•			(a)
Peru	•		•	(b)
Morocco			•	•
Liberia	•			
Columbia	•		•	
Ecuador	•		•	
Zaire	•	(c)		
Solavolt International systems				
Thailand	•	(d)	•	(d)
Hondurus	•		•	•
Jordan	•	•	•	•
Mali	•		•	•
St. Vincent	•		•	
Canouan	•		•	
Ivory Coast/Menee	•		•	
Burkina Fasso	•		•	
Tunisia/Es-Smirat	•		•	
Tunisia/Bir Amama	•		•	
Number of questionnaires sent	28		18	
Number of questionnaires received		13		9

[a] AID forwarded copies of the questionnaire to the Ministry of Energy and to the Provincial Health Officer in the Ministry of Health, both of which replied.

[b] CDC copy of questionnaire completed by Ministry of Health official.

[c] A narrative report was received. The author has extracted information from that report to complete a questionnaire for the benefit of this report.

[d] Jointly completed by AID and MOH officials.

TABLE III. - RESPONSES TO QUESTION 16.0

Country (respondent)	Endorse purchase?	Order systems?	If "Yes," how many?	Over what period of time?	If "No," why not?	If "No" because of cost, at what cost would purchase be considered?
India (WHO)	NO	N/R	N/R	N/R	High cost	$1500/system
Indonesia (AID)	NO	NO	N/A	N/A	Too many operational problems and too expensive	Unknown
Maldive Islands (WHO)	NO	N/R	N/R	N/R	Too expensive; high battery replacement cost; unproven reliability	$1500/system
Dominican Republic (AID)	Needs further analysis	Needs further analysis	Needs further analysis	Needs further analysis	Serious economic problems in country	Does not know
Haiti (MOH)	YES[a]	N/A[a]	10	As soon as possible	It is a question of funds	N/R
Guyana (AID)	YES	Yes (if project funding available)	Up to 30, probably more	1 year	N/A	N/A
Guatemala (MOH)[b]	NO	NO	N/A	N/A	a) Current budget does not include funds for PV-R/F; high cost, b) MOH using kerosene R/F's which cost between $600 to $1200 each	No more than $1200/unit
Gambia (AID)	YES	NO	N/R	N/R	System cost very expensive	N/R
Ivory Coast (Institute of Hygiene)	NO	N/R	N/R	N/R	Cost and inadequate training of maintenance personnel	$1500/system
Zimbabwe	N/R	N/R	N/R	N/R	N/R	N/R
Peru (MOH)[b]	YES	YES	According to (needs of) the health centers	Immediatly	It cost is too high for our economy	$4000/system
Morocco (Ministry of Energy	N/R	N/R	N/R	N/R	N/R	N/R
Zaire (AID)[c]	Unclear response	N/S	N/S	N/S	N/S	N/S
Thailand (AID and MOH)	NO	NO	N/A	N/A	It is AID's policy not to support equipment purchase on a large scale	N/R
Honduras (AID)	YES	N/R	Depends on MOH's needs; perhaps 200	N/R	N/R	N/R
Jordan (AID)	YES	N/R	2	Next year	N/R	N/R
Mali (AID)[d]	N/A	N/A	N/A	N/A	N/A	N/A

[a]Only the MOH responded from Haiti. The MOH questionnaire was worded slightly different from the AID/CDC questionnaire. This question in the MOH questionnaire was worded "Would you approve the procurement of additional systems?"

[b]The MOH completed the questionnaire designed for AID response.

[c]No specific comments on this subject in letter report. N/S indicates not stated.

[d]The questionnaire reported here was the MOH version, which did not contain this question.

TABLE IV. - RESPONSES TO QUESTION 17.0

Country (respondent)	MOH order systems?	If "Yes," how many?	Over what period of time?	If "No," why not?	If "No" because of cost, at what cost would purchase be considered?
India (WHO)	NO	N/A	N/A	High cost	$1500/system
Indonesia (AID)	NO	N/A	N/A	Too many operational problems and too expensive	Unknown
Maldive Islands (WHO)	NO	N/A	N/A	Costly and unreliable	$1500/system
Dominican Republic (AID)	N/R	N/R	N/R	N/R	N/R
Haiti (MOH)	NO[a]	N/R	N/R	It is a question of funds	$1000/system if possible
Guyana (AID)	YES and NO; Yes if foreign exchange available	For all electricity deficient health centers	3 to 5 years	Lack of foreign exchange	N/R
Guatemala (MOH)[b]	Maybe	N/R	N/R	N/R	No more than $1200/unit
Gambia (AID)	NO	N/R	N/R	System cost very expensive	N/R
Ivory Coast (Institute of Hygiene)	NO	N/A	N/A	Cost	$3000/system - difficult to determine without asking the minister
Zimbabwe	NO	N/A	N/A	Lack of funds	Possibly $2000/system
Peru (MOH)[b]	YES	Does not know	After 6 months	N/A	$4000/system
Morocco (Ministry of Energy	N/R	N/R	N/R	N/R	N/R
Zaire (AID)[c]	N/S	N/S	N/S	N/S	N/S
Thailand (AID)	NO	N/A	N/A	They (MOH) do not see PV-R/F as being cost effective; rural areas (at subdistrict level) will be electrified in the next few years; electric refrigeration is more acceptable	N/R
Honduras (AID)	YES (with donor funding)	N/R	N/A	N/R	N/R
Jordan (AID)	NO	N/A	N/A	Jordon is carrying out a rural electrification program which will cover the whole kingdom shortly	N/R
Jordan (MOH)	YES	20	Over 1 year	N/R	N/R
Mali (MOH)	NO	N/A	N/A	Financial problems	$1000/system

[a]Only the MOH responded from Haiti. The MOH questionnaire was worded slightly different than the AID/CDC questionnaire. This question in the MOH questionnaire was worded "Will the MOH order additional systems?"

[b]The MOH completed the questionnaire designed for AID response.

[c]No specific comments on this subject in letter report.

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15. Supplementary Notes

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16. Abstract

The NASA Lewis Research Center has concluded a project to develop and field test photovoltaic-powered refrigerator/freezers for vaccine storage in remote areas of developing countries. As a conclusion to this project, questionnaires were sent to the in-country administrators for each test site probing user acceptance of the systems and attitudes regarding procurement of additional systems. Responses indicate that the systems had a positive effect on the local communities, that they made a positive impression on the local health authorities, and that system cost and scarcity of funds are the major barriers to procurements of additional systems.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
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