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PRELIMINARY ASSISTANCE TO THE UTILIZATION OF SOLAR ENERGY IN RESETTLEMENT AREAS OF ETHIOPIA

XP/ETH/86/038

ETHIOPIA

Technical report: Conditions and requirements for PV applications in remote areas of Ethiopia*

Prepared for the Government of Ethiopia

by the United Nations Industrial Development Organization

Based on the work of James Goodman,
Expert in solar energy

Backstopping officer: J. Fürkus, Engineering Industries Branch

* This document has been reproduced without formal editing.

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Abbreviations

UNIDO	- United Nations Industrial Development Organization
ENEC	- Ethiopian National Energy Committee
E.W.W.C.A.	- Ethiopian Water Works Construction Authority
W.S.S.A.	- Water Supply and Sewage Authority
TDH	- Total dynamic head
L/S	- Litres/Second

EXECUTIVE SUMMARY

The purpose of this project is to assess the conditions and requirements for pv applications to provide electricity for water pumping, lighting and refrigeration for remote areas outside the National grid system in Ethiopia.

The extraordinary diverse terrain of Ethiopia with population and national grid centred in the highlands, leave the remote lowland areas dependent on fossil fuels for their small energy requirements at an enourmous cost to the government. The introduction of photovoltaic power to provide these small energy demands complements Government activities in other renewable energies (hydropower and geothermal) and relieves the central administration of the hidden costs of fuel supply, operation and maintenance of fossil fuel Systems.

The project proposes to train two engineers overseas who will then install 47 solar pumps at selected sites; this will give all regional water construction authority personnel direct experience in the installation and operation of these units.

The project proposes to install a solar powered vaccine refrigerator pilot project in six sites selected for their diverse climatic conditions but within easy access for monitoring, evaluation and training of E.P.I. (Expanded Project on Immunization) personnel.

The project, as part of the advisory role of the Ethionian National Energy Committee, will provide detailed designs, specifications and cost estimates for the

installation of lights at 50 schools and basic development education centres to be constructed in Gambela, Asosa and Metema through the OPEC fund. These designs will be used for funding proposals and will be considered in the current World Bank evaluation for a further 200 school construction project.

1. INTRODUCTION

Following the severe drought of 1984 - 85, the Ethiopian National Energy Committee of the Provisional Military Govt. of Ethiopia approached UNIDO to finance and recruit a technical expert to assist the government in assessing conditions for pv applications in the drought, resettlement and remote areas. The purpose of the project was specified to assess conditions and requirements for pv applications to provide electricity for water pumping, lighting and refrigeration for remote areas outside the national grid system in Ethiopia.

UNIDO appointed James Goodman of Solar Electric International, a solar systems design, manufacture and supply company to carry out the mission.

Work commenced on 16th October 1986 and concluded with presentation of this final report at the end of December 1986. The author visited Ethiopia for a period of 7 weeks during which time data was collected, potential sites visited, both those identified in the initial project proposal and those further recommended by regional authorities. Extensive discussions were held with authorities in the Ministry of Health (EPI) and the Ministry of Education (School Building and Maintenance Unit). On completion of the field work, the computer design work on system outputs was completed in the company offices in Nairobi and London. An interim report on the design options was presented to UNIDO during debriefing on 10th December 1986.

The author wishes to extend his thanks to all authorities and individuals who assisted him in executing the mission. Dr. Ghebru Wolde Georghis, Chairman of ENEC, initiated a rapid start to the field work with his direct approach and delegated an excellent team to assist the author. In particular the author would like to thank the team of Yonael Teklu, Asress W/Giorgis and Mr. Lema for their excellent companionship and good humour throughout the gruelling tour and to Mulugeta Adam for organisation and other administrative matters in Addis. Furthermore thanks must be extended to the staff of UNIDO in Addis Ababa who enabled the mission to be completed successfully.

The report is divided into three sections:

A - Water pumping
B - Vaccine refrigeration
C - Lighting for schools

Which follow on from a general proposal objectives, background and justification. The results of the Site Survey are found in Annex II.

2. BACKGROUND

The Ethiopian government has a policy priority of maximum utilisation of renewable energies with, until now, particular emphasis on hydro and geo-thermal power. In these sectors large scale projects are under construction which will supply energy directly to the national grid or to isolated, but large, population centres. There are considerable

areas which are denied access to the national grid; these areas generally being the lowland border areas. In some of these areas, particularly in the western lowlands the Government is actively encouraging new settlements to relieve pressure on the overpopulated highlands. All energy requirements in these areas are met by fossil fuel resources, a large drain on forei . exchange and demanding elaborate organisational suppl; and maintenance services.

The Ethiopian National Energy Committee, whose staff members have had extensive experience both in solar cell manufacture and in solar installation, has closely monitored pv development worldwide. To complement activities in other renewable energy fields and to provide those small energy demands essential for community development (pv water pumping, vaccine refrigeration and lighting), the government through E.N.E.C. is introducing solar power as a component of its energy policy. The approach favoured by E.N.E.C. is realistic in terms of worldwide pv developments and has the full support of the author.

In brief this approach is:

a) the design, manufacture and assembly of pv modules and systems in Ethiopia (or any other developing country) is economically unrealistic at present. The rapid changes in the technology currently occuring which, together with the increasingly larger installations commissioned in the western world, are resulting in the forecasted reduction in price per peak watt. No developing country should become involved in

manufacture of solar cells until these changes in technology and price have reached the "high plateau" but policy planners should be aware now of the enormous possibilities and flexibility of solar for development planning. This is the philosophy of the ENEC approach, to introduce mature system applications to form the basis of future policy.

b) Up until 1986, all solar installation in Ethiopia were bi-lateral aid donated equipment of projects implemented by non government organisations (n.g.o.). The former consists of a successful small scale school lighting project, a large scale (4 KW plus array) installation which does not address the main village energy demand, namely cooking, and only provides a light in all houses in a village (this is of more benefit to the supplier in gaining field experience of the system than to the recipients and a totally impractical solar pump unit incorporating a suction pipe. The most successful n.g.o. project is the introduction of solar powered a.c. submersible pumps on the Omo river in Gamu Gofa which has been evaluated by E.N.E.C.

The government has an active policy of standardisation and it is a prime objective of the project proposal to introduce equipment standards which are realistic, of proven field performance, and that address the basic energy requirements of remote communities which at present can only be provided by fossil fuels.

(It is important to note that energy for cooking cannot be met economically by solar power).

3. OBJECTIVES

The long term objectives of this proposal are for the establishment of a solid base for future policy decision-making in the three sectors of community development which are basic to their future. The three sectors; water pumping for clean, potable water supply, refrigeration for effective immunisation programmes and lighting for nightime community development activities are analysed in separate sections together with specifications and implementation costs.

The immediate objectives of the proposal are;

3.1 Water pumping

a) replace diesel powered pumps with pv pumps for certain selected sites; to provide the communities at those sites 'cost free' water and to relieve E.W.W.C.A. of high maintenance demands in low priority (demographic) areas.

b) to provide 'hands on' experience to all regional E.W.W.C.A. personnel in the installation and operation of pv pumping units.

3.2 Vaccine refrigeration

a) to establish a pilot project to give regional

EPI personnel direct experience in running solar powered vaccine refrigerators.

b) to provide a base for evaluation and monitoring of equipment in diverse climatic conditions representative of the country as a whole.

3.3 Lighting

a) to provide design, specification and cost estimates to the OPEC funded school building project in Illubabor, Welega and Gonder as a basis for funding proposals.

b) to provide items as outlined in (a) for the World Bank evaluation study for funding of a further 200 schools and Basic Education development centres in Ethiopia.

4. PROJECT OUTPUTS AND ACTIVITIES

4.1 Water pumping.

Once funding has been found, tender put out and the contract awarded for the supply of the pv pumps, two engineers, one from ENEC and one from E.W.W.C.A. will spend up to one month at the manufacturers being trained in all aspects of operation, maintenance and installation procedures. One of the conditions of contract is for the contractor to provide computer programmes to ENEC, which are capable of accurate simulation of system sizing, and compatable with

hardware being installed at ENEC. The hardware available should be specified to the manufacturer as soon as the contract is awarded.

On their return to Ethiopia and on the arrival of the systems (3 months from date of contract award) the two engineers will install one or two units in each region, training the E.W.W.C.A. personnel through 'hands on' experience. These technicians will then install the other units in their region as operational programmes permit.

The capability of E.W.W.C.A. personnel to adequately install a.c. submersible pumps is beyond doubt and the excellent installation of a 4 kW array at Mito leaves no doubt to the capability of ENEC engineers. There is a high standard of professionalism in all personnel encountered in both organisations.

The main government contribution, providing adequate 'on-point' storage facilities, will be implemented as soon as the first units are installed using designs from Jima. Installing a pump and array only takes 2 days but a ferrocement tank can take up to a month to complete. Initially the pv pumps will use existing storage until operational programmes allow for suitable storage facility construction. Once these have been constructed the existing steel tanks can be removed to sites where diesel units are the only practical power source.

4.2 Vaccine Refrigerator pilot project

This tender will be put out separately from the water pumping tender. When the contract is awarded the manufacturer will submit designs for array stands which will be constructed by the Ministry of Health prior to the arrival of the units and the manufacturers engineer. The engineer will spend 3 weeks in country installing the units and training EPI personnel and local operators in installation, maintenance and training procedures. It is expected that 3 months after the award of contract the units will be in Addis Ababa and ready for installation.

4.3 Lighting for Schools

The designs, specifications and cost estimates have been forwarded to the UNESCO advisor to the OPEC funded 50 school project based at the School Building and Maintenance Unit of the Ministry of Education. The advisor will use this as a basis when seeking further funds for lighting from the the OPEC fund and he will also present the package to the World Bank evaluation of a further 200 school construction project currently underway in Ethiopia.

5. Project Inputs

5.1 Water Pumping

The system installed costs for a typical system at a remote site some 400 Km from a regional E.W.W.C.A. yard is given in section A5 with a full breakdown on foreign and local cost components: For each system, which includes supply of pv pumps, freight, installation and provision of fencing, storage tank and distribution point, the costs can be summarised:

a) Foreign component $ 15,311.95 (including freight)

b) Local component $ 10,975.48 or 22,682 Birr.

Foreign component:

47 pumps are to be supplied as per specifications in draft terms of reference; assume tracking approach, and that the largest available systems will be chosen for the 7 sites (2 in Humera, 5 in Wollo) not detailed. Refer Annex II, survey summary for component breakdown costs: it will be noticed that the cost estimates for the units specified is in the range of $ 14,900 - f.o.b. For budget cost assume f.o.b. cost as $ 15,000 per unit.

f.o.b cost for 47 systems	$ 705,000
seafreight/insurance from country or origin to Asab	$ 35,000
Total c.i.f. Asab	$ 740,000

These budget costs are strictly estimates for UNIDO analysis only. The freight costs are particularly difficult to estimate as the country of origin of eventual supplier is unknown.

UNIDO contribution	
c.i.f. cost	$ 740,000
10% spares	$ 70,500
Vehicle	$ 17,000
Overseas training	
2 man-months including air fares	$ 9,000
Total UNIDO contribution for pv pumping	$ 836,500

Local component

The cost of breakdown (section A5) is fairly representative of the spread of sites.

Total government contribution for 47 sites in US$ - $ 515,001.00
Including a 10% contingency

Govt. contribution $ 566,500 or approx. 1,200,000 Birr.

5.2 Vaccine Refrigerator pilot project

See section B6 cost estimates for UNIDO contribution - $ 40,400
Govt. contribution - 12,100 Birr or $ 5,845.41

5.3 Lighting

Based on section C.10 and calculating two systems per school the cost estimates for a 50 schools project is as follows:

Foreign currency component: US$ 68,305
Local component: US$ 16,966 or 35,120 Birr.

Including US$ 3,000 or approx. 6,200 Birr for the transportation of equipment and installation team to the project sites

Total Government contribution: 41,320 Birr or approx. US$ 20,000.

A. WATER PUMPING

A.1. GENERAL DISCUSSION PAPER ON THE USE OF SOLAR WATER PUMPING FOR REMOTE REGIONS IN ETHIOPIA, with reference to survey records.

The ideal feature of photovoltaic power for small scale energy requirements is the ability to match energy supply and demand; a feature not available in small diesel systems. Diesel generator and direct belt driven pumping systems are not generally available below 3 kW; a glance at the survey results show how in many cases the installed system is oversized (mostly as a result of emergency aid than poor design). Hence, field efficiencies result in the order of 10 - 20% rather than factory figures of up to 35% with operation below capacity and poor maintenance accounting for performance drop. In these cases the prime mover and subsystem (transmission/ pump or generator/motor/pump) mismatch creates large penalties because the engine is operating below rated output. These unnecessary penalties are transferred to the community in the form of extra fuel costs. There is very little reliable data available on actual operational costs of diesel engines in the field whereas solar technology has been rigouously examined and analysed by a host of bodies. (It is probably true to say that if diesel powered pumping systems were at the same stage of evolvement as solar pumps they would have been consigned to oblivion). The greater technical simplicity, with fewer parts that can fail, longer life span and no fuel requirements of solar pumps

are important considerations, difficult to quantify economically, in installing rural water supplies. Conventional diesel systems in the remote parts surveyed present some organisational problems:

a) Breakdown

At several of the sites surveyed e.g. Harewa, Shinile, Wachyga Busha, Dolo Mekala the systems had not functioned for 3 months or so for a variety of reasons (contactor fuse at Dolo Mekala, mono pump transmission bearings at Shinile, Harewa). E.W.W.C.A. who are responsible for installation and maintenance of systems, is overstretched and their priorities clearly must lie with larger systems serving larger populations. There large systems will either be mains or diesel powered submersibles.

b) Rationalisation of equipment

A quick glance through the survey indicates the enormous range of equipment that each regional E.W.W.C.A. has to maintain and hence provide the investment capital for spare parts. Operational budget constraints present severe problems in spare part holdings. The notable exception is the Metema sites where a standard system of a Motori Slanzi prime mover with belt driven mono pump is installed at all sites. However, even here, the transmission bearing problems of the mono pumps (see Breakdown above) was evident.

c) Personnel

All the operators of the systems were dedicated to their responsibilities. However, they are not trained to more than superfically maintain their systems, laying a real onus on E.W.W.C.A. This maintenance difficulty was stressed by every regional manager. Introducing solar pumps does not require specific training in day to day operation.

d) Fuel

Fuel costs in regional centres are given in the site selection criteria. They do not represent the actual cost of delivering the fuel from regional centres to the remote areas; this actual cost is difficult to quantify because;

a) Ethiopia is a centrally planned economy with a basic fixed fuel price, not subject to market forces.

b) the institutional "hidden" cost of organizing and delivering fuel from regional centres could not be evaluated.

In some cases, e.g. Mile in Harerge, the supply had been so irregular that an individual in the community now purchased fuel in Dire Dawa and sold the water. This is an example where only those with sufficient cash

flow have access to potable water. This is a special case; in most communities money is collected by the water committee for fuel so there is either water for all or none at all, the latter being the case at Wachyga Lusha. In the new settlement and developing areas, such as Gambella and Metema, communities are totally dependent on the regional and central administration for providing fuel as they establish themselves economically; a heavy burden on the administration.

e) Distribution and Storage Systems (See A3)

Except for the onpoint storage and distribution systems, the elaborate large elevated steel tanks and several distribution lines and tap stands present both a large extra capital cost and extra running costs through increased system head. In future, for remote solar installations, on point ferro-cement storage tank with closeby multi tap points is advisable and for installation costs and analysis this is the advised design. However, for computer designs of surveyed sites existing storage and distribution systems have been accounted for in system head. Introduction of on point ferrocement tanks as part of government contribution to the project will increase water output at these sites.

f) Hand pumps and Diesel Systems: the time factor

A general comment made at every handpump site was the inordinate length of time waiting for

water; an opportunity cost of labour.

This feature of waiting for water is common at all small rural water projects, handpump and diesel systems. However, in the latter it is due to pumping twice a day (an indication of inadequate storage capacity) and has the advantage that it is relatively quick (and somewhat of a social event) whereas the demands on a single handpump in a village of 400 families are enormous - over 13 hours/day operation.

A.2 SITE SELECTION CRITERIA

A brief review of some of the criteria for identifying sites is considered useful for future work and is presented here.

a) Fuel costs and supply lines.

As outlined in the report, solar energy can replace fossil fuels in the remote areas where supply of fuel is difficult and expensive and in demographic terms, a low government priority. The comparatively populated highland areas of the country, well served with road and major supply points were not considered. Similarly, those areas with hydro development projects noted or underway (e.g. the mini hydro project north of Asosa, in Welega, which will eventually provide power to the Asosa settlements) and those areas to which national grid extensions are planned are not

considered. However, there are many sites within these areas which don't have energy access - the so called "near but far" places, which must be considered in plans future.

Fossil fuel is shipped to Asab and from there by road all over the country with considerable distances involved - Asab to Abobo, south of Gambella in Illubabor is a distance of nearly 2,000 km.

To illustrate the variability of fuel cost due to distance at the main centres:

	Diesel cost/litre		Distance from Addis
Addis Ababa	0.79 Birr.	$ 0.38	-
Jima	0.83 Birr.	$ 0.40	356 Km.
Metu	0.90 Birr	$ 0.43	619 Km.
Gambella, Illubabor (Ubala is some 80 Km south of Gambella).			
Gonder, Gonder (Metema is 175 Km N. W. of Gonder but fuel goes by plane).			
Yavello, Sidamo	0.91 Birr.	$ 0.44	570 Km.
Moyale, Sidamo	Fuel not available.		770 Km.
Harer, Harerge	0.80 Birr	$ 0.39	Fuel via Awash
Dire Dawa, Harerge	0.74 Birr	$ 0.38	"
Dessie, Wollo	0.75 Birr	$ 0.36	Fuel direct from Asab.

In terms of fuel costs, Illubabor is the most expensive; however, fuel supply for all sites surveyed represents a huge cost and committment by the W.S.S.A. (see "Economic Analysis" for analysis of varying fuel costs).

b) Fuel and Maintenance

Availability of fuel and maintenance is an important component of any rural water project. Currently the Ethiopian Water Works construction Authority installs the equipment and is responsible for maintenance and the Water Supply and Sewerage authority is responsible for running the systems (i.e. fuel supply). In some regions other national agencies assist in fuel supply e.g. RRC for Metema and Humera in Gonder and the army in the Ogaden. However, the extra ordinary diverse geography of Ethiopia and the huge task of providing potable water to all is stretching any organization to the limits. Consequently major construction projects are currently directed at population centres in the remote areas (e.g. Ogaden towns) and resettlement areas (e.g. Metema and Gambella) which leaves some smaller communities with a low priority both in well construction and fuel and maintenance services once the well is constructed. This is illustrated by the small communities along the Dire Dawa - Djibouti railroad where at 3 of the 4 wells visited, the generator or the pump bearings had failed 2 - 3 months before the visit; at the 4th well an individual had taken the responsibility of purchasing diesel in Dire Dawa and selling the water. This is the role of solar water pumping; to provide a minimum amount of water relatively maintenance free and with no fuel supply problems.

c) Site Locations (Population and well depth criteria)

The most suitable state of the art in solar pumps (and the stated preference of the ENEC)

is for A.C. submersible pumps which have a range up to 1.5 KW. At the top end of the range, a unit this size can provide up to 12 m^3 water/day from a well with a system head of 90 metres. This, at 10 litres/day/person can provide for a community of 1,000 people (see printouts for head vs. output for various insolations). The shallower the well and the smaller the system head the greater the output and the larger the community that can be supplied; alternatively surplus water can be used for expansion or the establishment of small irrigation plots (either fruit trees, green vegetables or tree nurseries) as at Harer and Gonder.

In general, hand pumps are ideal in a head range up to 20 - 25m; beyond this range some of the community (young, old and infirm) have some difficulty in hand pumping. There are severe restrictions when there is only one hand pump for the community as at Ubala and the Bara Abol villages (Finkao 6, 7 and 8) where up to 400 families use one handpump; a phenomenal organisation and timing schedule is required if every family is to pump water without long queues (if each family takes 2 minutes to take it's 20 - 30 litres this represents full time pumping of 13 hours a day !). In newly established settlements this time factor, represented by an opportunity cost of labour, together with lack of funds to pay for diesel provide an ideal location for solar pumps. This is the justification for the high priority for solar pumps on Gambella and Metema wells. In all handpump sites visited the main complaint of the water committees was the time factor; however a major feature of all rural

water systems in Ethiopia, both handpump and diesel pump systems, is the queue of containers and/or people at every distribution point.

d) Site Locations: Shading of array

Every site visited except for Harewa (near Dire Dawa) present no problems of shading of the array. The exception, Harewa is a situation where the community has spring up around the well. For future site surveys in locations like Harewa the following formulae are useful in calculating the location for the array to avoid shading:

Distance from the obstruction (wall, tree, tower) of height C = $\frac{C}{\tan \phi}$

Where ϕ = Solar altitude, angle of sun above horizon.

$\phi = \sin^{-1}(\sin(L)\sin(DEC) + \cos(L)\cos(DEC)\cos(HA))$

Where L = latitude (+ve for N hemisphere).

DEC = Solar declination, tilt of the earth w.r.t. sun for the day of the year (+ ve for N hemisphere.

= $23.45^{\circ} \times \sin(360 \times (284 + DAY)/365)$

Where DAY = No. of the day of the year

Jan 1st. = 1, Dec. 31 = 365

HA = hour angle, angular deviation away from solar noon (- refer morning, +ve afternoon).

= $(time - 12) \times 15^{\circ}$

Note: For Horizontal (N - S) tracking the formulae still apply but consider carefully the hour angle.

e) Security of System

See under tracking.

f) Insolation

Refer to FAO DATA or CESEN PUBLICATION. In the lowlands where the solar pumps are most viable at present, radiation is generally high and even. There are exceptions e.g. Gambella with 307 Langleys, 3.57 Kwh/m^2/day in August. Design tools provided as part of this project will enable ENEC to run printants for all sites in Ethiopia.

g) The array sits on a mesh reinforced slab on flat ground. Many of the sites are in black cotton (montmorillite) clay soils and drainage precautions must be taken. In all site selctions the soil and drainage conditions should be noted.

h) A preliminary evaluation of site viability w.r.t. hydrogeological parameters is possible if well drilling logs and pump test data is available. As part of the ongoing project all regional E.W.W.C.A. offices should be asked to submit on a quarterly basis all essential information to ENEC for viability analysis. As format varies from region to region copies of the attached form can be circulated.

SITE SURVEY REPORT

Location

Radiation station:

Population:

No. of wells:

Wells: aquifer type

depth

yield

drawdown

Pumping units:

motor

pump

no. of hours of operation

fuel consumption

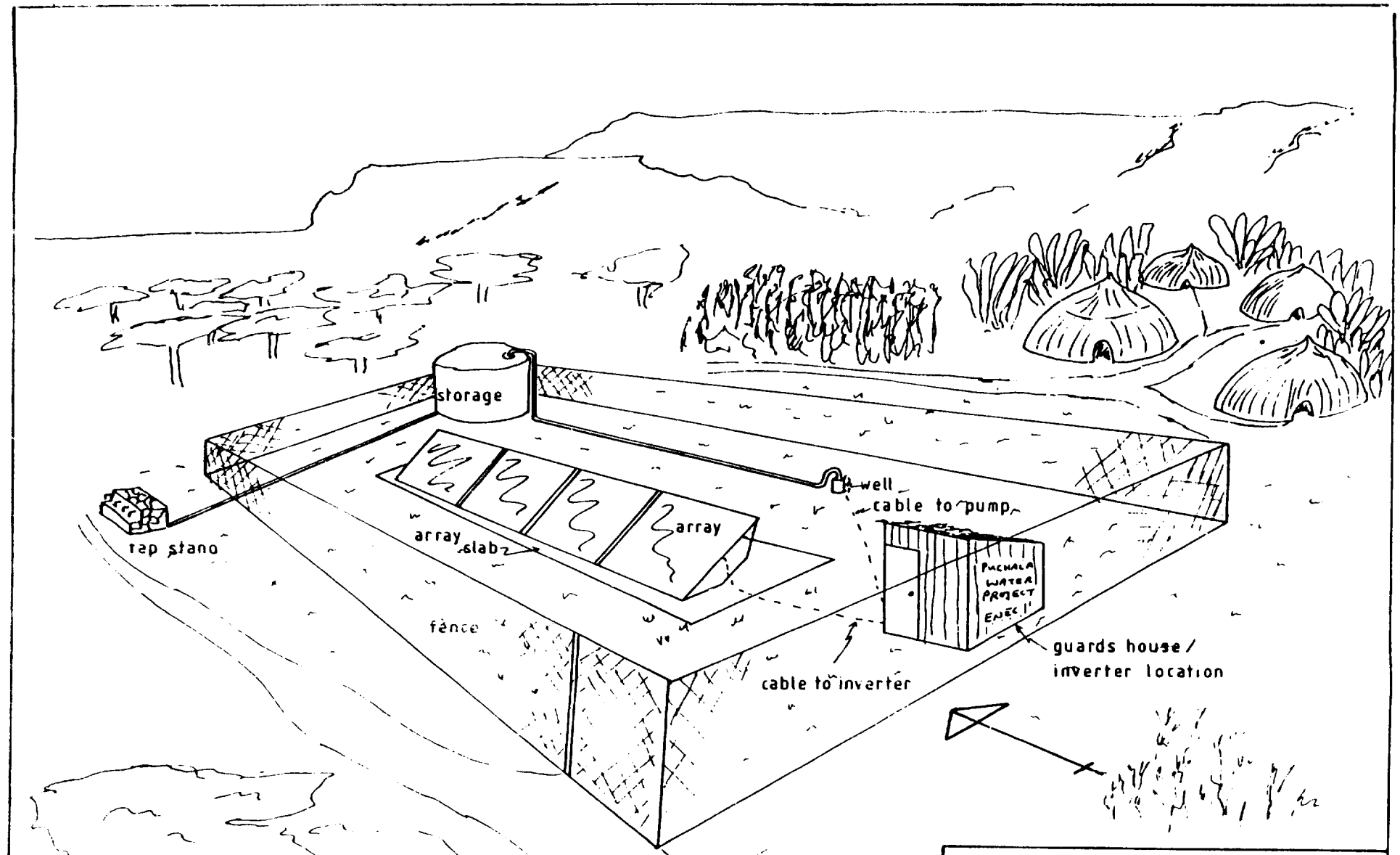
Distribution pipework Ø

length

storage

Array location:

Design:



note
all pipes and cables are buried

XR / ETH / 86 / 038
ideal installation schematic
(manual tracking)
december 1986 j goodman

A.3 STORAGE AND DISTRIBUTION SYSTEMS

Solar Water pumps have their major output between 11 a.m. and 3 p.m. when most rural communities are in the fields, at school or at market. Adequate storage facilities are an essential component of any solar installation and indeed of any water system (except handpumps). A large variety of storage tanks were inspected during the survey and the majority were steel tanks of between 2 - 8 m^3 capacity at an elevation of 2 - 6 metres above ground level. The advantage of steel tanks is that they are quick and easy to install if a crane is available. The disadvantage is that they are generally too small and very expensive.

In the computer printouts, the outputs are average daily water outputs based on average monthly radiation data. No two days are generally the same; consequently daily output varies and this must be accounted for in storage capacity.

a) Storage Construction Costs

These figures are from E.W.W.C.A., Jima and represent costs of construction in Jima; transport is extra. Note that a crane or other lifting device is required to lift steel tank off transport and onto support structures (exceptions are bolt together section tanks e.g. Braithewaite or Southern Cross tanks).

25 m^3	rectangular masonry tank	15,842 Birr or $	7653
50 m^3	rectantular masonry tank	33,206 Birr or $	16042
25 m^3	ferrocement tank	10,982 Birr or $	5305
10 m^3	steel tank (including masonry support)	22,024 Birr or $	10640

The Government contribution to this solar pump prcject will be in the storage construction. The most suitable choice from the cost viewpoint and from community participation is the 25m³ ferrocement tank. A 10 tonne truck can transport all the cement, steel and wire mesh together with a skilled mason and assistants from EWWCA regional workshop; the community can provide the cleaned sand and labour. Repair of ferrocement tanks is relatively simple and on-site requiring basic hand tools and cement.

The capacity of 25m³ allows a good margin of safety for variation in day to day radiation for most of the sites considered. Naturally this figure depends upon the design figure for daily water consumption and in these remote areas a figure of 10 liter/day/person of potable water is accepted, based on discussions with E.W.C.S. personnel. However, a generalisation for water system operation is that people tend to use as much water as is available but experience in solar water systems has shown that communities remarkably quickly adapt to daily varying outputs and always allow that margin of safety.

b) Distribution Systems

From economic, installation and energy viewpoint the distribution system should be as simple as possible. Generally the storage tank should as close to the well head as possible to reduce friction loss and extra pumping head. The distribution system to be a gravity fed tap stand(s) preferably with push taps.

In areas such as southern Sidamo and the Ogaden where cattle watering is required, the system design head has included use of existing storage tanks. Overflow pipes are then run to the cattle troughs which are either converted to storage or have secondary ferrocement tanks constructed beside them.

The existing distribution systems on the wells surveyed were quite elaborate but entailed a large extra cost (both in construction and running costs) with elevated storage tanks and tap stands in the village. To illustrate this point, the computer runs on Wachyga Busha with existing distribution system and a new "on point" distribution are considered. The well is situated some 375 metres north of the village storage tank, an 8 m^3 tank some 7 metre above Ground level. Water is gravity fed from this elevated tank to 3 tap stands in the village itself. The difference in system head between the two alternatives is 20 metres which, for small pumping systems, represents a great difference in energy requirements or a substantial difference in water output for the same energy input:- in this case 14.7^3 to 8.7^3 for fixed array and 19.6 m^3 to 11.5 m^3 for tracked array (70% in both cases). Solar powered water pumping and distribution systems should be designed with a strong bias towards energy efficiency; the input power of these deep well units should just pump demand water to the surface with simple on point distribution and storage systems requiring minimum energy. It is a reasonable assumption that with the task ahead of providing everyone with accessible

potable water that the water should be provided but it is unnecessary, and presently not economic, to have that water delivered "just outside the front door". In fact the system at Wachyga Busha has not worked for some months, due to lack of funds for diesel, and people walk up to 2 - 3 km to collect water from seasonal wells in the valley. The philosophy of 1st stage development water supplies should be to provide a minimum daily quantity of potable water as an alternative to unreliable, polluted and distant sources; at a later stage, as improved health and wellbeing results, convenience of that water is enhanced by introducing more elaborate distribution systems.

A.4. TRACKING ARRAYS

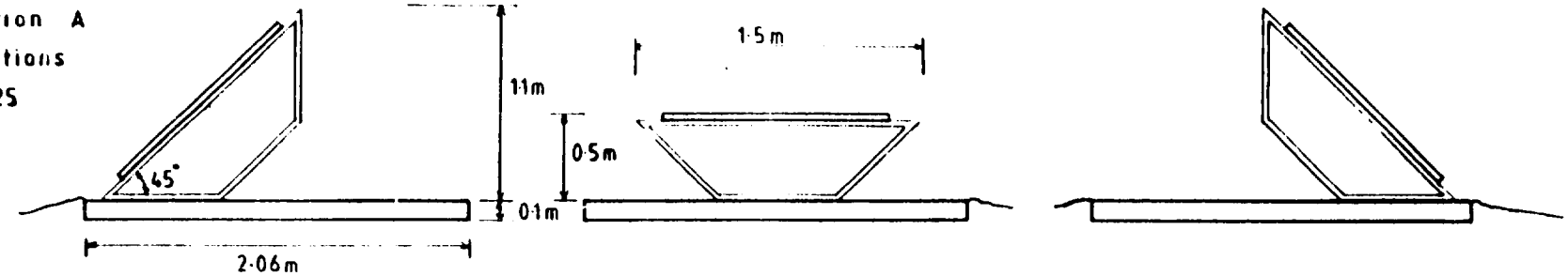
A series of computer simulations were run for a number of sites on different forms of tracking to gauge the effect on output. The runs for Metema Village No. 1 are included in this section to illustrate the variability of output for a variety of tilt angles and manual tracking. The difference in output between a fixed array, south facing, at tilt angles of 15° and 20° is negligible although the month to month variation was smaller for the 15° tilt angle. As any water supply design for solar must be based on output of the worst month, a run of 15° tilt with array facing the north is included; this proved inconclusive with a 10% overall reduction in average water output, and without a levelling in the month to month variation.

Double axis tracking give the largest average output but this is rather cumbersome for the array size under consideration if it is to be manually tracked. The most realistic tracking approach is the horizontal (N - S) axis tracking in which the array is tilted along the N - S axis towards the east (45^{o} to horizontal) in the morning, flat around midday (11 am-2 pm) and towards the west (45^{o} to horizontal) in the afternoon. (See technical drawings). The array is not fixed onto the slab and is tilted easily by hand.

In the survey summary (Annex II) computer runs are given for both fixed array (the array is bolted to the slab) facing south with a 15^{o} Tilt angle (to the horizontal) and for horizontal (N - S) axis tracking. The outputs for the horizontal (N - S) tracking are consistently 30% and above greater than for fixed arrays and in economic terms this is a considerable advantage.

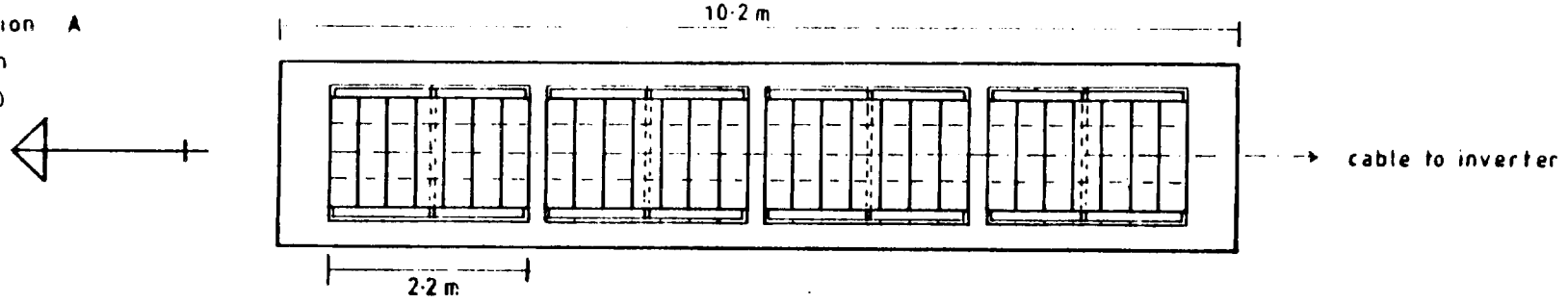
In operational terms a fixed array is fixed by definition and the only requirement is a cleaning of the array. In the horizontal (N - S) axis tracking an operator is required to tilt the arrays once or twice a day, as well as keep the arrays relatively dust free. Every village or settlement visited has a water committee which is responsible for collecting fees (to pay for diesel if a generator is installed), guard the system and to fairly distribute the water. Potable water is an essential part of living and as such any system providing such is treated with respect; certainly the experience of SEI is that we recommend this

option A
sections
1:25

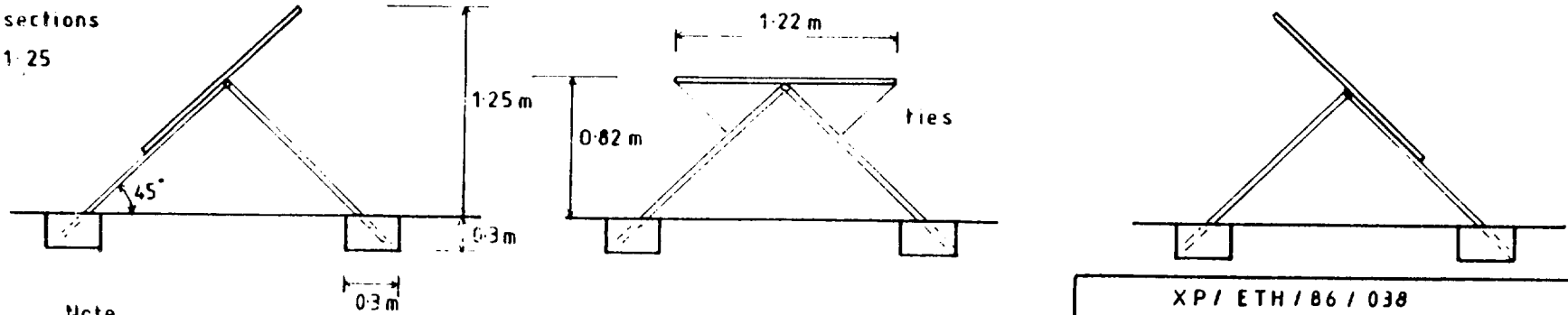


afternoon midday morning

option A
plan
1:50



option B
sections
1:25



Note

1 For sections, North is into the paper

2 For plan, North as shown

XP/ETH/86/038	
some stand options for horizontal	
(N-S)axis manual tracking	
December 1986	J. goodman

DESIGN PROVIDED BY: ARCO SOLAR EUROPE
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 4.2 12/20/85)

CUSTOMER: UNIDO SURVEY DATE: 7DEC86
ADDRESS: ETHIOPIA OPER: DJS

APPLICATION: AC WATER PUMPING

NOTE: VILLAGE NO 1
INSOLATION DATA LOCATION: METEMA ETHIOPIA (User Supplied)

LATITUDE: 12.95 DEG N LONGITUDE: 36.07 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	15.0 DEGREES	Grundfos SP1-28	
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-4	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	9.1 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	80.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	457	528	26.9	NA	9.5
FEB	514	567	29.6	NA	9.9
MAR	535	557	30.1	NA	9.7
APR	554	547	28.9	NA	9.5
MAY	516	491	28.7	NA	8.6
JUN	484	454	27.8	NA	8.0
JUL	477	452	26.1	NA	8.1
AUG	414	405	26.0	NA	7.1
SEP	479	489	26.0	NA	8.9
OCT	511	552	27.3	NA	9.9
NOV	497	567	27.9	NA	10.0
DEC	465	546	27.5	NA	9.7

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: ARCO SOLAR EUROPE
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 4.2 12/20/85)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 7DEC86
OPER: DJS

APPLICATION: AC WATER PUMPING

NOTE: VILLAGE NO 1
INSOLATION DATA LOCATION: METEMA ETHIOPIA (User Supplied)

LATITUDE: 12.95 DEG N LONGITUDE: 36.07 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	20.0 DEGREES	Grundfos SP1-28	
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-4	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	9.0 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	80.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	457	546	26.9	NA	9.8
FEB	514	578	29.6	NA	10.0
MAR	535	557	30.1	NA	9.7
APR	554	537	28.9	NA	9.3
MAY	516	476	28.7	NA	8.4
JUN	484	438	27.8	NA	7.6
JUL	477	437	26.1	NA	7.7
AUG	414	397	26.0	NA	6.8
SEP	479	486	26.0	NA	8.8
OCT	511	559	27.3	NA	10.0
NOV	497	584	27.9	NA	10.3
DEC	465	567	27.5	NA	10.1

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: ARCO SOLAR EUROPE
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 4.2 12/20/85)

CUSTOMER: UNIDO SURVEY DATE: 7DEC86
ADDRESS: ETHIOPIA OPER: DJS

APPLICATION: AC WATER PUMPING

NOTE: VILLAGE NO 1
INSOLATION DATA LOCATION: METEMA ETHIOPIA (User Supplied)

LATITUDE: 12.95 DEG N LONGITUDE: 36.07 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	15.0 DEGREES	Grundfos SP1-28	
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-4	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	8.1 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	80.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	457	386	26.9	NA	6.3
FEB	514	456	29.6	NA	7.7
MAR	535	504	30.1	NA	8.8
APR	554	549	28.9	NA	9.5
MAY	516	531	28.7	NA	9.3
JUN	484	507	27.8	NA	9.0
JUL	477	495	26.1	NA	9.0
AUG	414	417	26.0	NA	7.4
SEP	479	462	26.0	NA	8.4
OCT	511	464	27.3	NA	8.1
NOV	497	424	27.9	NA	7.0
DEC	465	383	27.5	NA	6.2

NOTE: ARRAY TO FACE TRUE NORTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: ARCO SOLAR EUROPE
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 4.2 12/20/85)

CUSTOMER: UNIDO SURVEY DATE: 7DEC86
ADDRESS: ETHIOPIA OPER: DJS

APPLICATION: AC WATER PUMPING

NOTE: VILLAGE NO 1
INSOLATION DATA LOCATION: METEMA ETHIOPIA (User Supplied)

LATITUDE: 12.95 DEG N LONGITUDE: 36.07 DEG E
GROUND REFLECTANCE: .20 (J)

SELECTED SYSTEM DATA

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

ARRAY

DOUBLE AXIS TRACKING
MAX. PWR. CURRENT: 12.2 A.
MAXIMUM POWER: 1486.0 W.

AS INC M55 3.05 A. @ 17.4 V.
7 (S) X 4 (P) = 28 TOTAL

PUMP SYSTEM

Grundfos SP1-28
102 VDC 1500 W XX-4
COUPLED TO ARRAY @ 105 VOLTS

AVG. DAILY OUTPUT: 12.6 CU.M
SYSTEM HEAD: 80.0 M.

SYSTEM DESIGN ANALYSIS

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	457	698	26.9	NA	12.9
FEB	514	736	29.6	NA	13.4
MAR	535	716	30.1	NA	13.2
APR	554	713	28.9	NA	13.2
MAY	516	658	28.7	NA	12.5
JUN	484	618	27.8	NA	12.0
JUL	477	605	26.1	NA	11.9
AUG	414	514	26.0	NA	10.1
SEP	479	620	26.0	NA	12.2
OCT	511	709	27.3	NA	13.3
NOV	497	747	27.9	NA	13.5
DEC	465	731	27.5	NA	13.2

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: ARCO SOLAR EUROPE
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 4.2 12/20/85)

CUSTOMER: UNIDO SURVEY DATE: 7DEC86
ADDRESS: ETHIOPIA OPER: DJS

APPLICATION: AC WATER PUMPING

NOTE: VILLAGE NO 1
INSOLATION DATA LOCATION: METEMA ETHIOPIA (User Supplied)

LATITUDE: 12.95 DEG N LONGITUDE: 36.07 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------
HORIZONTAL (N-S) AXIS TRACKING
MAX. PWR. CURRENT: 12.2 A.
MAXIMUM POWER: 1486.0 W.

AS INC M55 3.05 A. @ 17.4 V.
7 (S) X 4 (P) = 28 TOTAL

---------PUMP SYSTEM---------
Grundfos SP1-28
102 VDC 1500 W XX-4
COUPLED TO ARRAY @ 105 VOLTS

AVG. DAILY OUTPUT: 12.2 CU.M
SYSTEM HEAD: 80.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	457	611	26.9	NA	11.8
FEB	514	686	29.6	NA	12.8
MAR	535	702	30.1	NA	13.1
APR	554	711	28.9	NA	13.2
MAY	516	649	28.7	NA	12.4
JUN	484	602	27.8	NA	11.7
JUL	477	593	26.1	NA	11.6
AUG	414	512	26.0	NA	10.1
SEP	479	615	26.0	NA	12.1
OCT	511	675	27.3	NA	12.9
NOV	497	666	27.9	NA	12.5
DEC	465	624	27.5	NA	11.9

NOTE: TRACKER LIMIT ANGLE IS 30.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT
UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: ARCO SOLAR EUROPE
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 4.2 12/20/85)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 7DEC86
OPER: DJS

APPLICATION: AC WATER PUMPING

NOTE: VILLAGE NO 1
INSOLATION DATA LOCATION: METEMA ETHIOPIA (User Supplied)

LATITUDE: 12.95 DEG N LONGITUDE: 36.07 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------
HORIZONTAL (N-S) AXIS TRACKING
MAX. PWR. CURRENT: 12.2 A.
MAXIMUM POWER: 1486.0 W.

AS INC M55 3.05 A. @ 17.4 V.
7 (S) X 4 (P) = 28 TOTAL

---------PUMP SYSTEM---------
Grundfos SP1-28
102 VDC 150C XX-4
COUPLED TO AR. .Y @ 105 VOLTS

AVG. DAILY OUTPUT: 11.9 CU.M
SYSTEM HEAD: 80.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	457	601	26.9	NA	11.4
FEB	514	674	29.6	NA	12.5
MAR	535	691	30.1	NA	12.8
APR	554	701	28.9	NA	13.0
MAY	516	642	28.7	NA	12.2
JUN	484	597	27.8	NA	11.5
JUL	477	588	26.1	NA	11.5
AUG	414	507	26.0	NA	9.9
SEP	479	607	26.0	NA	11.9
OCT	511	664	27.3	NA	12.6
NOV	497	654	27.9	NA	12.3
DEC	465	613	27.5	NA	11.4

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

tracking approach. The community becomes involved in running it's own water system and as there are no technical skills required everyone can participate in maximising water output.

In terms of security the tracking approach has it's drawbacks in that the array is not bolted to a slab. However, a chain loosely run between the support stands, and anchored to the slab, coupled with a mesh fence (a requirement even for a fixed array) and a guard (which all systems have anyway) minimises this problem. For some sample tracking options refer to the drawing attached at the end of this section.

A.5. SYSTEM INSTALLED COSTS

Typical cost for a system with 60 metre T.D.H. producing 20m³ water/day at a new well site in remote area e.g. Gambela district.

Exchange rate US$ 1 = 2.07 Birr.

1.	P.V. pumping system (modules, stands, cables, inverter, pump)	US$ 14311.95
2.	Sea freight, insurance to Asab (estimate only - this will depend on quantity)	US$ 1000.00
3.	Transport Asab - Jima	1500 Birr.

4.	Transport of pumping system, cement, reinforcement steel, mesh and pipe work 1 no 10 tonne E.W.W.C.A. truck. Jima - Gambella (roundtrip)	800	Birr
5.	Construction of base slab 10m x 2.2m x 0.10m with mesh reinforcement.	2000	"
6.	Construction of 25m³ ferrocement tank using local labour and sand (community contribution)	10982	"
7.	Pipework (2" dia) for system of 60m head including drop pipe, gate valves, bends and 8 fawcett distribution point	1700	"
8.	Skilled mason for 1 month including field allowance to supervise tank construction.	600	"
9.	E.W.W.C.A. pump installation team to wire array install pump	1200	"
10.	Erection of fence around array 25m x 15m x 1.5m high of 50mm x 50mm mesh including gate.	2700	"
		c/f	c/f

11.	Erection of guard house including mounting of pump and inverter	1200 Birr.	
	Total:	22682 Birr.	US$ 15311.95

Total cost: $ 15311.95 foreign component
$ 10957.48 local component

Total system: $ 26269.44
==========

Or $ 17.7/Wp complete system with 25m³ storage tank and on point distribution system.

Note: The P.V. pumping system c.i.f. cost Ethiopia is $ 10.30/Wp. The balance of $ 7.4/Wp for installation costs (or $ 10957.48) of P.V. pump is not that much greater than for diesel pump installation and is of the order of 20%. The major additional cost for p.v. installation is a mesh fence.

B. VACCINE REFRIGERATION

B.1. BACKGROUND AND JUSTIFICATION

EPI Programme

The cold chain in Ethiopia is limited at present to the areas of high population density due to institutional and financial restraints; However, the government is committed to extend the EPI project countrywide. A feature of most settlements is a health post staffed by dedicated workers who provide nutritional training, administer basic health care and provide some drugs. Any immunisation programme in the remote areas are executed by outreach programmes from the main centres. For example, the settlements at Abobo and Ubala, some 80 - 100 km south of Gambela are served by an outreach programme based at Gambela hospital. The programme is severely hampered by lack of vehicles which makes scheduled visits irregular with the end result an inadequate programme. The government are well aware of this and the main thrust of their programme is to extend the cold chain into the rural areas where vaccine deliveries can be independent of immunisation schedules.

The Ministry of Health has standardised on kerosene refrigerators to facilitate training and maintenance programmes but they are aware of the limitations of kerosene refrigerators even though they are relatively inexpensive. Reliability, operation and maintenance costs and initial capital

costs are the criteria, in order of importance, for any cold chain. WHO and World Bank surveys have shown that from 15 - 50% of the time, kerosene refrigerators are not operating. This down time has implications not only for the direct financial implications of a batch of vaccine rendered inviable (at $ 19/litre this can be substantial) but also for the credibility of any vaccination programme. Ineffective vaccinations resulting in people contracting the disease will lose the trust of communities. The supply and quality of kerosene, availability of spares and the difficulties of maintenance greatly affects kerosene operation. The supply of fuel is the most critical both in terms of delivery and avaibilibility the community may not have sufficient cash flow year round to purchase, or, if supplied from regional centres, the usual end of month and end of budgetary cycle constraints make funds frequently scarce.

B.2. INTRODUCING SOLAR VACCINE REFRIGERATORS

In 1983, the Ministry of Health together with WHO approached SIDA for financing a pilot project for a number of easily accessible sites, in different climatic conditions of the country, for evaluation of this technology. At this stage, there were very few proven systems available, what was available was expensive, and perhaps more importantly it was the responsibility of the supplier to separately aquire system components which made warranty claims impossible. The project was not funded. However,with the present state of the art there are many proven cheaper systems with

warranties of 5 - 7 years which make the financial implications more attractive coupled with proven use and comprehensive EPI evaluations. Perhaps the most significant report is the UNDP/World Bank study in the Gambala in 1985 ("Pre-investment report on solar photovoltaic applications in the health and telecommunications sectors") financed by WHO. The summary of life cycle costs suggest that PV is slightly cheaper ($ 0.53/dose of vaccine) than kerosene refrigeration ($ 0.62/dose of vaccine) when all the costs, capital, installation and O&M costs are considered. For annualised costs, PV costs vary between $ 0.80 and $ 1.00 per month per litre of refrigeration capacity, about the same for kerosene refrigeration.

B.3. THE PV REFRIGERATOR

The real advantages of the PV refrigerator is that the fuel supply problem is eliminated and that demands on operating budgets for the purchase of fuel is removed. In some areas, of course, kerosene will always be readily available. The units require very little maintenance most of which is related to defrosting and temperature controls (as with kerosene); monthly checks of battery levels (if non sealed type) and cleaning the array. The units use equipment standard to all household a.c. fridges whose realiability is well demonstrated with a life span of at least 10 years. Training of operators is considerably easier than with kerosene refrigerators whose burner, flue and wick must be serviced each week to ensure reasonable operation.

The performance of PV systems is principally affected by the initial sizing of the array and battery bank; typically 3 - 5 days of battery back up is provided. In the event of array malfunction this allows time to either repair the fault or move vaccines to another location.

Operating availability of PV systems is significantly higher than for kerosene - fueled systems with only 1 - 5% of the time as 'downtime' compared to kerosene system avaibality of 15 - 50%. The financial implications of wasted vaccine is of prime importance to limited budgets.

B.4. THE PILOT PROJECT

Six sites were selected in the 1983 proposal and these same sites will be used. They represent the diverse climatic conditions of Ethiopia but are in locations which are easily accessible to EPI staff for evaluation, monitoring and training. This is a realistic approach in terms of introducing this technology.

The sites are

ADDIS ABABA		
IJAJI	-	175 Km W. of Addis
BUTAJIRA	-	210 Km S.W. of Addis
EFFESON	-	270 Km N. E. of Addis
AWAS A	-	310 Km S. of Addis
ASAB		

See attached site plans and array locations for all sites except Asab.

B.5. PROJECT INPUTS

The project is aimed at evaluation, monitoring and training in a new technology and the sites choosen are in areas where there is electricity supply, easy access but with a variety of climatic conditions. In these areas it is the experience of operation and training that is essential and other facilities can be used to store the larger number of vaccines that will be required. The equipment should represent the complete versatility of the technology and will include a 40 - 50 vaccine storage capacity as well as ice making facility. This latter component is important for outreach programmes where the health worker on a bicycle and with a cold box can service several neighbouring settlements.

Refer to cost estimates for pilot project, including installation, for breakdown of government and UNIDO contributions. For full specifications and terms of tender refer to the draft terms of reference, section 3.2,vaccine refrigerator pilot project.

B.6. COST ESTIMATES FOR SOLAR VACCINE REFRIGERATOR PILOT PROJECT

		US$	BIRR.
1.	Supply of 6 No. Solar powered vaccine refrigerators with 40-50 litre storage capacity, ice making facility and complete with adequate sized solar array stand and battery storage bank for up to 5 days "no sun" conditions.	$ 24,000	
2.	10% spares package consisting of 1 compressor unit, 2 solar modules, repair kits, batteries (to manufacturer's recommendations)	$ 2,400	
3.	Transport to Assab - estimate seafreight.	$ 3,000	
4.	Manufacturers engineer to install fridges and train EPI technicians, three weeks plus airfare.	$ 7,000	
5.	Array stand foundations - to be specified by manufacturer (assume 1.0m^3 reconcrete/stand) 6m^3		3,600
6.	Fencing for each stand - 1.5m high 200m x 200m mesh supported by steel posts set in concrete with gate, including labour.		4,900
		c/f	c/f

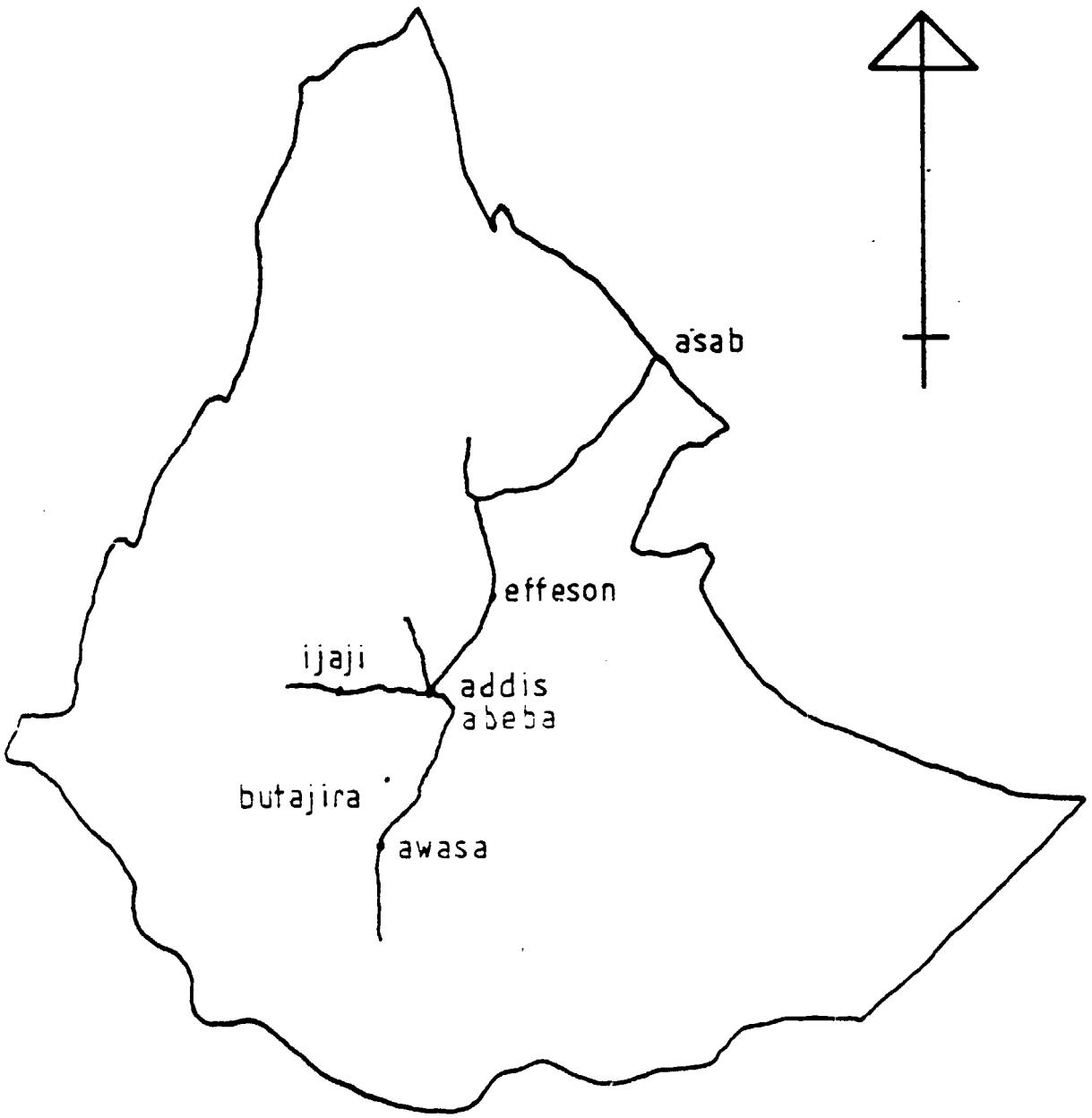
7.	Transport of materials, solar equipment and installation team.		2,500
	Total:	$ 36,400	11,000 Birr.
	+ Contingencies 10%	$ 40,400	12,100 Birr.

UNIDO contribution $ 40,400

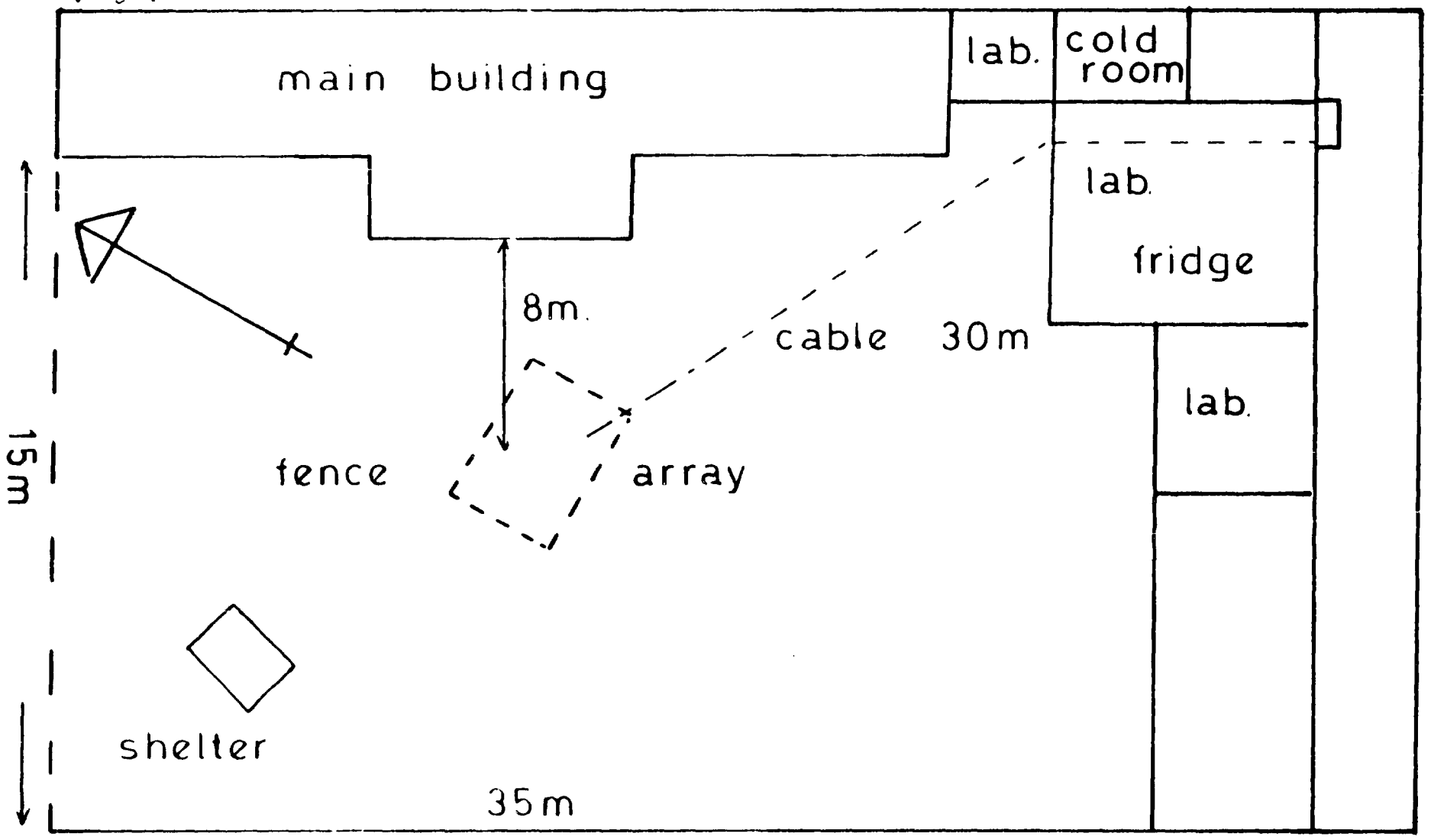
Govt. contribution 12,100 Birr.

Note: 1. Transport of manufacturers representative to be provided by EPI.

2. Manufacturer to advise beforehand specifications for array stand foundation so that this is ready on arrival.

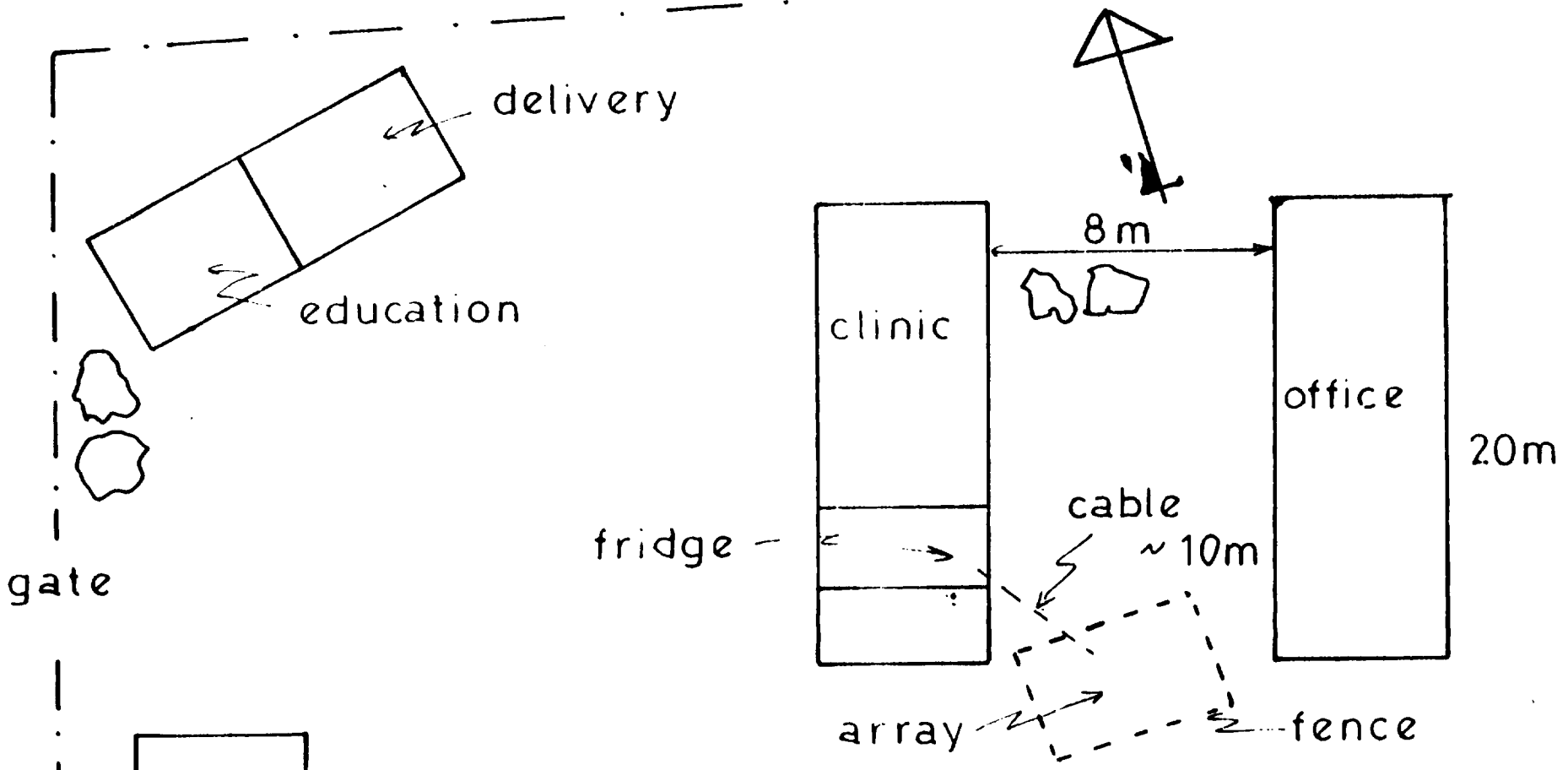


XP / ETH / 86 / 038	
location of sites for EPI solar vaccine	
refrigerator pilot project	
december 1986	j goodman



central laboratory
addis ababa

not to scale


delivery
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ijaji health centre
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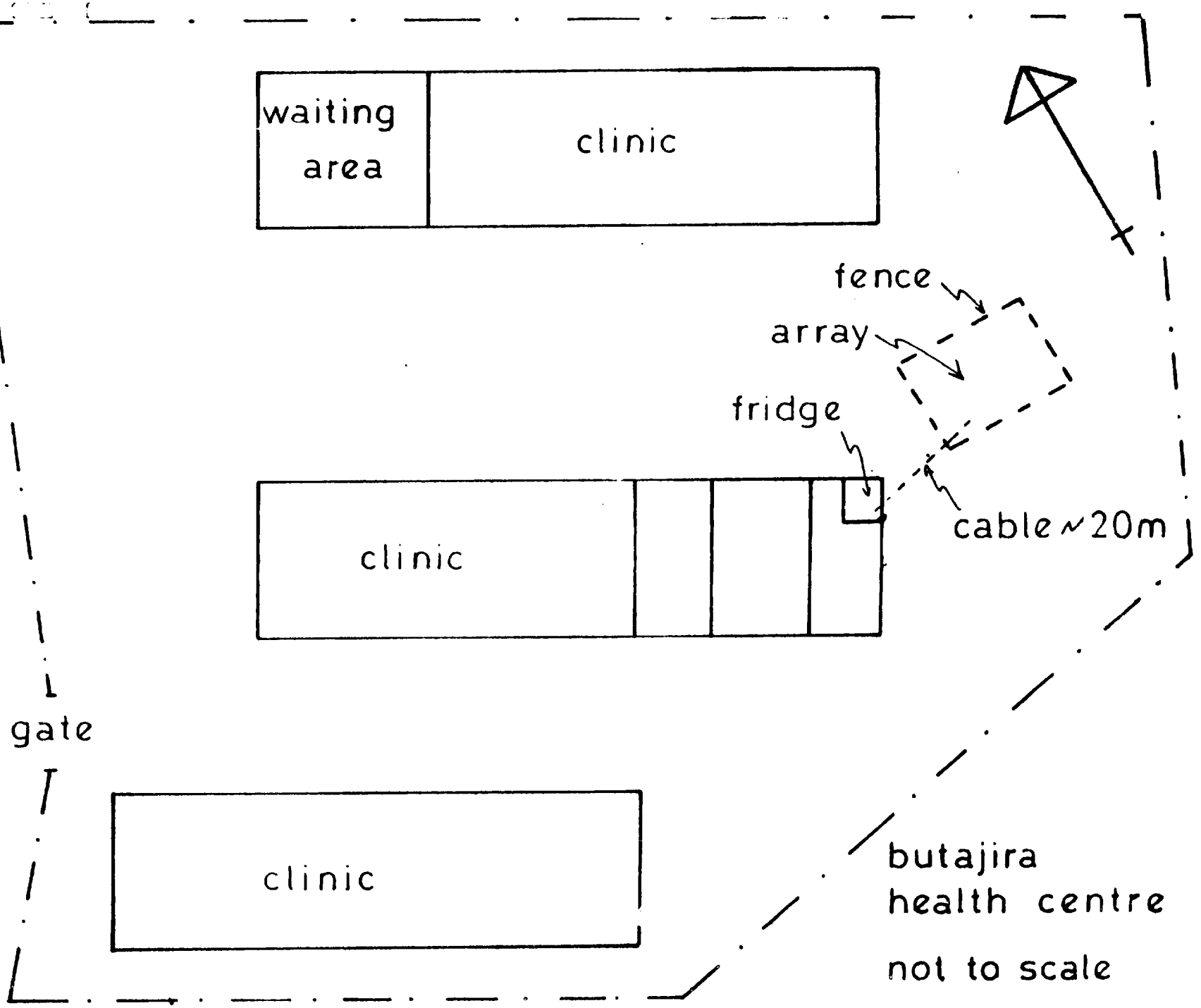
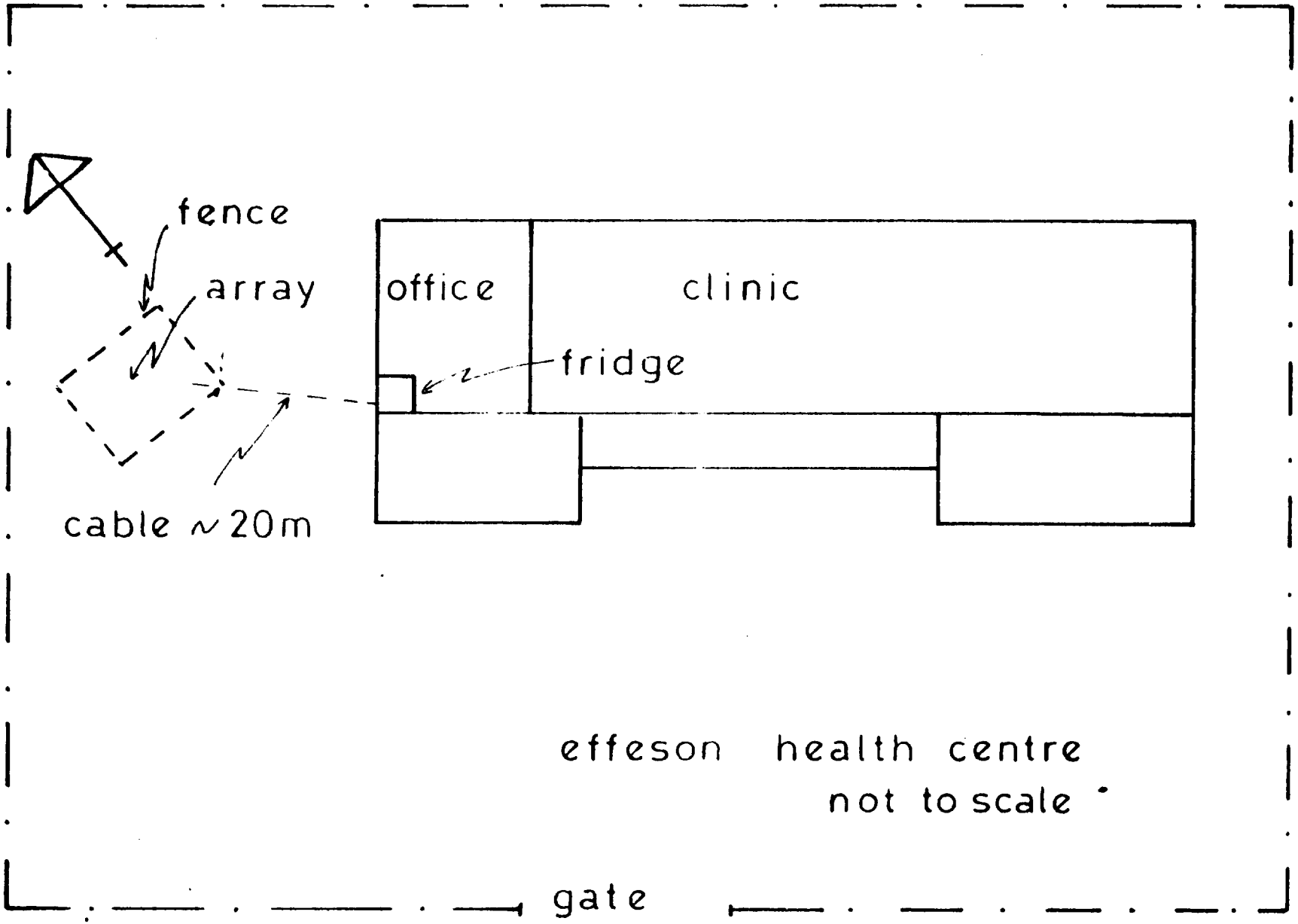
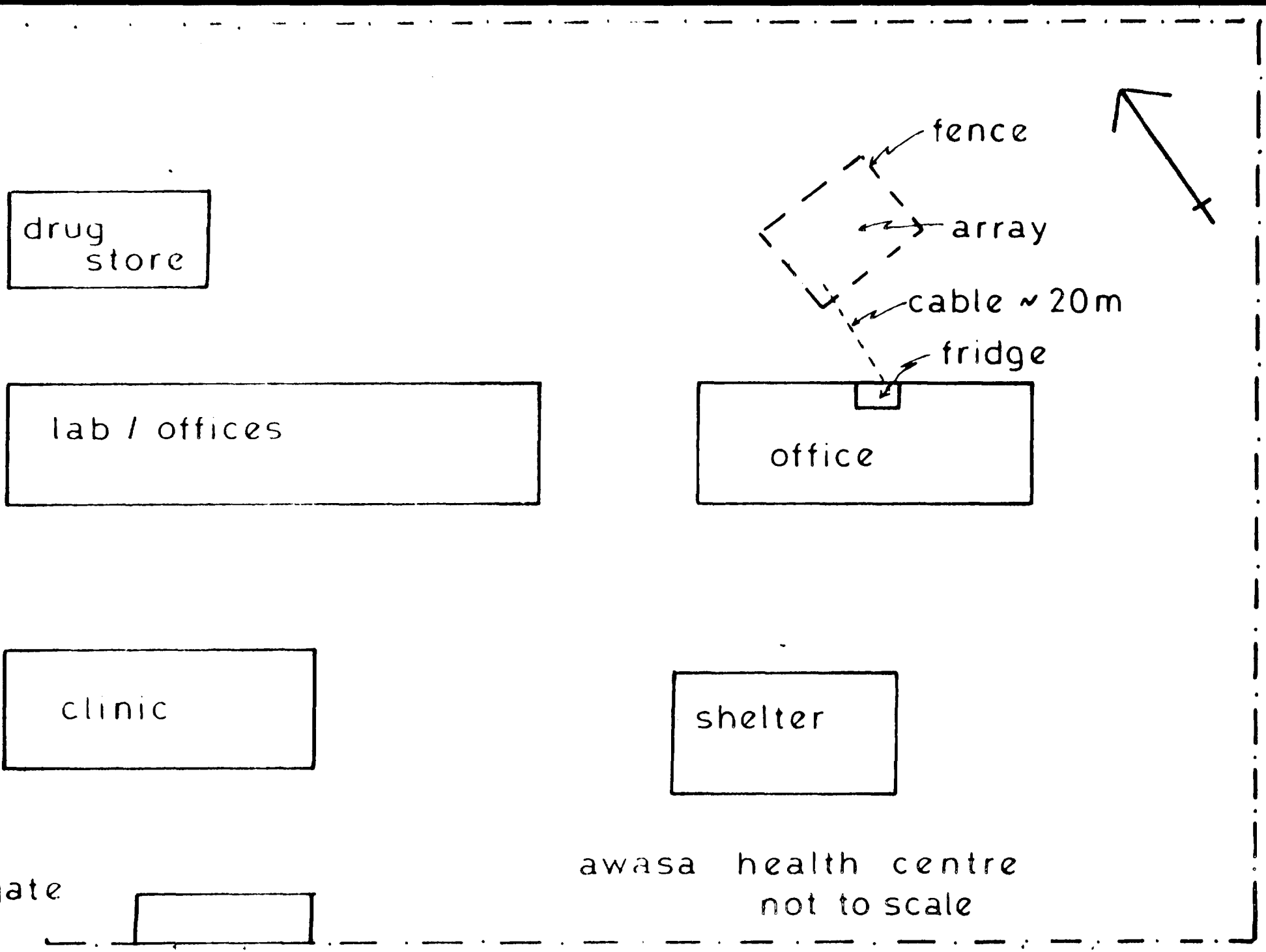

waiting area
clinic
fence
array
fridge
clinic
cable ~20m
gate
clinic
butajira health centre
not to scale


fence
array
office
clinic
fridge
cable ~ 20m
effeson health centre
not to scale
gate


fence
array
cable ~ 20m
fridge
drug store
lab / offices
office
clinic
shelter
gate
awasa health centre
not to scale

C. SOLAR POWERED LIGHTING FOR SCHOOLS AND BASIC DEVELOPMENT EDUCATION CENTRES

As outlined in the project, introducing solar powered lighting into the primary schools and Basic Development Education Centres will considerably extend the daily use of these units. Adult literacy classes and reading rooms in the evening will provide the government the means and the community the ability to actively engage in development education. These simple 12 volt direct current systems are a convenient tool.

C.1. P.V. LIGHTING SYSTEM

Experience has shown that the smaller the system the better with a modular approach which can directly respond to budget constraints. The one module/one battery per school or reading room, rather than the large array/large battery storage and distribution system, approach is preferred. Any malfunction of a smaller system is isolated to that particular system and, from an implementation viewpoint, as money comes available more units can be installed in the same village centre.

C.2. MODULE SITING, INSTALLATION AND SYSTEM DESCRIPTION

The module is fixed on a bracket 3-4 metres above ground on a 4" G.I. pipe, one end of which is embedded in concrete. The pipe is as close to the school office of BEDC office or store as possible.

This 'stand alone' mounting rather than roof mounting is to avoid installation snags where the roof ridge does not run E-W and trying to position the module facing true south is difficult. The battery and charge controller are placed either in the office or store of the school or BEDC depending on which wall is more south facing. The battery should be placed in a box to avoid tampering. The controller is mounted on the wall. The wire from the module runs to controller and hence to battery; wiring to lights runs along the top of the wall and then to the middle of each of the 3 trusses of the BDEC (and to the 3 trusses nearest the office/store of the primary school) where the 13 watt flourescent lights are positioned. Switches for these lights are located by the door. The 13 watt flourescent lights give an equivalent of about 5 times an incandescent bulb i.e. the same as a 60 watt bulb.

C.3. MODULE SIZING AND LOAD FACTOR

Once the lighting requirement and the number of hours of operation per day, on average, is decided upon, the daily load can be calculated;

No. of amps per lamp x no. of lamps x no. of hours = daily load in ampere hours.

The current drain of the lights is calculated by dividing the wattage by 12. Once the daily load is known then refer to the system design analysis computer printouts and in particular to the average AH/day output of the module specified. There is a

range of monthly outputs and any sizing must consider the lowest monthly output which for Asosa, Gambella and Metema falls in Augugt. If systems output and system input match for this month then in all other months there will be a surplus enegy maintaining the battery at a high state of charge, a desirable feature.

C.4. MODULE OUTPUT ANALYSIS FOR GAMBELLA, ASOSA AND METEMA

The three module types chosen for the computer runs are fairly representative of the available market range:

ARCO M55	53 watt module	3.05 Amps at 17.4V
ARCO M65	42.1 watt module	2.90 Amps at 14.5V
ARCO M75	47 watt module	2.94 Amps at 16.0V

Note that the M65 module has a maximum voltage of 14.5 volts which is ideal for charging 12 volt batteries without the need for a charge controller. This "self regulating" characteristic as it is called is generally an option in the product range of most module manufacturers; it has lower daily output. However, it is advisable to have a low voltage cut out with the self regulating modules to avoid deep discharging the battery.
Worst month outputs in AH (ampere hours) are:

	Metema	Gambella	Asosa
M55	12.6	9.4	10.0
M65	10.2	8.0	8.9
M75	12.0	9.1	9.7

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/BATTERY)
(SASY/B Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 11th December 1986
OPER: J GOODMAN

APPLICATION: INDUSTRIAL D.C.

INSOLATION DATA LOCATION: ASOSA (User Supplied)

LATITUDE: 10.04 DEG N LONGITUDE: 34.31 DEG E
GROUND REFLECTANCE: .20 (J)

SYSTEM VOLTAGE: 12 V.D.C.
AVG. LOAD: 1 AH/DAY (nighttime)

----------SELECTED SYSTEM DATA----------

VOLTAGE LOSS: .5 V. THROUGH CABLE.

----------ARRAY----------		----------BATTERY----------	
TILT ANGLE:	15.0 DEGREES	DAYS OF AUTONOMY:	161.6
MAX. PWR. CURRENT:	2.9 A.	MINIMUM BATT. TEMP. @ 19.4 C.	
MAXIMUM POWER:	47.0 W.	TOTAL STORAGE:	202.0 AH
AS INC M75	2.94 A. @ 16.0 V.	GNB ABSOLYTE 35A9	2 V, 202 AH
1 (S) X 1 (P) =	1 TOTAL	6 (S) X 1 (P) =	6 TOTAL

SYSTEM DESIGN ANALYSIS
(BASED ON 90 % OF RATED OUTPUT)

MONTH	FLAT LANG	PANEL LANG	-AVG. AH/DAY- OUTPUT	LOAD	END OF MONTH CAPACITY
JAN	481	547	15.8	1.0	100.0 %
FEB	493	536	15.5	1.0	100.0 %
MAR	441	454	13.4	1.0	100.0 %
APR	533	523	15.1	1.0	100.0 %
MAY	441	420	12.5	1.0	100.0 %
JUN	393	371	11.1	1.0	100.0 %
JUL	379	361	10.8	1.0	100.0 %
AUG	331	324	9.7	1.0	100.0 %
SEP	444	449	13.5	1.0	100.0 %
OCT	461	490	14.6	1.0	100.0 %
NOV	446	499	14.8	1.0	100.0 %
DEC	442	509	14.9	1.0	100.0 %

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

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STAND-ALONE SYSTEM DESIGN PROGRAM (PV/BATTERY)
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SYSTEM DESIGN ANALYSIS
(BASED ON 90 % OF RATED OUTPUT)

MONTH	FLAT LANG	PANEL LANG	-AVG. AH/DAY- OUTPUT	LOAD	END OF MONTH CAPACITY
JAN	481	547	12.6	1.0	100.0 %
FEB	493	536	12.3	1.0	100.0 %
MAR	441	454	11.1	1.0	100.0 %
APR	533	523	12.1	1.0	100.0 %
MAY	441	420	10.8	1.0	100.0 %
JUN	393	371	9.9	1.0	100.0 %
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DATE: 11th December 1986
OPER: J GOODMAN

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----------ARRAY----------		----------BATTERY----------	
TILT ANGLE:	15.0 DEGREES	DAYS OF AUTONOMY:	161.6
MAX. PWR. CURRENT:	3.1 A.	MINIMUM BATT. TEMP. @ 19.4 C.	
MAXIMUM POWER:	53.1 W.	TOTAL STORAGE:	202.0 AH
AS INC M55	3.05 A. @ 17.4 V.	GNB ABSOLYTE 3SA9	2 V, 202 AH
1 (S) X 1 (P) =	1 TOTAL	6 (S) X 1 (P) =	6 TOTAL

SYSTEM DESIGN ANALYSIS
(BASED ON 90 % OF RATED OUTPUT)

MONTH	FLAT LANG	PANEL LANG	-AVG. AH/DAY- OUTPUT	LOAD	END OF MONTH CAPACITY
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MAY	441	420	13.0	1.0	100.0 %
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JUL	379	361	11.1	1.0	100.0 %
AUG	331	324	10.0	1.0	100.0 %
SEP	444	449	14.0	1.0	100.0 %
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(SASY/B Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 11th December 1986
OPER: J GOODMAN

APPLICATION: INDUSTRIAL D.C.

INSOLATION DATA LOCATION: GAMBELA (User Supplied)

LATITUDE: 8.25 DEG N LONGITUDE: 34.58 DEG E
GROUND REFLECTANCE: .20 (J)

SYSTEM VOLTAGE: 12 V.D.C.
AVG. LOAD: 1 AH/DAY (nighttime)

----------SELECTED SYSTEM DATA----------

VOLTAGE LOSS: .5 V. THROUGH CABLE.

----------ARRAY----------		----------BATTERY----------	
TILT ANGLE:	15.0 DEGREES	DAYS OF AUTONOMY:	161.6
MAX. PWR. CURRENT:	2.9 A.	MINIMUM BATT. TEMP. @	26.1 C.
MAXIMUM POWER:	42.1 W.	TOTAL STORAGE:	202.0 AH
AS INC M65	2.90 A. @ 14.5 V.	GNB ABSOLYTE 35A9	2 V, 202 AH
1 (S) X 1 (P) =	1 TOTAL	6 (S) X 1 (P) =	6 TOTAL

SYSTEM DESIGN ANALYSIS
(BASED ON 90 % OF RATED OUTPUT)

MONTH	FLAT LANG	PANEL LANG	-AVG. AH/DAY- OUTPUT	LOAD	END OF MONTH CAPACITY
JAN	468	527	11.1	1.0	100.0 %
FEB	474	511	10.9	1.0	100.0 %
MAR	448	459	10.2	1.0	100.0 %
APR	486	475	10.6	1.0	100.0 %
MAY	398	379	9.3	1.0	100.0 %
JUN	380	358	9.0	1.0	100.0 %
JUL	370	351	9.0	1.0	100.0 %
AUG	314	307	8.0	1.0	100.0 %
SEP	407	410	10.2	1.0	100.0 %
OCT	439	464	10.9	1.0	100.0 %
NOV	440	488	11.4	1.0	100.0 %
DEC	455	519	11.4	1.0	100.0 %

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

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ADDRESS: ETHIOPIA

DATE: 11th December 1986
OPER: J GOODMAN

APPLICATION: INDUSTRIAL D.C.

INSOLATION DATA LOCATION: GAMBELA (User Supplied)

LATITUDE: 8.25 DEG N LONGITUDE: 34.58 DEG E
GROUND REFLECTANCE: .20 (J)

SYSTEM VOLTAGE: 12 V.D.C.
AVG. LOAD: 1 AH/DAY (nighttime)

----------SELECTED SYSTEM DATA----------

VOLTAGE LOSS: .5 V. THROUGH CABLE.

----------ARRAY----------		----------BATTERY----------	
TILT ANGLE:	15.0 DEGREES	DAYS OF AUTONOMY:	161.6
MAX. PWR. CURRENT:	2.9 A.	MINIMUM BATT. TEMP. @	26.1 C.
MAXIMUM POWER:	47.0 W.	TOTAL STORAGE:	202.0 AH
AS INC M75	2.94 A. @ 16.0 V.	GNB ABSOLYTE 35A9	2 V, 202 AH
1 (S) X 1 (P) =	1 TOTAL	6 (S) X 1 (P) =	6 TOTAL

SYSTEM DESIGN ANALYSIS
(BASED ON 90 % OF RATED OUTPUT)

MONTH	FLAT LANG	PANEL LANG	-AVG. AH/DAY- OUTPUT	LOAD	END OF MONTH CAPACITY
JAN	468	527	14.8	1.0	100.0 %
FEB	474	511	14.4	1.0	100.0 %
MAR	448	459	13.2	1.0	100.0 %
APR	486	475	13.6	1.0	100.0 %
MAY	398	379	11.1	1.0	100.0 %
JUN	380	358	10.5	1.0	100.0 %
JUL	370	351	10.4	1.0	100.0 %
AUG	314	307	9.1	1.0	100.0 %
SEP	407	410	12.1	1.0	100.0 %
OCT	439	464	13.6	1.0	100.0 %
NOV	440	488	14.2	1.0	100.0 %
DEC	455	519	14.8	1.0	100.0 %

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APPLICATION: INDUSTRIAL D.C.

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SYSTEM VOLTAGE: 12 V.D.C.
AVG. LOAD: 1 AH/DAY (nighttime)

----------SELECTED SYSTEM DATA----------

VOLTAGE LOSS: .5 V. THROUGH CABLE.

----------ARRAY----------		----------BATTERY----------	
TILT ANGLE:	15.0 DEGREES	DAYS OF AUTONOMY:	161.0
MAX. PWR. CURRENT:	3.1 A.	MINIMUM BATT. TEMP. @ 25.1 C.	
MAXIMUM POWER:	53.1 W.	TOTAL STORAGE:	202.0 AH
AS INC M55	3.05 A. @ 17.4 V.	GNB ABSOLYTE 35A9	2 V, 202 AH
1 (S) X 1 (P) =	1 TOTAL	6 (S) X 1 (P) =	6 TOTAL

SYSTEM DESIGN ANALYSIS
(BASED ON 90 % OF RATED OUTPUT)

MONTH	FLAT LANG	PANEL LANG	-AVG. AH/DAY- OUTPUT	LOAD	END OF MONTH CAPACITY
JAN	468	527	16.4	1.0	100.0 %
FEB	474	511	15.9	1.0	100.0 %
MAR	448	459	14.3	1.0	100.0 %
APR	486	475	14.8	1.0	100.0 %
MAY	398	379	11.7	1.0	100.0 %
JUN	380	358	11.0	1.0	100.0 %
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CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 11th December 1986
OPER: J GOODMAN

APPLICATION: INDUSTRIAL D.C.

INSOLATION DATA LOCATION: METEMA (User Supplied)

LATITUDE: 12.95 DEG N LONGITUDE: 36.07 DEG E
GROUND REFLECTANCE: .20 (J)

SYSTEM VOLTAGE: 12 V.D.C.
AVG. LOAD: 1 AH/DAY (nighttime)

----------SELECTED SYSTEM DATA----------

VOLTAGE LOSS: .5 V. THROUGH CABLE.

----------ARRAY----------		----------BATTERY----------	
TILT ANGLE:	15.0 DEGREES	DAYS OF AUTONOMY:	161.6
MAX. PWR. CURRENT:	3.1 A.	MINIMUM BATT. TEMP	@ 25.95 C.
MAXIMUM POWER:	53.1 W.	TOTAL STORAGE:	202.0 AH
AS INC M55	3.05 A. @ 17.4 V.	GNB ABSOLYTE 35A9	2 V, 202 AH
1 (S) X 1 (P) =	1 TOTAL	6 (S) X 1 (P) =	6 TOTAL

SYSTEM DESIGN ANALYSIS
(BASED ON 90 % OF RATED OUTPUT)

MONTH	FLAT LANG	PANEL LANG	-AVG. AH/DAY- OUTPUT	LOAD	END OF MONTH CAPACITY
JAN	457	527	16.4	1.0	100.0 %
FEB	514	566	17.5	1.0	100.0 %
MAR	535	557	17.2	1.0	100.0 %
APR	554	548	16.9	1.0	100.0 %
MAY	516	493	15.2	1.0	100.0 %
JUN	494	465	14.4	1.0	100.0 %
JUL	477	453	14.1	1.0	100.0 %
AUG	414	406	12.6	1.0	100.0 %
SEP	479	489	15.3	1.0	100.0 %
OCT	511	551	17.2	1.0	100.0 %
NOV	497	566	17.5	1.0	100.0 %
DEC	465	545	16.9	1.0	100.0 %

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AVG. LOAD: 1 AH/DAY (nighttime)

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MAX. PWR. CURRENT:	2.9 A.	MINIMUM BATT. TEMP. @	25.95 C.
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MAY	516	493	10.5	1.0	100.0 %
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CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 11th December 1986
OPER: J GOODMAN

APPLICATION: INDUSTRIAL D.C.

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LATITUDE: 12.95 DEG N LONGITUDE: 36.07 DEG E
GROUND REFLECTANCE: .20 (J)

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PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTE[illegible]CE.

If 3 number 13 W flourescent lights is considered the optimum to light the individual rooms and that these will be switched on for 3 hours a night, the daily load is:

$$\frac{13}{12} \text{ X } 3 \text{ X } 3 = 9.75 \text{ AH.}$$

watts/12 X no. of lamps X no.of hours = ampere hours.

In this case, an M65 would be a suitable module for Metema, an M75 module for Asosa and an M55 would not quite be adequate for Gambella for this month. August in Gambella has substantially less radiation than other months and use of lights for only 2½ hours per night in this month would be sufficient. Alternatively two modules could be used and the excess power used to provide 2 more 13 watt lights in another room. In this case the total load would be 16.02 AH with output at 18.2 AH(2 times the output of a module). All modules should come with a warranty of 10 years on the power output and this is specified.

C.5. BATTERY TYPE

Maintenance free, deep cycle, sealed batteries of ABSOLYTE type are the only batteries to be considered. These batteries are spill proof, leak proof, do not need the addition of water and electrolyte, have a long life and a low self-discharge rate, and are warranted for 10 years. They are ideal for these remote situations where water or electrolyte is generally unavailable.

Warranty claims are difficult and time consuming to negotiate for any battery that requires maintenance.

C.6. CHARGE CONTROLLER

Although ABSOLYTE type batteries can take a high rate of charge they cannot accept charging at high voltage level so for the M55 and M75 modules (and similar types) it is necessary to incorporate a charge regulator in the system. All systems, whether charge regulated or not, should contain a low voltage cut out switch which prevents deep discharging of the batteries.

C.7. LIGHTS

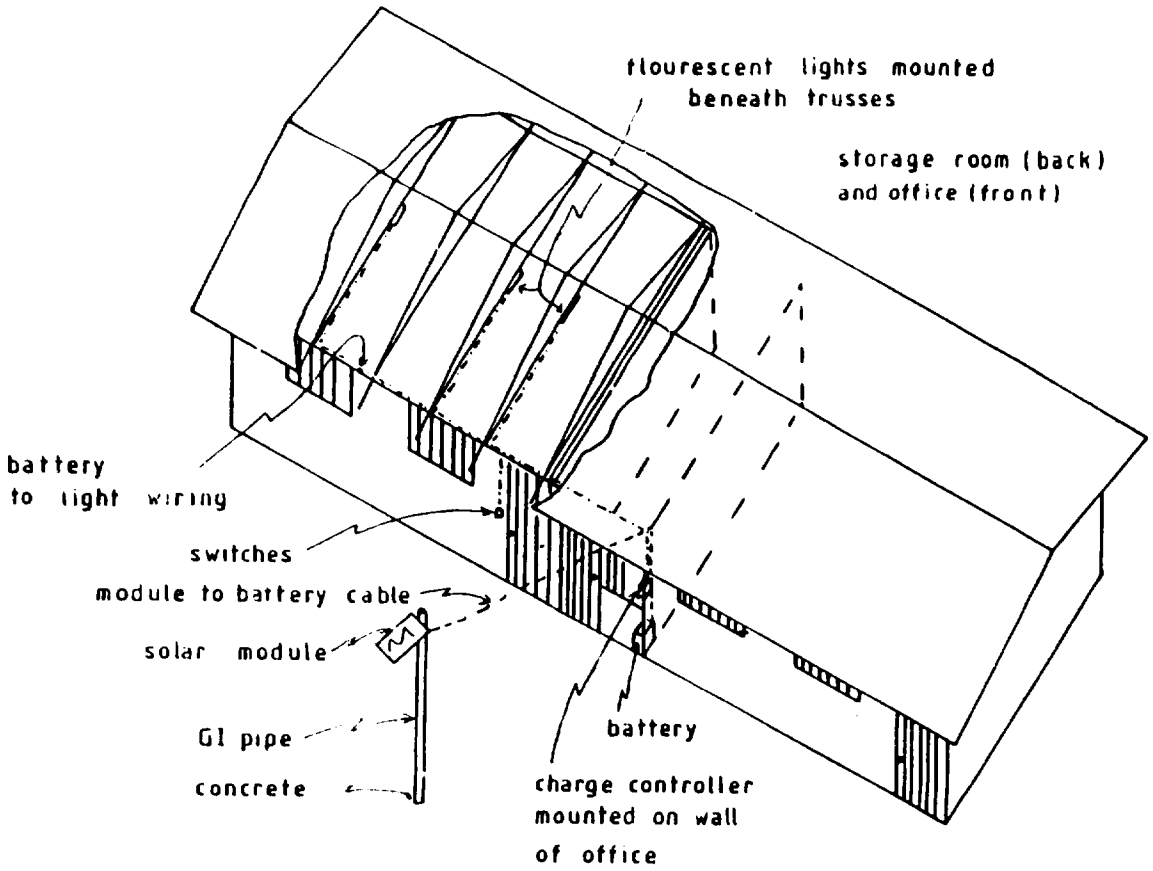
12 V fluorescent lights come in 8W, 13W, 20W and 40W options. Sufficient spare tubes (one for each fixture) should be specified at outset.

C.8. BALANCE OF SYSTEM

All wiring and switches required for these systems can be obtained from the Ethiopian Domestic Distribution Corporation.

The G.I. pipe is locally available and the mounting bracket can be fabricated locally. G.I. pipe is specified rather than treated eucalyptus due to the risk of termite attack.

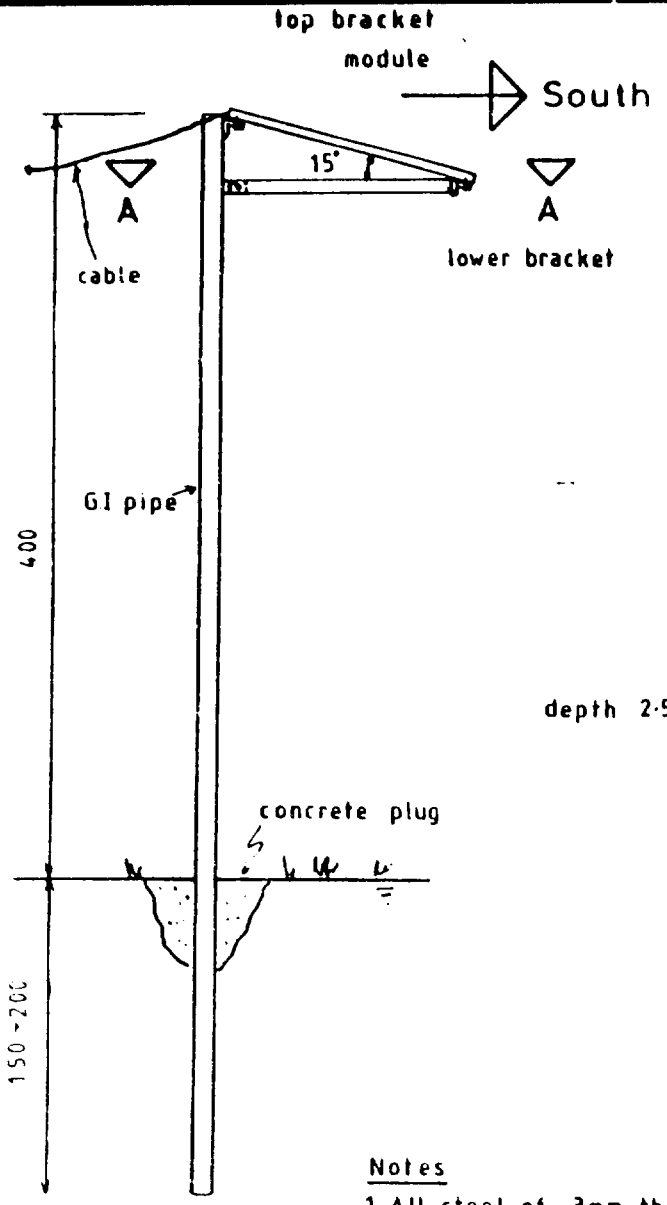
Costs, both local and foreign component are annexed.

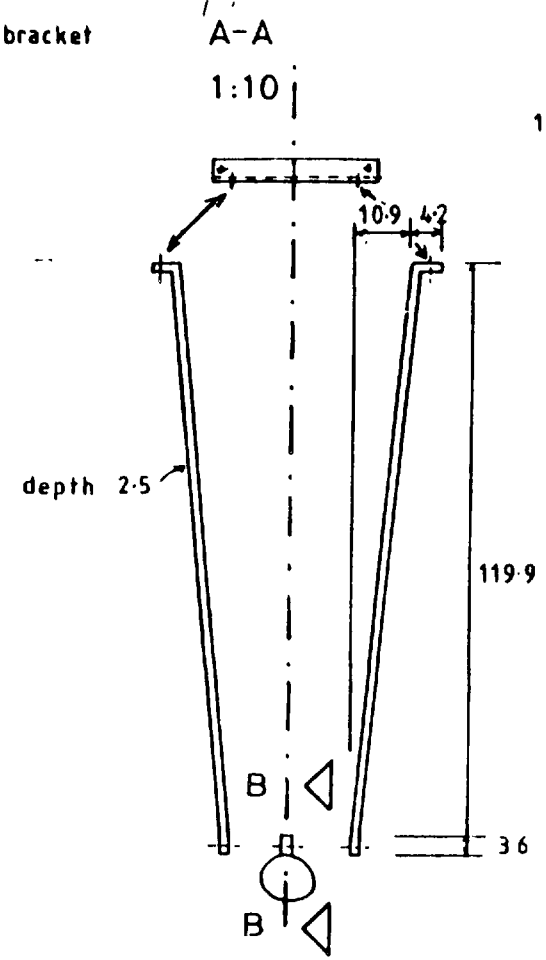


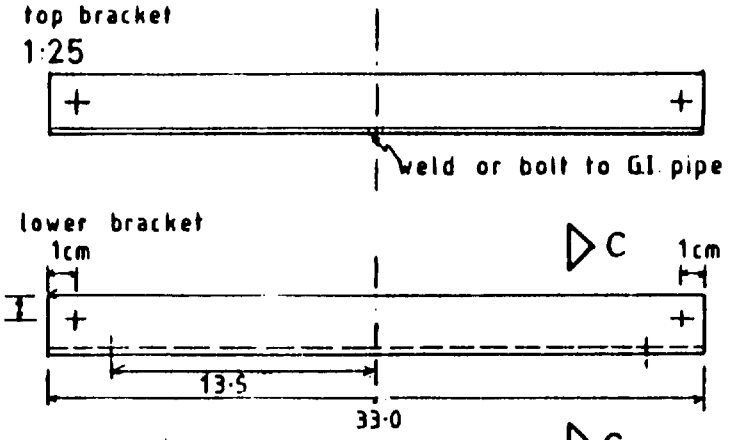
Notes :

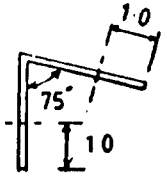
1. The module is facing due south at an angle of 15° to the horizontal.
2. The module and stand should be as close as possible to the building
3. If the front of the building faces more N than S locate module at the rear of the building :
   battery and controller will now be in the store.
   an extra 6metres of light wiring required if switches are to be kept by entrance.
4. Installations for Block 2 and the reading room of the BDEC are identical.

XP / ETH / 86 / 038	
isometric view of a solar lighting	
installation in a village school	
December 1986	j.goodman

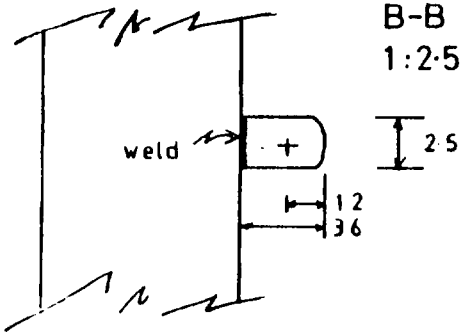








C-C
1:1
25 x 25 mm angle



Notes

1 All steel of 3mm thickness.
2 All holes of 12mm dia. Use 6 or 8mm dia bolts.
3. For greater rigidity bolt steel strip from top to lower bracket.
4. Use inner tube rubber washers between module and brackets.
5 Paint all steelwork.

XP / ETH / 86 / 038	
module support structure (M 75)	
(different modules — re dimension)	
december 1986	j.goodman

C.9. WIRING DESIGN

In the computer runs the allowable voltage drop through the cable is given as 0.5 Volt. To calculate the appropriate wire size apply the following formula;

$$\text{Resistance} = \frac{1}{57} \times \frac{L(\text{length of loop in metres})}{\text{c.s.a. (in mm}^2)}$$

(resistivity of Copper)

Apply Ohms law to 0.5 voltage drop and the max. module output current to obtain resistance value.

e.g. module current 2.94 amps

$$R = \frac{V}{I} = \frac{0.5}{2.94} \quad \text{hence c.s.a.} = \frac{\text{length of loop in mtr.}}{57 \times \frac{(0.5)}{2.94}}$$

Choose the next size up.

C.10. INSTALLATION COSTS FOR A ONE MODULE/ONE BATTERY LIGHTING SYSTEM

		Local component	
1.	6m length 4"Ø G.I. pipe	134.27	Birr.
2.	8 module bracket	45.00	"
3.	Array wiring (2mm²c.s.a.)	11.23	"
4.	Light wiring (1.5mm² c.s.a.)	40.70	"
5.	Battery box	20.00	"
6.	Switches, battery terminal connectors wiring chips	20.00	"

c/f

7.	Installation - 2 days max for 1 electrician and 1 assistant		80.00
			351.20 Birr.
		Or, $	169.60

Foreign Component

1 No M75 module	-	$ 285	
1 No ABSOLYTE 5000 Battery- 100 A/H @ 100 HR rate.	-	$ 147	
1 No charge controller (low voltage cutout) SCI 1 - 12.	-	$ 150	
3 No 13 watt slimlyte	-	$ 46.05	
Freight costs (as part of quantity shipment)	-	$ 75.00	
c.i.f.		US$ 683.05	$ 169.66
Total:			$ 852.71

Note: These prices are based on quantity reductions from manufacturers and with suppliers margins built in. This provides a more realistic cost estimate than "off the shelf" costs.

COUNTRY : ETHIOPIA * STATION : ASOSA * NUMBER : 63343

* LATITUDE: 10.04 * LONGITUDE : 34.31 * ELEVATION : 1750 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	0	0	31	32	118	189	207	208	207	103	21	0	1116
TEMP. AVERAGE	22.2	23.6	24.4	24.4	22.4	20.4	19.5	19.4	20.2	20.4	20.9	22.0	21.7
TEMP MEAN MAX	29.9	31.5	31.8	31.5	28.0	25.2	23.9	23.9	25.6	25.8	27.4	29.3	27.8
TEMP MEAN MIN	14.5	15.7	17.0	17.2	16.7	15.5	15.1	14.9	14.8	14.9	14.4	14.6	15.4
TEMP MEAN DAY	25.0	26.5	27.1	26.9	24.4	22.1	21.1	21.0	22.1	22.3	23.2	24.5	23.8
TEMP MN NIGHT	19.6	20.9	21.9	21.9	20.3	18.6	17.9	17.7	18.1	18.2	18.3	19.0	19.4
VAPOUR PRESS.	12.8	13.7	14.7	15.3	20.0	19.6	18.8	18.9	18.5	17.5	16.3	14.8	16.7
WIND SPEED 2M	1.7	1.7	1.4	1.7	1.7	1.4	1.4	1.4	1.4	1.4	1.4	1.7	1.5
SUNSHINE X	81	73	50	71	48	37	33	19	50	61	67	73	55
TOT RADIATION	481	493	441	533	441	393	379	331	444	461	446	442	440
EVAPOTRANSP.	131	133	144	155	121	98	97	91	106	110	104	118	1408

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 181 INTERM. DAYS : 34 WET DAYS : 150

SEASON NR : 1
SEASON BEGINS ON 30 APR.
BEGIN HUMID ON 16 MAY
HUMID PERIOD (151 DAYS) ENDS ON 13 OCT.
END OF SEASON ON 31 OCT.
TOTAL LENGTH OF SEASON IS 185 DAYS

COUNTRY : ETHIOPIA * STATION : FILIKLIK * NUMBER : 63344

* LATITUDE: 10.03 * LONGITUDE : 38.13 * ELEVATION : 1800 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	0	7	35	34	101	130	280	243	110	17	17	5	979
TEMP. AVERAGE	20.7	21.9	22.8	22.9	22.3	20.6	17.6	17.2	17.9	19.2	19.7	19.7	20.2
TEMP MEAN MAX	28.4	29.9	30.5	30.6	29.8	27.4	23.2	22.6	24.6	26.3	27.2	27.4	27.3
TEMP MEAN MIN	13.0	13.8	15.0	15.1	14.7	13.7	12.0	11.8	11.2	12.1	12.1	11.9	13.0
TEMP MEAN DAY	23.5	24.8	25.6	25.7	25.0	23.0	19.6	19.1	20.3	21.7	22.3	22.4	22.7
TEMP MN NIGHT	18.1	19.1	20.1	20.1	19.6	18.1	15.9	15.1	15.3	16.4	16.7	16.6	17.6
VAPOUR PRESS.	12.2	12.9	13.6	15.6	14.0	15.8	15.5	15.5	14.8	12.0	11.7	11.2	13.7
WIND SPEED 2M	1.7	1.8	1.8	1.8	1.7	1.4	1.2	1.3	1.6	2.2	2.2	1.8	1.7
SUNSHINE X	69	68	55	55	64	47	25	26	40	64	86	78	56
TOT RADIATION	443	476	460	472	501	430	349	357	406	472	508	458	444
EVAPOTRANSP.	124	131	151	145	150	115	92	92	103	135	130	119	1487

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 215 INTERM. DAYS : 54 WET DAYS : 96

SEASON NR : 1
SEASON BEGINS ON 2 MAY
BEGIN HUMID ON 12 JUNE
HUMID PERIOD (97 DAYS) ENDS ON 16 SEP.
END OF SEASON ON 29 SEP.
TOTAL LENGTH OF SEASON IS 151 DAYS

COUNTRY : ETHIOPIA * STATION : GAMBELA * NUMBER : 63377

* LATITUDE: 8.15 * LONGITUDE : 34.35 * ELEVATION : 480 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	8	12	31	68	163	165	256	271	177	113	50	13	1327
TEMP. AVERAGE	28.0	29.2	30.5	29.7	27.4	26.6	26.8	26.3	26.7	27.0	26.1	27.2	27.6
TEMP MEAN MAX	37.8	38.4	38.9	37.3	34.5	32.5	31.7	31.6	32.9	33.9	32.9	35.6	34.8
TEMP MEAN MIN	18.2	20.0	22.0	22.1	20.2	20.7	21.9	20.9	20.5	20.1	19.3	18.8	20.4
TEMP MEAN DAY	31.6	32.5	33.5	32.4	29.9	28.7	28.6	28.2	28.9	29.5	28.5	30.2	30.2
TEMP MN NIGHT	24.6	26.0	27.5	27.0	24.8	24.5	25.0	24.2	24.3	24.3	23.5	23.9	25.0
VAPOUR PRESS.	17.4	17.8	19.2	21.3	22.6	24.4	25.7	25.7	24.9	23.9	20.3	19.8	21.9
WIND SPEED 2M	1.3	1.5	1.3	1.3	1.5	1.3	1.3	1.5	1.5	1.5	1.5	1.3	1.4
SUNSHINE %	73	65	51	59	38	35	32	15	40	53	62	73	49
TOT RADIATION	468	474	448	486	398	380	370	314	407	439	440	455	423
EVAPOTRANSP.	156	160	179	169	146	119	121	111	128	141	132	145	1707

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 168 INTERM. DAYS : 49 WET DAYS : 148

SEASON NR : 1
SEASON BEGINS ON 22 APR.
BEGIN HUMID ON 8 MAY
HUMID PERIOD (149 DAYS) ENDS ON 3 OCT.
END OF SEASON ON 5 NOV.
TOTAL LENGTH OF SEASON IS 198 DAYS

COUNTRY : ETHIOPIA * STATION : POKO * NUMBER : 63378

* LATITUDE: 8.15 * LONGITUDE : 34.25 * ELEVATION : 560 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	6	5	23	50	111	139	197	177	170	106	47	11	1042
TEMP. AVERAGE	27.5	29.3	30.6	30.0	28.0	26.5	25.5	25.4	25.9	27.0	26.7	27.0	27.5
TEMP MEAN MAX	36.5	38.0	38.5	37.4	35.0	32.6	31.2	31.5	32.1	33.8	34.0	35.7	34.7
TEMP MEAN MIN	18.4	20.5	22.6	22.6	21.0	20.4	19.8	19.3	19.6	20.2	19.4	18.3	20.2
TEMP MEAN DAY	30.7	32.4	33.4	32.7	30.5	28.7	27.5	27.6	28.1	29.4	29.3	30.1	30.0
TEMP MN NIGHT	24.3	26.3	27.8	27.4	25.5	24.3	23.4	23.1	23.5	24.4	23.9	23.6	24.8
VAPOUR PRESS.	16.9	17.9	19.3	21.6	23.4	24.2	23.8	24.3	23.7	23.9	21.0	19.6	21.6
WIND SPEED 2M	1.3	1.5	1.3	1.3	1.5	1.3	1.3	1.5	1.5	1.5	1.5	1.3	1.4
SUNSHINE %	73	64	51	60	37	35	33	15	39	53	62	73	49
TOT RADIATION	468	470	448	490	395	380	374	314	404	439	440	455	423
EVAPOTRANSP.	153	160	175	167	145	121	117	111	125	141	137	143	1695

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 179 INTERM. DAYS : 67 WET DAYS : 119

SEASON NR : 1
SEASON BEGINS ON 30 APR.
BEGIN HUMID ON 5 JUNE
HUMID PERIOD (120 DAYS) ENDS ON 2 OCT.
END OF SEASON ON 2 NOV.
TOTAL LENGTH OF SEASON IS 187 DAYS

COUNTRY : ETHIOPIA * STATION : DABAT * NUMBER : 63329

* LATITUDE: 13.00 * LONGITUDE : 37.46 * ELEVATION : 2683 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	8	1	6	14	141	199	331	304	163	61	21	5	1254
TEMP. AVERAGE	12.4	12.8	13.7	15.0	14.6	14.2	13.0	12.3	12.8	12.7	10.9	11.8	13.0
TEMP MEAN MAX	20.5	20.8	22.0	23.1	21.7	20.4	17.8	16.6	18.2	19.5	17.4	19.9	19.8
TEMP MEAN MIN	4.3	4.7	5.3	6.8	7.4	7.9	8.1	8.0	7.3	5.8	4.4	3.7	6.1
TEMP MEAN DAY	15.3	15.7	16.7	17.9	17.1	16.4	14.7	13.8	14.7	15.1	13.2	14.6	15.4
TEMP MN NIGHT	9.7	10.1	10.8	12.1	12.0	11.9	11.1	10.6	10.6	9.9	8.3	8.5	10.5
VAPOUR PRESS.	6.5	6.4	6.6	7.5	8.8	11.0	11.8	11.3	10.6	9.0	6.9	6.6	8.6
WIND SPEED 2M	1.9	1.9	1.7	1.5	1.9	1.9	1.2	1.0	1.2	1.6	1.6	1.4	1.6
SUNSHINE %	94	90	88	76	62	58	14	12	39	86	92	92	68
TOT RADIATION	500	535	575	554	502	482	315	308	474	537	506	477	480
EVAPOTRANSP.	84	89	125	126	124	104	80	78	90	98	77	72	1147

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 191 INTERM. DAYS : 29 WET DAYS : 145

SEASON NR : 1
SEASON BEGINS ON 29 APR.
BEGIN HUMID ON 10 MAY
HUMID PERIOD (146 DAYS) ENDS ON 2 OCT.
END OF SEASON ON 20 OCT.
TOTAL LENGTH OF SEASON IS 175 DAYS

COUNTRY : ETHIOPIA * STATION : METEMA * NUMBER : 63314

* LATITUDE: 12.57 * LONGITUDE : 36.04 * ELEVATION : 803 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	1	0	0	1	67	160	209	211	187	45	4	0	885
TEMP. AVERAGE	26.9	29.7	30.2	28.9	28.7	27.8	26.1	26.0	26.1	27.3	27.9	27.5	27.8
TEMP MEAN MAX	35.1	39.1	40.0	40.3	39.0	35.7	31.9	31.8	31.8	34.5	35.9	36.1 ←	35.9
TEMP MEAN MIN	18.7	20.2	20.3	17.5	18.4	19.9	20.3	20.1	20.3	20.1	19.9	18.8	19.5
TEMP MEAN DAY	29.9	33.1	33.7	33.0	32.4	30.6	28.2	28.0	28.1	29.8	30.7	30.5	30.7
TEMP MN NIGHT	24.2	26.5	26.8	25.0	25.0	24.9	23.9	23.7	23.8	24.4	24.7	23.9	24.7
VAPOUR PRESS.	12.8	12.9	11.2	8.4	20.9	25.4	26.7	26.6	18.6	12.3	12.0	12.8	16.7
WIND SPEED 2M	1.9	1.9	1.7	1.5	1.9	1.9	1.2	1.0	1.2	1.6	1.6	1.4	1.6
SUNSHINE %	79	83	77	76	66	59	57	40	60	78	88	87	70
TOT RADIATION	457	514	535	554	516	494	477	414	479	511	497	465	491
EVAPOTRANSP.	165	175	201	187	192	160	134	121	137	165	153	145	1935

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 232 INTERM. DAYS : 27 WET DAYS : 106

SEASON NR : 1
SEASON BEGINS ON 25 MAY
BEGIN HUMID ON 14 JUNE
HUMID PERIOD (107 DAYS) ENDS ON 28 SEP.
END OF SEASON ON 5 OCT.
TOTAL LENGTH OF SEASON IS 134 DAYS

ANNEX I

DRAFT TERMS OF REFERENCE AND SPECIFICATIONS

Project Title:

Project Number:

I.1. OBJECTIVES OF THE PROJECT

a) To provide and install solar powered water pumps in the remote regions of Ethiopia. This component will include overseas training for 2 engineers (one from Ministry of Energy, one from E.W.C.C.A.) in all aspects of solar pump installation, maintenance and system design.

b) To provide and install 6 no. solar powered vaccine refrigerators as a pilot project in selected sites in Ethiopia. The component will include on-site training for an engineer from E.P.I. of Ministry of Health in all aspects of installation, maintenance and onward training.

c) To introduce solar powered lighting in the school building projects underway (OPEC Fund, UNESCO advisor) and under evaluation (World Bank). Designs, costings and draft tender documents to be submitted to the School Building and Maintenance Unit of the Ministry of Education.

I.2. BACKGROUND INFORMATION

Maximum utilisation of renewable energies is the priority of the Ethiopian government and the implementation of this project will complement Government project activities in developing hydro and geothermal resources. These latter large scale projects are designed to serve either the national grid or large population centres (and to replace fossil fuel use) whilst the low energy demands of remote settlements can be met by photovoltaics. The introduction of solar powered water pumping, vaccine refrigeration and lighting for clinics and schools by the Government is an important step towards providing basic amenities to the whole community. The introduction of these three mature developments of photovoltaic applications will provide a base for standardisation of water pumping equipment, a pilot project for the EPI of the Ministry of Health to evaluate and monitor vaccine refrigerators (again for standardisation procedures) and through technical assistance introduce lighting for schools to make the aim of adult literacy a reality.

This project will allow all regional water supply management and technicians direct experience of systems with no fuel supply problems and relatively free of maintenance. The maintenance aspect, difficult to quantify economically, is the most demanding function in resources and time of EWCCA and was cited by all regional managers as such. The Swedish Free Mission, a non-government body has successfully introduced Grundfos a.c. submersible

solar pumps in Gamu-Gofa; these units have been evaluated by ENEC and compare more favourably than other installed government to government aid donated solar pumps of various types. As a result, ENEC wish to standardise an pv powered submersible pumps. ENEC, who have closely monitored worldwide p.v. developments, wish to propagate the use of these units in selected remote sites. These units are, without doubt, the most appropriate and reliable on the market today.

The main government body sponsoring the project is the Ethiopian National Energy Committee (E.C.E.C.) whose engineers will supervise and help train the various government implementing bodies namely:

a) Ethiopian Water Works Construction Authority for water pumps. One engineer from E.W.W.C.A. will receive overseas training in installation and maintenance.

b) E.P.I., Ministry of Health for vaccine refrigerators. An EPI technician will receive on site training for installation and maintenance.

c) School Building and Maintenance Unit of the Ministry of Education for school lighting.

I.3. SPECIFICATIONS

I.3.1. WATER PUMPING

Terms of tender.

a) The contractor shall provide 47 number pv. powered water pumping systems for the sites listed at the given system heads and average daily water outputs (under the radiation and temperature parameters provided in annex).

f.o.b. costs and c.i.f. Asab by sea freight.

Site	System head m	Average output m^3	Nearest Radiation Station and FAO index No.
1) Harerge			
Hassene	80	12.0	HARER 63470
Hadew	46	26.3	JIJIGA 63473
El Amhar	50	24.7	" "
Warder, Well	24	58.5	KEBRI DEHAR 63492
Shinile RRC	34	40.6	DIRE DAWA 63471
Shinile	32	43.3	" "
Gad	58	21.2	
Mile	30	45.9	
Harewa	61	20	
2) Gamu-Gofa			
Gebele Bono No. 1	55	22.6	GIDOLE 63528
Gardula No 2	55	22.6	" "
Wachyga Busha	60	19.6	SODO 63484

Site		System head m	Average output m^3/day	Nearest Radiation Station & FAO Index No.
3) Sidamo				
El leh		28.0	48.1	MEGA 63545
El Gofa		50.0	24.5	"
Melbana 1		50.0	24.5	"
Melbana 2		80.0	11.8	"
Chilango		81.0	10.8	"
Bokol Bona 3		80.0	11.8	"
Dolo Mekala 1		111.5	8.7	"
Tuka No. 1		27.0	49.5	"
4) Illubabor				
Finkao	5	50	21.6	GAMBELA 63377
	6			
	7			
Ubala	1			
	2			
	3	50.0m	17.6	ABOBO 63455
	4			
	5			
	6	86.0m	9.8	ABOBO 63445
5) Gojam				
Guba		90m	11.0	METEMA 63314

Site	System head m.	Average output	Nearest Radiation Station and FAO Index No.
6) Gonder			
Metema village 1	80m	11.9	METEMA 63314
2	50m	25.2	"
3	52m	24.3	"
4, Kobit.	70m	12.2	"
4, Kobit	70m	12.2	"
Kumer	17m	20	"
Johannes Ketema	41m	29.0	"
Shehdi Irrigation	22m	57.8	"
Kumer Irrigation	17m	81.2	"
Humera } Humera }	provide average outputs, cost for same range of pumps as at Metema in 40,50,60,70 metre range		HUMERA 63030
7) Wollo			
	Provide average outputs & costs in range of pumps offered in 40,50, 60 & 70m range for the two radiation stations		ALAMATA [illegible] WELDIYA [illegible]
8) Shewa			
Ogolcho-Abur[illegible]	33	3.2	OGOLCHA 40

Note: 1. The f.o[illegible]d c[illegible] should be for 40 units as spe[illegible] its cost for Humera (2 No.) and Wollo [illegible]) should be annexed.

2. The 10% spares components cost (3.1.b). (vii) fo each province should be specified as a separate item.

I.3.1. b) (i) The pump/motor type should be an a.c. powered submersible pump, with pump and motor directly coupled, preferably of stainless steel manufacture. It is advantageous if the same motor drives the range of pumps required to fulfill the specifications of 3.1. (a).

(ii) The inverter should have a proven field experience, high efficiency and be standard to all systems offered.

(iii) Detailed drawings of array and stand to be provided together with detailed specifications of the modules.

(iv) The contractor is expected to show simulations (computer or otherwise) of average daily water output under the head, radiation and temperature parameters provided.

(v) Warranties and guarantees on the system and individual components thereof (if different) should be clearly stated.

(iv) The contractor shall make available to the Ethiopian National Energy Committee computer programmes enabling ENEC to run their own system sizings as part of the ongoing project.

(vii) The systems listed on 3.1 (a) are listed province by province, each with a regional H.Q. of the Ethiopian Water Works Construction Authority. A suitable spares list (to manufacturers recommendations) of not less than 10% of the f.o.b. value on the units to be held at each regional H.Q. should be priced with costs.

(viii) The contractor will provide training for 2 engineers (one from ENEC, one from EWWCA) at their factory in all aspects of system maintenance, systems sizing and installation. The duration will be for 2 man months and should include international air fares and living allowances.

(ix) The contractor will provide detailed drawings for any civil works required for the system, prior to the arrival of the equipment.

(x) To enable ENEC to assist in installation, monitoring and maintenance the contractor shall include as part of the tender a lump sum for the provision of a Toyota 4WD Land Cruiser Stationwagon.

COUNTRY : ETHIOPIA * STATION : ADI UGRI * NUMBER : 63029

* LATITUDE: 14.53 * LONGITUDE : 38.49 * ELEVATION : 2022 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	0	4	10	28	42	49	190	177	46	8	17	3	574
TEMP. AVERAGE	16.3	17.3	20.7	19.2	19.4	19.1	19.5	19.4	17.1	16.9	16.3	15.6	17.4
TEMP MEAN MAX	29.0	29.6	31.2	31.8	31.5	30.5	25.2	24.2	28.2	29.9	28.5	27.6	28.9
TEMP MEAN MIN	3.5	4.9	10.1	6.6	7.2	7.6	5.7	4.6	6.0	3.9	4.1	3.6	5.8
TEMP MEAN DAY	20.9	21.8	24.5	23.8	23.7	23.2	18.9	18.5	21.0	21.5	20.6	19.8	21.5
TEMP MN NIGHT	12.1	13.2	17.1	14.9	15.1	14.9	11.8	12.0	12.7	11.4	11.3	10.7	13.1
VAPOUR PRESS.	9.8	9.7	11.5	11.3	10.8	10.8	13.9	14.0	11.7	11.6	12.0	10.8	11.5
WIND SPEED 2M	1.5	1.6	1.7	1.8	2.0	1.9	1.8	1.8	1.7	2.1	1.4	1.3	1.7
SUNSHINE %	96	90	90	90	97	87	69	58	80	98	94	96	87
TOT RADIATION	485	516	566	596	631	586	511	464	536	563	493	467	534
EVAPOTRANSP.	84	92	145	144	160	147	109	102	121	110	81	73	1368

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 288 INTERM. DAYS : 16 WET DAYS : 61

SEASON NR : 1
SEASON BEGINS ON 24 JUNE
BEGIN HUMID ON 1 JULY
HUMID PERIOD (62 DAYS) ENDS ON 31 AUG.
END OF SEASON ON 9 SEP.
TOTAL LENGTH OF SEASON IS 78 DAYS

COUNTRY : ETHIOPIA * STATION : HUMERA * NUMBER : 63030

* LATITUDE: 14.10 * LONGITUDE : 36.35 * ELEVATION : 550 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	0	0	0	1	45	72	171	195	123	7	6	0	620
TEMP. AVERAGE	27.0	28.4	30.3	31.7	31.7	30.3	27.1	26.8	27.2	28.7	29.4	28.3	28.9
TEMP MEAN MAX	36.4	37.9	40.4	41.7	41.2	39.2	33.9	33.0	34.3	37.4	38.3	36.9	37.6
TEMP MEAN MIN	17.5	18.8	20.1	21.6	22.2	21.3	20.3	20.6	20.0	20.0	20.5	19.6	20.2
TEMP MEAN DAY	30.4	31.8	33.9	35.3	35.1	33.5	29.5	29.0	29.7	31.8	32.5	31.3	32.0
TEMP MN NIGHT	23.9	25.2	26.9	28.2	28.3	27.0	24.5	24.4	24.3	25.2	25.8	24.7	25.7
VAPOUR PRESS.	12.8	12.0	11.2	9.8	10.8	13.8	18.3	23.6	19.8	13.4	13.1	13.5	14.3
WIND SPEED 2M	0.9	1.0	0.9	1.0	1.0	1.2	0.9	0.8	0.6	0.7	1.0	0.9	0.9
SUNSHINE %	86	91	88	86	77	79	70	55	76	90	94	95	82
TOT RADIATION	457	522	559	580	547	552	514	451	521	535	496	468	516
EVAPOTRANSP.	124	133	163	172	179	179	149	131	137	143	136	123	1769

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 267 INTERM. DAYS : 33 WET DAYS : 65

SEASON NR : 1
SEASON BEGINS ON 23 JUNE
BEGIN HUMID ON 8 JULY
HUMID PERIOD (66 DAYS) ENDS ON 11 SEP.
END OF SEASON ON 29 SEP.
TOTAL LENGTH OF SEASON IS 99 DAYS

COUNTRY : ETHIOPIA * STATION : DEBRE TABOR * NUMBER : 63320
* LATITUDE: 11.53 * LONGITUDE : 38.02 * ELEVATION : 2410 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	6	11	42	46	93	180	501	476	193	66	21	16	1651
TEMP. AVERAGE	18.6	18.1	18.6	18.5	18.5	17.0	15.0	14.9	15.6	15.2	15.5	15.6	16.8
TEMP MEAN MAX	29.1	27.8	28.2	27.2	26.9	24.9	21.1	21.0	23.0	23.0	23.8	24.5	25.0
TEMP MEAN MIN	8.0	8.4	9.0	9.8	10.1	9.0	8.8	8.7	8.1	7.3	7.1	6.7	8.4
TEMP MEAN DAY	22.4	21.6	22.1	21.6	21.5	19.8	17.1	17.0	18.2	17.9	18.4	18.7	19.7
TEMP MN NIGHT	15.0	14.9	15.3	15.5	15.5	14.1	12.6	12.5	12.7	12.0	12.1	12.0	13.7
VAPOUR PRESS.	12.6	11.2	10.9	10.4	12.6	13.9	13.8	13.6	13.6	11.9	11.6	11.2	12.3
WIND SPEED 2M	1.4	1.4	1.7	1.8	1.6	1.5	1.2	1.1	1.1	1.2	1.3	1.2	1.4
SUNSHINE X	75	83	77	69	55	42	12	12	50	78	82	80	59
TOT RADIATION	452	520	538	527	471	417	304	306	442	516	485	452	452
EVAPOTRANSP.	105	107	138	140	130	104	82	82	95	102	92	87	1264

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 196 INTERM. DAYS : 45 WET DAYS : 124
SEASON NR : 1
SEASON BEGINS ON 4 MAY
BEGIN HUMID ON 28 MAY
HUMID PERIOD (3 DAYS) ENDS ON 30 MAY
BEGIN HUMID ON 4 JUNE
HUMID PERIOD (123 DAYS) ENDS ON 4 OCT.
END OF SEASON ON 20 OCT.
TOTAL LENGTH OF SEASON IS 170 DAYS

COUNTRY : ETHIOPIA * STATION : WALDIA * NUMBER : 63321
* LATITUDE: 11.49 * LONGITUDE : 39.36 * ELEVATION : 1960 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	40	42	79	108	97	28	220	256	85	47	47	24	1073
TEMP. AVERAGE	16.1	16.8	16.8	18.2	19.0	19.5	20.2	19.6	19.3	17.4	16.1	16.3	17.9
TEMP MEAN MAX	23.6	25.0	25.7	27.2	27.9	29.0	26.1	25.5	25.2	25.1	24.3	24.3	25.7
TEMP MEAN MIN	8.6	8.6	7.9	9.1	10.0	9.9	14.2	13.7	13.4	9.7	7.9	8.2	10.1
TEMP MEAN DAY	18.8	19.8	20.0	21.4	22.2	22.9	22.3	21.7	21.4	20.1	19.0	19.1	20.7
TEMP MN NIGHT	13.6	14.1	13.8	15.0	15.8	16.0	17.9	17.3	17.0	14.3	12.8	13.0	15.1
VAPOUR PRESS.	11.3	11.7	11.3	12.3	10.5	9.3	14.2	14.6	14.3	11.9	10.8	11.1	11.9
WIND SPEED 2M	1.6	1.9	1.9	1.6	2.1	2.3	2.0	1.6	1.3	1.2	1.2	1.7	1.7
SUNSHINE X	61	68	73	68	65	57	36	47	44	71	72	70	61
TOT RADIATION	408	469	523	523	509	473	395	439	420	491	453	422	460
EVAPOTRANSP.	95	106	130	130	154	158	121	117	107	111	94	99	1422

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 171 INTERM. DAYS : 125 WET DAYS : 69
SEASON NR : 1
SEASON BEGINS ON 1 MAR.
END OF SEASON ON 27 MAY
TOTAL LENGTH OF SEASON IS 88 DAYS
SEASON NR : 2
SEASON BEGINS ON 28 JUNE
BEGIN HUMID ON 1 JULY
HUMID PERIOD (70 DAYS) ENDS ON 8 SEP.
END OF SEASON ON 25 SEP.
TOTAL LENGTH OF SEASON IS 90 DAYS
SEASON NR : 3
SEASON BEGINS ON 2 NOV.
END OF SEASON ON 19 NOV
TOTAL LENGTH OF SEASON IS 18 DAYS

COUNTRY : ETHIOPIA • STATION : DABAT • NUMBER : 63329

• LATITUDE: 13.00 • LONGITUDE : 37.46 • ELEVATION : 2685 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	8	1	6	14	141	199	331	304	163	61	21	5	1254
TEMP. AVERAGE	12.4	12.8	13.7	15.0	14.6	14.2	13.0	12.3	12.8	12.7	10.9	11.8	13.0
TEMP MEAN MAX	20.5	20.8	22.0	23.1	21.7	20.4	17.8	16.6	18.2	19.5	17.4	19.9	19.8
TEMP MEAN MIN	4.3	4.7	5.3	6.8	7.4	7.9	8.1	8.0	7.3	5.8	4.4	3.7	6.1
TEMP MEAN DAY	15.3	15.7	16.7	17.9	17.1	16.4	14.7	13.8	14.7	15.1	13.2	14.6	15.4
TEMP MN NIGHT	9.7	10.1	10.8	12.1	12.0	11.9	11.1	10.6	10.6	9.9	8.3	8.5	10.5
VAPOUR PRESS.	6.5	6.4	6.6	7.5	8.8	11.0	11.8	11.3	10.6	9.0	6.9	6.6	8.6
WIND SPEED 2M	1.9	1.9	1.7	1.5	1.9	1.9	1.2	1.0	1.2	1.6	1.6	1.4	1.6
SUNSHINE %	94	90	88	76	62	58	14	12	59	86	92	92	68
TOT RADIATION	500	535	575	554	502	482	315	308	474	537	506	477	480
EVAPOTRANSP.	84	89	125	126	124	104	80	78	90	98	77	72	1147

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 191 INTERM. DAYS : 29 WET DAYS : 145

SEASON NR : 1
SEASON BEGINS ON 29 APR.
BEGIN HUMID ON 10 MAY
HUMID PERIOD (146 DAYS) ENDS ON 2 OCT.
END OF SEASON ON 20 OCT.
TOTAL LENGTH OF SEASON IS 175 DAYS

COUNTRY : ETHIOPIA • STATION : METEMA • NUMBER : 63314

• LATITUDE: 12.57 • LONGITUDE : 36.04 • ELEVATION : 803 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	1	0	0	1	67	160	209	211	187	45	4	0	885
TEMP AVERAGE	26.9	29.7	30.2	28.9	28.7	27.8	26.1	26.0	26.1	27.3	27.9	27.5	27.8
TEMP MEAN MAX	35.1	39.1	40.0	40.3	39.0	35.7	31.9	31.8	31.8	34.5	35.9	36.1	35.9
TEMP MEAN MIN	18.7	20.2	20.3	17.5	18.4	19.9	20.3	20.1	20.3	20.1	19.9	18.8	19.5
TEMP MEAN DAY	29.9	33.1	33.7	33.0	32.4	30.6	28.2	28.0	28.1	29.8	30.7	30.5	30.7
TEMP MN NIGHT	24.2	26.5	26.8	25.0	25.0	24.9	23.9	23.7	23.8	24.4	24.7	23.9	24.7
VAPOUR PRESS	12.8	12.9	11.2	8.4	20.9	25.4	26.7	26.6	18.6	12.3	12.0	12.8	16.7
WIND SPEED 2M	1.9	1.9	1.7	1.5	1.9	1.9	1.2	1.0	1.2	1.6	1.6	1.4	1.6
SUNSHINE %	79	83	77	76	66	59	57	40	60	78	88	87	70
TOT RADIATION	457	514	535	554	516	494	477	414	479	511	497	465	491
EVAPOTRANSP	155	175	201	187	192	160	134	121	137	165	153	145	1935

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 232 INTERM. DAYS : 27 WET DAYS : 106

SEASON NR : 1
SEASON BEGINS ON 25 MAY
BEGIN HUMID ON 14 JUNE
HUMID PERIOD (107 DAYS) ENDS ON 28 SEP.
END OF SEASON ON 5 OCT.
TOTAL LENGTH OF SEASON IS 134 DAYS

COUNTRY : ETHIOPIA * STATION : DEBRE MARKOS * NUMBER : 63334

* LATITUDE: 10.21 * LONGITUDE : 37.43 * ELEVATION : 2440 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	17	21	50	67	90	165	299	297	218	76	26	15	1341
TEMP. AVERAGE	15.5	16.6	17.5	17.6	17.1	15.2	14.3	14.2	14.5	14.9	14.8	14.8	15.6
TEMP MEAN MAX	23.6	24.6	25.0	24.8	23.8	21.0	18.7	18.8	20.0	21.3	22.2	22.9	22.2
TEMP MEAN MIN	7.3	8.6	9.9	10.4	10.3	9.3	9.9	9.6	8.9	8.4	7.4	6.7	8.9
TEMP MEAN DAY	18.4	19.5	20.2	20.2	19.5	17.3	15.9	15.8	16.4	17.1	17.4	17.7	17.9
TEMP MN NIGHT	12.7	13.9	14.9	15.1	14.6	13.0	12.7	12.4	12.3	12.3	11.9	11.6	13.1
VAPOUR PRESS.	8.8	9.1	10.2	10.9	11.9	11.9	14.2	14.1	13.4	11.0	9.8	8.8	11.2
WIND SPEED 2M	0.9	1.0	1.0	1.1	0.7	0.5	0.6	0.5	0.6	1.0	0.9	0.9	0.8
SUNSHINE %	72	70	51	69	48	34	15	13	40	63	69	71	51
TOT RADIATION	451	482	445	526	441	383	313	309	406	468	451	435	425
EVAPOTRANSP.	92	96	114	118	104	86	75	75	83	95	86	86	1110

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 161 INTERM. DAYS : 64 WET DAYS : 140

SEASON NR : 1
SEASON BEGINS ON 3 APR.
BEGIN HUMID ON 22 MAY
HUMID PERIOD (141 DAYS) ENDS ON 9 OCT.
END OF SEASON ON 24 OCT.
TOTAL LENGTH OF SEASON IS 205 DAYS

COUNTRY : ETHIOPIA * STATION : ALAMATA * NUMBER : 63335

* LATITUDE: 12.31 * LONGITUDE : 39.41 * ELEVATION : 2200 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	32	42	195	85	37	8	159	180	37	17	18	31	841
TEMP. AVERAGE	19.4	20.0	21.5	21.8	24.0	25.5	23.6	22.4	22.7	21.6	20.4	19.3	21.9
TEMP MEAN MAX	27.3	27.1	29.5	29.7	32.6	35.0	31.5	29.7	30.9	29.9	28.6	27.1	29.9
TEMP MEAN MIN	11.5	12.8	13.5	13.9	15.3	15.9	15.6	15.0	14.4	13.2	12.1	11.4	13.7
TEMP MEAN DAY	22.3	22.6	24.4	24.7	27.1	28.9	26.4	25.0	25.6	24.5	23.3	22.0	24.7
TEMP MN NIGHT	16.8	17.6	18.8	19.1	20.9	22.0	20.6	19.5	19.4	18.2	17.0	16.1	18.8
VAPOUR PRESS.	13.1	13.3	14.1	14.1	13.7	15.0	21.3	20.9	16.3	14.2	12.7	12.3	15.1
WIND SPEED 2M	0.9	1.0	1.0	1.1	0.7	0.5	0.6	0.5	0.6	1.0	0.9	0.9	0.8
SUNSHINE %	73	86	77	74	77	71	52	53	55	83	84	83	72
TOT RADIATION	440	526	536	546	558	529	457	463	460	530	486	455	498
EVAPOTRANSP	96	102	131	135	142	134	122	117	118	126	103	93	1419

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 234 INTERM. DAYS : 42 WET DAYS : 89

SEASON NR : 1
SEASON BEGINS ON 19 FEB.
BEGIN HUMID ON 28 FEB.
HUMID PERIOD (34 DAYS) ENDS ON 2 APR.
END OF SEASON ON 21 APR.
TOTAL LENGTH OF SEASON IS 62 DAYS
SEASON NR : 2
SEASON BEGINS ON 29 JUNE
BEGIN HUMID ON 5 JULY
HUMID PERIOD (57 DAYS) ENDS ON 30 AUG
END OF SEASON ON 7 SEP.
TOTAL LENGTH OF SEASON IS 71 DAYS

COUNTRY : ETHIOPIA * STATION : GAMBELA * NUMBER : 63377

* LATITUDE: 8.15 * LONGITUDE : 34.35 * ELEVATION : 480 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	8	12	31	68	163	165	256	271	177	113	30	13	1327
TEMP AVERAGE	28.0	29.2	30.5	29.7	27.4	26.6	26.8	26.3	26.7	27.0	26.1	27.2	27.6
TEMP MEAN MAX	37.8	38.4	38.9	37.3	34.5	32.5	31.7	31.6	32.9	33.9	32.9	35.6	34.8
TEMP MEAN MIN	18.2	20.0	22.0	22.1	20.2	20.7	21.9	20.9	20.5	20.1	19.3	18.8	20.4
TEMP MEAN DAY	31.6	32.5	33.5	32.4	29.9	28.7	28.6	28.2	28.9	29.5	28.5	30.2	30.2
TEMP MN NIGHT	24.6	26.0	27.5	27.0	24.8	24.5	25.0	24.2	24.3	24.3	23.5	23.9	25.0
VAPOUR PRESS.	17.4	17.8	19.2	21.3	22.6	24.4	25.7	25.7	24.9	23.9	20.3	19.8	21.9
WIND SPEED 2M	1.3	1.5	1.3	1.3	1.5	1.3	1.3	1.5	1.5	1.5	1.5	1.3	1.4
SUNSHINE X	73	65	51	59	38	35	32	15	40	53	62	73	49
TOT RADIATION	468	474	448	486	398	380	370	314	407	439	440	455	423
EVAPOTRANSP.	156	160	179	169	146	119	121	111	128	141	132	145	1707

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 168 INTERM. DAYS : 49 WET DAYS : 148

SEASON NR : 1
SEASON BEGINS ON 22 APR.
BEGIN HUMID ON 8 MAY
HUMID PERIOD (149 DAYS) ENDS ON 3 OCT.
END OF SEASON ON 5 NOV.
TOTAL LENGTH OF SEASON IS 198 DAYS

COUNTRY : ETHIOPIA * STATION : POKO * NUMBER : 63378

* LATITUDE: 8.15 * LONGITUDE : 34.25 * ELEVATION : 560 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	6	5	23	50	111	139	197	177	170	106	47	11	1042
TEMP AVERAGE	27.5	29.3	30.6	30.0	28.0	26.5	25.5	25.4	25.9	27.0	26.7	27.0	27.5
TEMP MEAN MAX	36.5	38.0	38.5	37.4	35.0	32.6	31.2	31.5	32.1	33.8	34.0	35.7	34.7
TEMP MEAN MIN	18.4	20.5	22.6	22.6	21.0	20.4	19.8	19.3	19.6	20.2	19.4	18.3	20.2
TEMP MEAN DAY	30.7	32.4	33.4	32.7	30.5	28.7	27.5	27.6	28.1	29.4	29.3	30.1	30.0
TEMP MN NIGHT	24.3	26.3	27.8	27.4	25.5	24.3	23.4	23.1	23.5	24.4	23.9	23.6	24.8
VAPOUR PRESS	16.9	17.9	19.3	21.6	23.4	24.2	23.8	24.3	23.7	23.9	21.0	19.6	21.6
WIND SPEED 2M	1.3	1.5	1.3	1.3	1.5	1.3	1.3	1.5	1.5	1.5	1.5	1.3	1.4
SUNSHINE X	73	64	51	60	37	35	33	15	39	53	62	73	49
TOT RADIATION	468	470	448	490	395	380	374	314	404	439	440	455	423
EVAPOTRANSP.	153	160	175	167	145	121	117	111	125	141	137	143	1695

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 179 INTERM. DAYS : 67 WET DAYS : 119

SEASON NR : 1
SEASON BEGINS ON 30 APR
BEGIN HUMID ON 5 JUNE
HUMID PERIOD (120 DAYS) ENDS ON 2 OCT.
END OF SEASON ON 2 NOV.
TOTAL LENGTH OF SEASON IS 187 DAYS

COUNTRY : ETHIOPIA * STATION : DOELCHO * NUMBER : 63440

* LATITUDE: 8.04 * LONGITUDE : 39.02 * ELEVATION : 1800 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	12	47	44	85	41	72	132	118	89	32	11	6	689
TEMP AVERAGE	18.3	19.4	20.2	20.9	20.7	20.2	19.5	19.2	18.8	19.3	17.9	17.5	19.3
TEMP MEAN MAX	26.2	26.6	27.4	28.5	28.6	27.0	24.6	24.2	24.4	26.2	25.5	26.2	26.3
TEMP MEAN MIN	10.3	12.1	12.9	13.2	12.8	13.4	14.3	14.1	13.1	12.4	10.3	8.8	12.3
TEMP MEAN DAY	21.1	22.0	22.8	23.6	23.5	22.6	21.3	21.0	20.8	21.8	20.6	20.6	21.8
TEMP MN NIGHT	15.5	16.9	17.6	18.2	17.9	17.7	17.5	17.2	16.6	16.6	15.0	14.1	16.7
VAPOUR PRESS.	10.9	10.8	11.8	12.4	12.9	14.9	17.2	17.6	16.9	14.3	10.1	9.6	13.3
WIND SPEED 2M	1.3	1.0	1.0	0.8	0.9	1.5	1.1	1.0	0.7	0.8	1.2	0.9	1.0
SUNSHINE %	84	79	70	63	61	61	41	47	44	71	80	78	64
TOT RADIATION	505	524	520	501	484	474	403	433	422	504	501	472	478
EVAPOTRANSP.	112	107	127	123	125	118	101	103	96	111	108	100	1331

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 217 INTERM. DAYS : 76 WET DAYS : 72

SEASON NR : 1
SEASON BEGINS ON 30 MAR
END OF SEASON ON 30 APR
TOTAL LENGTH OF SEASON IS 32 DAYS
SEASON NR : 2
SEASON BEGINS ON 7 JUNE
BEGIN HUMID ON 1 JULY
HUMID PERIOD (73 DAYS) ENDS ON 11 SEP
END OF SEASON ON 2 OCT.
TOTAL LENGTH OF SEASON IS 118 DAYS

COUNTRY : ETHIOPIA * STATION : ZIWAY * NUMBER : 63441

* LATITUDE: 8.00 * LONGITUDE : 38.45 * ELEVATION : 1640 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	19	31	29	46	66	79	125	110	96	37	3	1	642
TEMP AVERAGE	18.7	19.8	20.2	20.2	19.7	20.1	19.5	19.1	19.0	19.1	18.8	17.6	19.3
TEMP MEAN MAX	25.4	27.1	27.7	28.2	27.7	27.3	25.1	24.6	25.1	25.8	25.2	25.4	26.2
TEMP MEAN MIN	11.9	12.5	12.6	12.2	11.6	12.8	13.9	13.6	12.8	12.3	12.3	9.8	12.4
TEMP MEAN DAY	21.1	22.4	22.9	23.1	22.5	22.7	21.5	21.1	21.1	21.4	21.0	20.4	21.8
TEMP MN NIGHT	16.3	17.3	17.5	17.4	16.8	17.4	17.4	17.0	16.6	16.4	16.2	14.6	16.8
VAPOUR PRESS.	15.3	15.7	15.6	16.1	16.5	16.7	17.7	17.5	17.1	16.1	15.2	13.9	16.1
WIND SPEED 2M	1.3	1.0	1.0	0.8	0.9	1.5	1.1	1.0	0.7	0.8	1.2	0.9	1.0
SUNSHINE %	77	76	73	72	69	68	57	55	47	72	82	82	69
TOT RADIATION	469	499	515	518	496	482	441	442	410	492	495	473	477
EVAPOTRANSP.	98	99	120	115	113	113	100	99	91	104	97	91	1240

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 207 INTERM. DAYS : 77 WET DAYS : 81

SEASON NR : 1
SEASON BEGINS ON 1 MAY
BEGIN HUMID ON 1 JULY
HUMID PERIOD (82 DAYS) ENDS ON 20 SEP.
END OF SEASON ON 6 OCT
TOTAL LENGTH OF SEASON IS 159 DAYS

COUNTR ETH. A * STATION : HAREN * NUMBER : 63470

* LATITUDE: 9.12 * LONGITUDE : 42.07 * ELEVATION : 1856 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	13	30	55	97	126	99	145	121	94	42	28	9	859
TEMP AVERAGE	18.4	20.0	20.6	20.0	20.1	19.1	19.7	17.9	18.3	18.7	18.5	18.2	19.1
TEMP MEAN MAX	24.2	26.1	26.6	25.1	25.5	24.1	24.4	22.2	23.2	24.1	23.9	23.5	24.4
TEMP MEAN MIN	12.6	13.9	14.5	14.9	14.7	14.0	14.9	13.5	13.4	13.2	13.0	12.8	13.8
TEMP MEAN DAY	20.5	22.2	22.7	21.8	22.0	20.9	21.3	19.4	20.0	20.6	20.4	20.0	21.0
TEMP MN NIGHT	16.4	17.9	18.5	18.2	18.2	17.2	17.9	16.2	16.4	16.5	16.3	16.0	17.2
VAPOUR PRESS	11.8	12.6	15.3	14.0	15.1	15.2	16.3	13.9	14.3	12.7	11.1	11.7	13.7
WIND SPEED 2M	1.0	0.8	1.0	0.9	0.8	1.0	0.8	0.9	0.8	0.6	1.1	1.6	0.9
SUNSHINE %	78	67	62	59	58	53	48	45	51	65	73	76	61
TOT RADIATION	478	476	488	487	476	449	432	428	448	479	471	458	464
EVAPOTRANSP	97	99	119	114	113	103	105	103	101	103	98	99	1254

TYPE OF GROWING SEASON NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS 165 INTERM DAYS : 89 WET DAYS : 111

SEASON NR : 1
SEASON BEGINS ON 21 MAR
BEGIN HUMID ON 29 APR
HUMID PERIOD (34 DAYS) ENDS ON 1 JUNE
BEGIN HUMID ON 24 JUNE
HUMID PERIOD (79 DAYS) ENDS ON 10 SEP.
END OF SEASON ON 7 OCT.
TOTAL LENGTH OF SEASON IS 201 DAYS

COUNTRY : ETHIOPIA * STATION : DIRE DAWA * NUMBER : 63471

* LATITUDE: 9.36 * LONGITUDE : 41.52 * ELEVATION : 1210 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	17	35	52	76	37	25	97	136	61	14	17	9	576
TEMP. AVERAGE	21.4	22.7	24.6	26.3	27.3	28.1	26.3	25.7	25.9	25.1	22.4	21.3	24.8
TEMP MEAN MAX	28.1	29.3	31.4	32.5	33.6	34.6	32.7	31.9	32.3	31.9	29.4	28.1	31.3
TEMP MEAN MIN	14.6	16.0	17.8	20.1	20.9	21.6	19.8	19.5	19.5	18.2	15.3	14.5	18.2
TEMP MEAN DAY	23.8	25.1	27.1	28.5	29.5	30.4	28.6	27.9	28.2	27.5	24.8	23.7	27.1
TEMP MN NIGHT	19.1	20.4	22.3	24.1	25.0	25.7	23.8	23.3	23.4	22.4	19.6	18.6	22.3
VAPOUR PRESS.	13.8	14.1	15.5	17.1	16.0	16.0	16.4	17.2	16.4	12.7	12.2	11.9	14.9
WIND SPEED 2M	1.4	1.6	1.8	2.6	3.0	3.5	3.1	2.9	2.7	2.2	2.0	1.6	2.4
SUNSHINE %	75	69	66	62	67	61	57	62	61	68	78	81	67
TOT RADIATION	453	466	484	479	493	460	446	473	466	472	473	460	468
EVAPOTRANSP	112	118	150	164	186	191	175	169	162	161	134	115	1837

TYPE OF GROWING SEASON : INTERMEDIATE SEASON

DRY DAYS : 308 INTERM DAYS : 57 WET DAYS : 0

SEASON NR : 1
SEASON BEGINS ON 10 JULY
END OF SEASON ON 5 SEP
TOTAL LENGTH OF SEASON IS 58 DAYS

COUNTRY : ETHIOPIA * STATION : ICHO * NUMBER : 63444

* LATITUDE: 7.49 * LONGITUDE : 39.32 * ELEVATION : 2800 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	46	87	135	135	101	95	157	165	144	103	54	23	1269
TEMP. AVERAGE	13.6	14.4	14.6	14.6	14.9	14.5	14.0	13.6	13.7	13.1	12.6	12.6	13.9
TEMP MEAN MAX	20.9	21.6	21.2	20.2	20.7	20.8	19.5	19.1	19.3	18.7	19.2	20.2	20.1
TEMP MEAN MIN	6.2	7.2	8.0	8.9	9.0	8.1	8.4	8.1	8.1	7.5	5.9	5.0	7.5
TEMP MEAN DAY	16.2	17.0	17.0	16.6	17.0	16.7	15.9	15.6	15.7	15.1	14.9	15.3	16.1
TEMP MN NIGHT	11.0	11.9	12.3	12.6	12.7	12.1	11.9	11.5	11.6	10.9	10.0	9.6	11.5
VAPOUR PRESS.	10.0	11.5	12.3	13.3	13.0	12.5	13.4	13.2	13.0	12.2	11.2	10.2	12.2
WIND SPEED 2M	1.5	1.5	1.5	1.5	1.4	1.6	1.5	1.[illegible]	1.5	1.4	1.5	1.5	1.5
SUNSHINE %	68	57	52	48	52	50	41	[illegible]4	48	47	58	73	53
TOT RADIATION	456	448	453	443	449	432	401	421	437	419	430	460	437
EVAPOTRANSP.	[illegible]3	88	101	93	96	91	86	88	88	85	80	81	1069

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 51 INTERM. DAYS : 86 WET DAYS : 228

SEASON NR : 1
SEASON BEGINS ON 17 [illegible].
BEGIN HUMID ON 15 FEB.
HUMID PERIOD (93 DAYS) ENDS ON 18 MAY
BEGIN HUMID ON 14 JUNE
HUMID PERIOD (137 DAYS) ENDS ON 28 OCT.
END OF SEASON ON 27 NOV.
TOTAL LENGTH OF SEASON IS 315 DAYS

COUNTRY : ETHIOPIA * STATION : ABOBO * NUMBER : 63445

* LATITUDE: 7.48 * LONGITUDE : 34.24 * ELEVATION : 930 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	9	40	69	93	159	126	345	258	225	184	57	3	1568
TEMP. AVERAGE	24.6	26.4	28.3	27.5	25.1	25.9	25.4	25.4	24.2	24.4	25.4	23.9	25.5
TEMP MEAN MAX	35.1	38.5	38.2	37.9	35.4	35.7	34.8	34.5	31.3	32.6	33.4	31.6	34.9
TEMP MEAN MIN	14.0	14.3	18.4	17.0	14.8	16.0	16.0	16.2	17.1	16.2	17.4	16.1	16.1
TEMP MEAN DAY	28.4	30.8	31.9	31.2	[illegible].8	29.4	28.8	28.6	26.7	27.3	28.2	26.6	28.9
TEMP MN NIGHT	20.9	22.2	24.9	23.8	[illegible].4	22.3	21.9	21.9	21.5	21.2	22.3	20.8	22.1
VAPOUR PRESS.	14.2	15.1	16.9	18.7	19.8	23.4	23.7	24.3	21.4	20.5	19.5	16.3	19.5
WIND SPEED 2M	1.4	1.7	1.4	1.4	1.7	1.4	1.4	1.7	1.7	1.7	1.7	1.4	1.6
SUNSHINE %	72	63	51	61	36	36	34	15	39	51	61	72	49
TOT RADIATION	469	469	449	493	389	381	375	313	404	433	440	457	422
EVAPOTRANSP.	146	155	174	166	145	127	126	120	126	141	139	132	1697

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 151 INTERM. DAYS : 56 WET DAYS : 158

SEASON NR : 1
SEASON BEGINS ON 10 APR.
BEGIN HUMID ON 5 MAY
HUMID PERIOD (27 DAYS) ENDS ON 31 MAY
BEGIN HUMID ON 18 JUNE
HUMID PERIOD (133 DAYS) ENDS ON 28 OCT
END OF SEASON ON 10 NOV
TOTAL LENGTH OF SEASON IS 215 DAYS

COUNTRY : ETHIOPIA * STATION : JIJIGA * NUMBER : 63473

* LATITUDE: 9 20 * LONGITUDE : 42.43 * ELEVATION : 1644 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	13	35	51	110	124	69	100	163	123	64	23	10	885
TEMP. AVERAGE	16.9	17.7	19.4	20.3	21.0	20.9	20.0	20.0	20.1	18.3	17.1	16.5	19.0
TEMP MEAN MAX	27.2	27.6	29.2	28.2	28.5	27.2	25.6	25.8	26.9	27.8	27.1	26.8	27.3
TEMP MEAN MIN	6.5	7.8	9.5	12.3	13.5	14.6	14.4	14.2	13.3	8.8	7.0	6.1	10.7
TEMP MEAN DAY	20.6	21.3	22.9	23.1	23.7	23.2	22.0	22.1	22.5	21.7	20.6	20.1	22.0
TEMP MN NIGHT	13.3	14.3	16.0	17.5	18.3	18.6	17.9	17.8	17.5	14.6	13.1	12.4	15.9
VAPOUR PRESS.	11.9	12.1	12.8	15.0	15.9	16.1	16.4	16.6	15.8	13.2	11.3	11.4	14.0
WIND SPEED 2M	1.5	1.3	1.3	1.4	1.3	1.5	1.3	1.5	1.3	1.1	1.6	2.1	1.4
SUNSHINE %	81	65	62	55	60	51	48	44	52	64	73	77	61
TOT RADIATION	487	469	488	472	484	442	432	424	452	475	470	461	463
EVAPOTRANSP	106	103	129	125	127	116	110	112	114	113	109	111	1375

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 158 INTERM. DAYS : 133 WET DAYS 74

SEASON NR : 1
SEASON BEGINS ON 27 MAR.
BEGIN HUMID ON 1 MAY
HUMID PERIOD (14 DAYS) ENDS ON 14 MAY
BEGIN HUMID ON 22 JULY
HUMID PERIOD (62 DAYS) ENDS ON 21 SEP.
END OF SEASON ON 20 OCT.
TOTAL LENGTH OF SEASON IS 208 DAYS

COUNTRY : ETHIOPIA * STATION : GODA * NUMBER : 63474

* LATITUDE: 7.01 * LONGITUDE : 40.00 * ELEVATION : 2700 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	22	41	63	131	113	63	96	118	122	107	66	16	958
TEMP. AVERAGE	12.1	12.9	13.8	13.8	14.1	13.9	13.7	13.4	13.3	12.5	11.5	11.5	13.0
TEMP MEAN MAX	20.1	20.7	20.9	19.8	20.3	20.5	20.0	19.6	19.0	17.7	18.0	19.3	19.7
TEMP MEAN MIN	4.1	5.1	6.3	7.8	7.9	7.3	7.3	7.1	7.5	7.2	5.0	3.7	6.4
TEMP MEAN DAY	15.0	15.7	16.2	16.0	16.3	16.3	15.9	15.6	15.3	14.3	13.8	14.3	15.4
TEMP MN NIGHT	9.3	10.2	11.0	11.7	11.9	11.5	11.3	11.0	11.1	10.4	9.0	8.5	10.6
VAPOUR PRESS.	9.0	9.1	10.1	11.8	11.9	11.3	12.1	12.1	11.9	11.6	10.3	9.1	10.9
WIND SPEED 2M	1.1	1.3	1.7	1.1	1.0	1.1	0.9	1.0	0.9	0.7	0.8	1.0	1.1
SUNSHINE %	67	62	57	45	47	49	42	41	37	27	50	66	49
TOT RADIATION	455	468	473	431	429	426	403	409	396	348	405	440	423
EVAPOTRANSP	82	89	108	90	92	89	85	87	83	76	72	76	1029

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 101 INTERM. DAYS : 79 WET DAYS : 189

SEASON NR : 1
SEASON BEGINS ON 11 MAR.
BEGIN HUMID ON 31 MAR.
HUMID PERIOD (60 DAYS) ENDS ON 29 MAY
BEGIN HUMID ON 4 JULY
HUMID PERIOD (131 DAYS) ENDS ON 11 NOV
END OF SEASON ON 30 NOV.
TOTAL LENGTH OF SEASON IS 265 DAYS

COUNTRY : ETHIOPIA * STATION : DUDULA * NUMBER : 63481

* LATITUDE: 6.58 * LONGITUDE : 39.11 * ELEVATION : 2540 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	33	33	51	86	41	75	193	179	118	62	23	21	915
TEMP. AVERAGE	14.0	13.7	14.1	15.0	15.6	14.4	14.0	13.9	13.4	13.2	13.0	12.9	13.9
TEMP MEAN MAX	24.6	24.1	25.2	25.1	25.9	25.7	22.9	22.6	21.8	22.2	24.0	23.6	24.0
TEMP MEAN MIN	3.3	3.2	3.0	4.9	5.2	3.1	5.1	5.1	4.9	4.2	2.0	2.1	3.8
TEMP MEAN DAY	17.8	17.4	18.1	18.6	19.3	18.5	17.2	17.0	16.4	16.4	16.9	16.7	17.5
TEMP MN NIGHT	10.3	10.0	10.2	11.4	11.8	10.3	10.7	10.6	10.2	9.7	8.8	8.7	10.2
VAPOUR PRESS.	9.9	9.7	10.3	11.8	11.7	11.0	11.8	12.4	11.7	10.8	9.7	8.9	10.8
WIND SPEED 2M	1.5	1.6	1.6	1.7	1.5	1.4	1.4	1.2	1.2	1.4	1.5	1.5	1.5
SUNSHINE %	67	67	59	53	56	56	33	38	48	53	68	73	56
TOT RADIATION	458	487	481	461	461	450	369	397	438	443	468	473	448
EVAPOTRANSP.	91	89	104	101	111	93	92	91	88	91	86	86	1123

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 176 INTERM. DAYS : 89 WET DAYS : 100

SEASON NR : 1
SEASON BEGINS ON 18 MAR.
END OF SEASON ON 1 MAY
TOTAL LENGTH OF SEASON IS 45 DAYS
SEASON NR : 2
SEASON BEGINS ON 3 JUNE
BEGIN HUMID ON 22 JUNE
HUMID PERIOD (101 DAYS) ENDS ON 30 SEP.
END OF SEASON ON 26 OCT.
TOTAL LENGTH OF SEASON IS 144 DAYS

COUNTRY : ETHIOPIA * STATION : SODO * NUMBER : 63484

* LATITUDE: 6.50 * LONGITUDE : 37.43 * ELEVATION : 2020 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	29	39	86	147	156	15	218	187	123	130	42	26	1333
TEMP. AVERAGE	21.2	21.9	21.4	20.6	19.8	18	17.2	17.4	19.2	20.1	21.1	21.0	20.0
TEMP MEAN MAX	29.1	29.7	28.9	28.1	26.	2	22.0	22.9	25.5	27.3	29.2	29.0	26.8
TEMP MEAN MIN	13.3	14.0	13.9	13.5	13	1	12.4	12.2	12.8	12.8	13.0	12.9	13.1
TEMP MEAN DAY	24.1	24.7	24.1	23.4	2	20.6	18	19.2	21.4	22.6	24.0	23.8	22.4
TEMP MN NIGHT	18.5	19.1	18.8	18.2	17.	16.5	1	15.4	16.8	17.3	18.0	17.8	17.4
VAPOUR PRESS.	15.6	15.8	16.6	18.4	17.8	17.1	1	15.3	18.0	16.7	17.5	14.4	16.6
WIND SPEED 2M	1.1	1.2	2.1	1.5	1.3	1.2	1.1	1.2	1.0	1.1	0.9	0.8	1.2
SUNSHINE %	73	67	65	60	50	48	27	32	46	62	80	75	57
TOT RADIATION	479	488	504	488	438	421	347	374	430	476	510	473	452
EVAPOTRANSP.	116	116	141	120	109	94	87	94	99	115	112	109	1312

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 121 INTERM. DAYS : 38 WET DAYS : 206

SEASON NR : 1
SEASON BEGINS ON 7 MAR
BEGIN HUMID ON 2 APR.
HUMID PERIOD (207 DAYS) ENDS ON 25 OCT
END OF SEASON ON 6 NOV.
TOTAL LENGTH OF SEASON IS 245 DAYS

COUNTRY : ETHIOPIA * STATION : YIHDALEM * NUMBER : 63488

* LATITUDE: 6.45 * LONGITUDE : 38.23 * ELEVATION : 1835 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	43	37	104	153	143	94	114	136	153	126	57	36	1216
TEMP. AVERAGE	18.7	19.3	19.8	19.2	19.0	18.2	18.0	18.5	18.4	18.8	18.3	18.9	18.8
TEMP MEAN MAX	28.5	29.0	29.0	27.2	26.8	25.3	23.7	24.1	24.6	25.8	26.4	27.5	26.5
TEMP MEAN MIN	8.9	9.5	10.6	11.1	11.1	11.1	12.2	12.9	12.2	11.7	10.2	10.2	11.0
TEMP MEAN DAY	22.2	22.8	23.1	22.1	21.8	20.8	20.0	20.5	20.6	21.3	21.2	21.9	21.5
TEMP MN NIGHT	15.3	15.9	16.6	16.3	16.1	15.6	15.8	16.4	16.1	16.0	15.2	15.5	15.9
VAPOUR PRESS.	13.4	13.4	15.0	16.7	16.9	16.7	16.5	16.4	17.1	15.4	14.7	12.7	15.4
WIND SPEED 2M	1.3	1.3	1.5	1.3	1.3	1.6	1.3	1.2	0.9	0.8	1.0	1.1	1.2
SUNSHINE %	76	71	63	63	60	55	36	38	50	68	77	79	61
TOT RADIATION	489	502	496	499	475	446	379	397	445	498	500	474	466
EVAPOTRANSP.	113	112	130	116	112	101	93	98	98	109	103	108	1293

TYPE OF GROWING SEASON . NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS . 88 INTERM. DAYS . 94 WET DAYS : 183

SEASON NR : 1
SEASON BEGINS ON 14 FEB
BEGIN HUMID ON 29 MAR.
HUMID PERIOD (66 DAYS) ENDS ON 2 JUNE
BEGIN HUMID ON 29 JUNE
HUMID PERIOD (119 DAYS) ENDS ON 25 OCT.
END OF SEASON ON 10 NOV.
TOTAL LENGTH OF SEASON IS 270 DAYS

COUNTRY : ETHIOPIA * STATION : KEBRI DEHAR * NUMBER : 63492

* LATITUDE: 6.40 * LONGITUDE : 44.18 * ELEVATION : 450 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	2	12	4	149	100	5	0	0	15	114	58	8	467
TEMP. AVERAGE	26.3	27.3	28.2	28.0	26.6	26.2	26.2	26.2	27.1	26.4	26.1	25.8	26.7
TEMP MEAN MAX	33.8	35.0	35.4	34.2	32.2	32.1	31.3	31.7	33.0	32.1	32.7	33.5	33.1
TEMP MEAN MIN	18.7	19.5	21.0	21.7	20.9	20.3	21.0	20.6	21.2	20.7	19.5	18.1	20.3
TEMP MEAN DAY	29.0	30.1	30.8	30.2	28.6	28.3	28.0	28.1	29.2	28.4	28.4	28.5	29.0
TEMP MN NIGHT	23.6	24.6	25.7	25.7	24.5	24.1	24.2	24.1	24.9	24.2	23.6	22.0	24.3
VAPOUR PRESS.	18.5	18.9	19.5	22.7	23.3	21.1	21.1	20.4	21.2	23.1	21.0	18.6	20.8
WIND SPEED 2M	1.8	1.7	1.5	1.1	1.6	2.5	3.1	3.2	2.1	1.1	1.2	1.6	1.9
SUNSHINE %	98	87	88	82	69	77	68	79	89	71	86	98	32
TOT RADIATION	555	548	578	557	491	510	478	534	579	493	520	541	532
EVAPOTRANSP.	163	156	177	153	142	150	160	172	163	135	134	150	1855

TYPE OF GROWING SEASON . NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS . 267 INTERM. DAYS : 81 WET DAYS : 17

SEASON NR : 1
SEASON BEGINS ON 31 MAR.
BEGIN HUMID ON 13 APR.
HUMID PERIOD (18 DAYS) ENDS ON 30 APR
END OF SEASON ON 27 MAY
TOTAL LENGTH OF SEASON IS 58 DAYS
SEASON NR : 2
SEASON BEGINS ON 30 SEP.
END OF SEASON ON 10 NOV.
TOTAL LENGTH OF SEASON IS 42 DAYS

COUNTRY : ETHIOPIA * STATION : HAGERE MARIAM * NUMBER : 63926
* LATITUDE: 5.38 * LONGITUDE : 38.19 * ELEVATION : 2000 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	26	47	83	180	167	67	62	93	79	140	41	28	973
TEMP. AVERAGE	19.4	20.1	17.3	19.5	18.7	19.0	17.8	16.4	18.4	18.8	18.1	19.2	18.6
TEMP MEAN MAX	28.7	28.8	29.3	26.4	29.4	26.5	24.5	21.3	25.7	25.7	25.4	27.9	25.8
TEMP MEAN MIN	10.1	11.4	11.7	12.5	11.9	11.5	11.0	11.5	11.0	11.8	10.8	10.4	11.3
TEMP MEAN DAY	22.8	23.2	19.6	22.0	21.1	21.7	20.2	18.2	21.0	21.2	20.7	22.3	21.2
TEMP MN NIGHT	16.1	17.1	15.5	17.0	16.2	16.3	15.3	14.6	15.6	16.1	15.3	15.8	15.9
VAPOUR PRESS.	10.8	11.8	10.8	14.0	14.4	13.8	12.6	11.0	13.1	13.2	11.8	10.7	12.3
WIND SPEED 2M	1.1	1.2	2.1	1.5	1.3	1.2	1.1	1.2	1.0	1.1	0.9	0.8	1.2
SUNSHINE %	76	72	63	63	53	57	39	39	52	57	70	79	59
TOT RADIATION	496	511	498	497	446	448	387	398	453	461	482	481	463
EVAPOTRANSP.	118	117	129	122	111	108	102	101	109	113	103	107	1336

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 123 INTERM. DAYS : 148 WET DAYS : 94
SEASON NR : 1
SEASON BEGINS ON 6 MAR.
BEGIN HUMID ON 30 MAR.
HUMID PERIOD (64 DAYS) ENDS ON 1 JUNE
END OF SEASON ON 23 JUNE
TOTAL LENGTH OF SEASON IS 110 DAYS
SEASON NR : 2
SEASON BEGINS ON 28 JUNE
BEGIN HUMID ON 29 SEP.
HUMID PERIOD (32 DAYS) ENDS ON 30 OCT.
END OF SEASON ON 8 NOV.
TOTAL LENGTH OF SEASON IS 134 DAYS

COUNTRY : ETHIOPIA * STATION : GIDOLE * NUMBER : 63928
* LATITUDE: 5.37 * LONGITUDE : 37.29 * ELEVATION : 2550 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	32	70	129	171	122	94	73	104	92	163	74	47	1171
TEMP. AVERAGE	16.4	17.2	17.7	17.3	17.8	15.4	15.4	15.8	16.8	16.9	16.8	16.4	16.7
TEMP MEAN MAX	24.3	25.1	24.8	23.4	22.9	21.7	20.8	21.5	22.8	22.8	23.2	23.5	23.1
TEMP MEAN MIN	8.5	9.2	10.5	11.2	12.7	9.0	9.9	10.1	10.8	10.9	10.4	9.2	10.2
TEMP MEAN DAY	19.3	20.0	20.2	19.5	19.6	17.6	17.3	17.8	18.9	19.0	19.1	18.9	18.9
TEMP MN NIGHT	13.6	14.4	15.1	15.1	16.0	13.0	13.3	13.7	14.5	14.6	14.4	13.6	14.3
VAPOUR PRESS.	10.1	11.2	12.3	13.2	14.7	12.2	10.8	10.6	11.9	13.3	10.9	10.8	11.8
WIND SPEED 2M	1.1	1.2	2.1	1.5	1.3	1.2	1.1	1.2	1.0	1.1	0.9	0.8	1.2
SUNSHINE %	80	78	51	63	50	62	42	34	50	58	73	80	60
TOT RADIATION	510	532	452	497	435	466	397	380	445	465	492	498	464
EVAPOTRANSP.	105	106	127	111	102	94	94	99	101	102	97	95	1233

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 30 INTERM. DAYS : 155 WET DAYS : 160
SEASON NR : 1
SEASON BEGINS ON 2 FEB.
BEGIN HUMID ON 15 MAR.
HUMID PERIOD (93 DAYS) ENDS ON 15 JUNE
BEGIN HUMID ON 2 AUG.
HUMID PERIOD (29 DAYS) ENDS ON 30 AUG.
BEGIN HUMID ON 24 SEP.
HUMID PERIOD (41 DAYS) ENDS ON 3 NOV.
END OF SEASON ON 14 DEC.
TOTAL LENGTH OF SEASON IS 316 DAYS

COUNTRY : ETHIOPIA * STATION : MEGA * NUMBER : 63545
* LATITUDE: 4.05 * LONGITUDE : 38.20 * ELEVATION : 2219 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	34	32	70	149	103	16	22	10	11	120	74	1[illegible]	672
TEMP. AVERAGE	20.9	19.6	20.6	19.7	18.2	16.9	16.3	16.9	17.9	18.3	18.3	20.4	18.7
TEMP MEAN MAX	26.8	26.7	25.3	23.7	21.6	20.5	19.7	20.9	22.9	22.0	22.8	25.6	23.2
TEMP MEAN MIN	15.0	12.4	15.9	15.6	14.8	13.3	12.8	12.9	12.9	14.6	14.8	15.1	14.2
TEMP MEAN DAY	23.0	22.1	22.3	21.1	19.4	18.2	17.5	18.3	19.7	19.6	20.2	22.2	20.3
TEMP MN NIGHT	18.8	17.0	18.9	18.2	17.0	15.6	15.0	15.4	16.0	16.9	17.3	18.4	17.0
VAPOUR PRESS.	11.9	11.4	13.1	17.0	16.5	14.8	11.5	11.4	14.1	16.0	15.0	14.6	13.9
WIND SPEED 2M	2.5	2.2	2.0	1.7	1.8	2.3	2.5	2.6	2.5	1.8	1.7	1.8	2.1
SUNSHINE %	80	75	68	60	37	57	47	33	64	51	66	65	58
TOT RADIATION	518	527	518	484	383	442	410	373	498	442	475	456	460
EVAPOTRANSP.	135	130	136	113	97	97	109	115	117	107	106	114	1376

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 230 INTERM. DAYS : 60 WET DAYS : 75
SEASON NR : 1
SEASON BEGINS ON 16 MAR.
BEGIN HUMID ON 1 APR.
HUMID PERIOD (50 DAYS) ENDS ON 20 MAY
END OF SEASON ON 1 JUNE
TOTAL LENGTH OF SEASON IS 78 DAYS
SEASON NR : 2
SEASON BEGINS ON 29 SEP.
BEGIN HUMID ON 6 OCT.
HUMID PERIOD (27 DAYS) ENDS ON 1 NOV.
END OF SEASON ON 26 NOV.
TOTAL LENGTH OF SEASON IS 59 DAYS

COUNTRY : ETHIOPIA * STATION : GIDAMI * NUMBER : 63360
* LATITUDE: 8.58 * LONGITUDE : 34.35 * ELEVATION : 2040 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	82	9	74	56	190	381	273	142	234	198	41	4	1684
TEMP. AVERAGE	20.7	20.9	21.3	2[illegible].0	20.5	19.2	17.7	19.7	18.1	19.3	19.9	19.8	19.8
TEMP MEAN MAX	28.5	29.1	28.5	28.6	28.8	25.2	22.4	23.0	23.0	25.3	26.2	26.4	26.3
TEMP MEAN MIN	12.8	12.7	14.0	13.3	12.1	13.2	13.0	16.4	13.2	13.2	13.6	13.2	13.4
TEMP MEAN DAY	23.5	23.9	23.9	23.7	23.5	21.4	19.4	20.9	19.8	21.4	22.1	22.1	22.1
TEMP MN NIGHT	18.0	18.1	18.7	18.3	17.5	17.0	16.0	18.5	16.2	16.9	17.[illegible]	17.2	17.5
VAPOUR PRESS.	14.2	14.1	15.2	16.4	18.8	18.2	16.8	19.3	16.2	16.8	16.[illegible]	14.5	16.4
WIND SPEED 2M	1.5	1.5	1.3	1.5	1.5	1.3	1.3	1.3	1.3	1.3	1.3	1.5	1.4
SUNSHINE %	29	29	22	61	41	37	31	15	43	58	63	73	41
TOT RADIATION	321	345	339	494	411	388	368	314	418	455	441	452	395
EVAPOTRANSP.	110	110	116	129	113	94	90	89	97	107	100	105	1260

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 103 INTERM. DAYS : 79 WET DAYS : 183
SEASON NR : 1
SEASON BEGINS ON 1 JAN.
END OF SEASON ON 30 JAN.
TOTAL LENGTH OF SEASON IS 30 DAYS
SEASON NR : 2
SEASON BEGINS ON 2 MAR.
END OF SEASON ON 31 MAR.
TOTAL LENGTH OF SEASON IS 30 DAYS
SEASON NR : 3
SEASON BEGINS ON 21 APR.
BEGIN HUMID ON 2 MAY
HUMID PERIOD (184 DAYS) ENDS ON 1 NOV.
END OF SEASON ON 11 NOV
TOTAL LENGTH OF SEASON IS 205 DAYS

I.3.2. Vaccine Refrigerator pilot project

Terms of Tender

a) The contractor shall provide 6 mumber solar powered refrigerators for the EPI pilot project to be located at the following sites (see attached meteorological data).

Site	Nearest Radiation Site	F.A.O. Index No.
ADDIS ABABA	Addis	63450
IJAJI	Bako	63357
BUTAJIRA	Butajira	63439
EFFESON	Robit	63346
EWASA	Awasa	63460
ASAB	Massawa	63023

Specify both f.o.b. and c.i.f. Addis Ababa rates.

b) The systems should be complete with refrigerator, solar array and battery bank, and capable of operation under the given radiation and temperature parameters. The system should be sized for 3 - 5 day "no sun" scenario.

c) Warranties and guarantees on the system as a whole and individual components thereof (if different) should be clearly stated.

d) The refrigerator capacity is to be of a minimum of 40 - 50 litre vaccine refrigeration at WHO specified vaccine storage temperatures and to include an ice making capacity of 2 Kg/24 hours.

e) The manufacturers representative will install the units and train EPI technicians in installation procedures, and conduct on site training in all aspects of maintaining the systems. In-country transport will be provided by Ministry of Health/EPI and expected duration of duty is 3 weeks.
Specify lump sum cost of engineer's services.

COUNTRY : ETHIOPIA * STATION : ADDIS ABABA (OBS.) * NUMBER : 63450

* LATITUDE: 9.02 * LONGITUDE : 38.45 * ELEVATION : 2408 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	18	38	65	84	87	135	272	286	190	30	10	10	1225
TEMP AVERAGE	15.3	16.4	17.4	17.4	17.9	16.6	15.4	15.2	15.5	15.4	14.8	14.7	16.0
TEMP MEAN MAX	22.9	23.9	24.4	23.8	24.5	22.7	20.0	19.9	20.7	22.0	22.2	22.4	22.5
TEMP MEAN MIN	7.7	8.9	10.4	11.0	11.2	10.4	10.8	10.4	10.2	8.8	7.3	6.9	9.5
TEMP MEAN DAY	18.1	19.1	19.9	19.7	20.2	18.8	17.0	16.8	17.3	17.7	17.4	17.4	18.3
TEMP MN NIGHT	12.7	13.8	15.0	15.2	15.5	14.3	13.7	13.4	13.4	12.8	11.8	11.6	13.6
VAPOUR PRESS.	8.7	9.1	9.7	11.1	10.7	12.3	13.5	13.6	12.7	9.4	8.6	8.2	10.6
WIND SPEED 2M	0.9	1.0	1.0	1.1	0.7	0.5	0.6	0.5	0.6	1.0	0.9	0.9	0.8
SUNSHINE %	74	67	63	54	55	40	22	27	42	69	83	84	56
TOT RADIATION	466	477	492	468	464	401	336	360	414	493	505	484	446
EVAPOTRANSP.	93	95	115	110	110	91	82	84	89	103	90	88	1150

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 147 INTERM. DAYS : 95 WET DAYS : 123

SEASON NR : 1
SEASON BEGINS ON 4 MAR.
BEGIN HUMID ON 31 MAY
HUMID PERIOD (124 DAYS) ENDS ON 1 OCT.
END OF SEASON ON 8 OCT.
TOTAL LENGTH OF SEASON IS 219 DAYS

COUNTRY : ETHIOPIA * STATION : ALABA KOLITO * NUMBER : 63452

* LATITUDE: 7.22 * LONGITUDE : 38.06 * ELEVATION : 1850 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	32	89	98	124	107	64	131	128	112	48	32	5	970
TEMP AVERAGE	19.2	20.1	20.0	20.0	19.5	18.8	18.2	18.2	18.8	18.6	18.2	17.9	19.0
TEMP MEAN MAX	27.6	28.1	27.7	27.0	25.9	25.3	23.5	23.8	25.1	26.6	27.1	27.8	26.4
TEMP MEAN MIN	10.8	12.1	12.3	12.9	12.0	12.3	12.8	12.6	12.5	10.5	9.2	7.9	11.5
TEMP MEAN DAY	22.2	23.0	22.8	22.5	22.1	21.1	20.1	20.2	21.0	21.4	21.3	21.4	21.6
TEMP MN NIGHT	16.3	17.3	17.3	17.5	16.8	16.4	16.2	16.1	16.4	15.5	14.7	14.0	16.2
VAPOUR PRESS.	12.7	12.7	13.8	14.7	16.8	16.3	16.3	16	16.7	15.2	12.1	10.9	14.5
WIND SPEED 2M	0.9	0.9	0.9	0.9	0.9	1.1	0.6	0	0.8	0.8	1.0	1.0	0.9
SUNSHINE %	73	73	75	69	64	53	42	[illegible]	42	72	80	76	63
TOT RADIATION	474	506	540	523	492	442	404	417	415	510	506	471	475
EVAPOTRANSP	107	107	126	119	113	100	93	95	97	111	106	103	1277

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS 112 INTERM. DAYS : 134 WET DAYS : 119

SEASON NR : 1
SEASON BEGINS ON 29 JAN
BEGIN HUMID ON 4 APR
HUMID PERIOD (34 DAYS) ENDS ON 7 MAY
BEGIN HUMID ON 30 JUNE
HUMID PERIOD (87 DAYS) ENDS ON 24 SEP
END OF SEASON ON 9 OCT
TOTAL LENGTH OF SEASON IS 254 DAYS

COUNTRY : ETHIOPIA * STATION : KULUMBA * NUMBER : 63438

* LATITUDE: 8.08 * LONGITUDE : 39.08 * ELEVATION : 2600 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	22	38	84	60	92	88	134	140	108	34	18	5	823
TEMP. AVERAGE	15.5	16.5	17.8	18.4	18.3	17.2	16.2	16.0	16.1	16.8	15.8	15.1	16.6
TEMP MEAN MAX	22.8	23.7	24.6	24.8	24.4	23.2	21.2	21.0	21.4	23.0	22.6	22.6	22.9
TEMP MEAN MIN	8.2	9.2	10.9	12.0	12.1	11.2	11.2	11.0	10.7	10.6	9.0	7.5	10.3
TEMP MEAN DAY	18.1	19.1	20.2	20.7	20.5	19.4	18.0	17.8	18.0	19.0	18.2	17.7	18.9
TEMP MN NIGHT	13.0	14.0	15.4	16.1	16.0	15.0	14.3	14.1	14.0	14.4	13.2	12.1	14.3
VAPOUR PRESS.	9.2	9.0	10.2	10.6	11.1	12.4	14.0	14.4	14.3	12.2	8.8	8.2	11.2
WIND SPEED 2M	1.3	1.0	1.0	0.8	0.9	1.5	1.1	1.0	0.7	0.8	1.2	0.9	1.0
SUNSHINE %	64	66	53	50	56	58	36	43	34	59	74	75	55
TOT RADIATION	439	477	456	451	465	463	385	418	385	461	480	462	445
EVAPOTRANSP.	99	97	114	109	112	105	91	94	87	100	97	91	1196

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 143 INTERM. DAYS : 132 WET DAYS : 90

SEASON NR : 1
SEASON BEGINS ON 26 FEB.
BEGIN HUMID ON 28 JUNE
HUMID PERIOD (91 DAYS) ENDS ON 26 SEP.
END OF SEASON ON 6 OCT.
TOTAL LENGTH OF SEASON IS 223 DAYS

COUNTRY : ETHIOPIA * STATION : BUTAJIRA * NUMBER : 63439

* LATITUDE: 8.07 * LONGITUDE : 38.27 * ELEVATION : 2100 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	30	52	128	93	120	134	194	163	127	6	4	11	1062
TEMP. AVERAGE	17.2	17.6	17.8	18.3	18.5	17.6	16.6	16.2	16.7	17.0	16.6	16.3	17.2
TEMP MEAN MAX	23.0	23.1	24.9	25.1	24.7	24.0	22.3	22.0	23.2	24.0	23.9	24.2	24.0
TEMP MEAN MIN	9.3	10.1	10.7	11.4	12.3	11.2	10.8	10.3	10.1	9.9	9.3	8.4	10.3
TEMP MEAN DAY	20.0	20.3	20.4	20.7	20.7	19.9	18.6	18.2	19.0	19.5	19.2	19.1	19.6
TEMP MN NIGHT	14.5	15.0	15.3	15.8	16.3	15.3	14.4	13.9	14.2	14.2	13.8	13.2	14.7
VAPOUR PRESS.	12.2	12.1	13.2	13.8	16.4	16.1	15.1	14.2	15.4	13.8	13.2	10.7	14.0
WIND SPEED 2M	1.3	1.4	1.9	1.1	1.1	1.0	1.0	0.8	0.6	1.4	1.5	1.6	1.2
SUNSHINE %	73	74	79	69	64	53	42	43	42	73	81	77	63
TOT RADIATION	469	506	538	524	495	445	407	418	415	511	504	469	475
EVAPOTRANSP.	103	103	123	111	109	95	91	93	89	110	99	103	1229

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 137 INTERM. DAYS : 59 WET DAYS : 169

SEASON NR : 1
SEASON BEGINS ON 15 FEB.
BEGIN HUMID ON 7 MAR.
HUMID PERIOD (24 DAYS) ENDS ON 30 MAR.
BEGIN HUMID ON 4 MAY
HUMID PERIOD (147 DAYS) ENDS ON 27 SEP.
END OF SEASON ON 1 OCT.
TOTAL LENGTH OF SEASON IS 229 DAYS

COUNTRY : ETHIOPIA * STATION : BAKO BHEWA * NUMBER : 63357

* LATITUDE: 9.07 * LONGITUDE : 37.05 * ELEVATION : 1890 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	16	29	61	69	130	199	269	198	191	95	34	16	1227
TEMP. AVERAGE	19.8	21.1	21.7	22.4	21.2	19.6	18.8	18.8	19.1	19.2	18.8	18.9	20.0
TEMP MEAN MAX	29.3	29.9	30.8	30.5	28.2	25.6	23.6	23.9	25.0	27.0	27.8	28.2	27.4
TEMP MEAN MIN	10.3	12.3	12.9	14.3	14.1	13.6	13.9	13.6	13.1	11.3	10.1	9.6	12.4
TEMP MEAN DAY	23.2	24.3	24.9	25.3	23.7	21.8	20.5	20.6	21.2	21.9	21.9	22.2	22.6
TEMP MN NIGHT	16.6	18.1	18.7	19.6	18.6	17.4	16.9	16.8	16.8	16.1	15.4	15.2	17.2
VAPOUR PRESS.	11.8	13.0	12.7	13.0	16.4	17.1	17.1	17.4	17.2	14.9	12.8	11.8	14.6
WIND SPEED 2M	1.5	1.7	1.7	1.6	1.5	1.1	1.2	1.1	1.2	1.8	1.7	1.7	1.5
SUNSHINE %	70	67	60	44	30	43	23	29	40	64	76	74	55
TOT RADIATION	452	477	480	306	446	412	340	367	407	475	481	452	441
EVAPOTRANSP.	121	126	151	150	126	99	92	94	98	123	116	117	1413

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 192 INTERM. DAYS : 39 WET DAYS : 138

SEASON NR : 1
SEASON BEGINS ON 21 APR.
BEGIN HUMID ON 14 MAY
HUMID PERIOD (139 DAYS) ENDS ON 29 SEP.
END OF SEASON ON 11 OCT.
TOTAL LENGTH OF SEASON IS 174 DAYS

COUNTRY : ETHIOPIA * STATION : GIMBI * NUMBER : 63358

* LATITUDE: 9.05 * LONGITUDE : 35.47 * ELEVATION : 1870 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	5	8	34	59	234	345	373	396	299	127	38	2	1920
TEMP. AVERAGE	19.6	21.4	22.2	21.6	20.6	18.6	17.9	18.4	18.7	19.7	19.6	20.2	19.9
TEMP MEAN MAX	26.3	28.4	29.1	28.5	27.5	24.4	24.2	24.4	24.8	25.6	27.0	27.5	26.5
TEMP MEAN MIN	12.8	14.3	15.2	14.6	13.7	12.7	11.6	12.4	12.5	13.7	12.1	12.9	13.2
TEMP MEAN DAY	22.0	23.9	24.7	24.1	23.1	20.7	20.2	20.5	20.8	21.8	22.2	22.8	22.2
TEMP MN NIGHT	17.2	18.9	19.7	19.1	18.1	16.4	15.6	16.1	16.3	17.3	16.6	17.3	17.4
VAPOUR PRESS.	10.9	12.0	12.8	12.9	18.0	17.8	17.6	18.4	17.9	16.7	15.0	13.2	15.3
WIND SPEED 2M	1.1	1.3	1.4	1.3	0.9	0.8	1.2	0.9	0.9	1.2	1.2	1.2	1.1
SUNSHINE %	77	75	53	47	42	32	23	19	43	59	63	73	51
TOT RADIATION	478	505	454	317	416	371	340	315	418	457	438	449	429
EVAPOTRANSP.	106	116	135	133	108	87	84	83	95	107	101	106	1263

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 162 INTERM. DAYS : 30 WET DAYS : 173

SEASON NR : 1
SEASON BEGINS ON 19 APR.
BEGIN HUMID ON 29 APR.
HUMID PERIOD (174 DAYS) ENDS ON 19 OCT.
END OF SEASON ON 8 NOV.
TOTAL LENGTH OF SEASON IS 204 DAYS

COUNTRY : ETHIOPIA * STATION : GONA TSION * NUMBER : 63345
* LATITUDE 10.02 * LONGITUDE : 38.14 * ELEVATION : 2550 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	2	11	26	40	131	146	291	245	144	33	20	6	1095
TEMP. AVERAGE	16.4	17.4	18.2	18.6	17.9	16.8	14.5	14.2	15.1	15.8	15.0	14.8	16.2
TEMP MEAN MAX	23.1	24.3	24.8	25.2	23.9	22.7	18.8	18.4	20.0	21.5	21.2	21.8	22.1
TEMP MEAN MIN	9.6	10.5	11.5	12.0	11.9	10.8	10.1	10.0	10.1	10.1	8.7	7.8	10.3
TEMP MEAN DAY	18.8	19.9	20.6	21.0	20.1	18.9	16.0	15.7	16.8	17.8	17.2	17.3	18.3
TEMP MN NIGHT	14.1	15.1	15.9	16.3	15.8	14.6	12.8	12.6	13.1	13.6	12.5	12.0	14.0
VAPOUR PRESS.	9.3	9.7	10.2	12.0	10.7	12.4	12.7	12.8	12.3	9.7	8.7	8.2	10.7
WIND SPEED 2M	1.7	1.8	1.8	1.8	1.7	1.4	1.2	1.3	1.6	2.2	2.2	1.8	1.7
SUNSHINE %	69	67	55	56	55	43	25	25	40	64	83	79	55
TOT RADIATION	443	472	460	476	467	415	349	354	406	472	498	461	439
EVAPOTRANSP.	103	106	127	124	120	100	86	86	94	112	102	96	1256

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 202 INTERM. DAYS : 22 WET DAYS : 141

SEASON NR : 1
SEASON BEGINS ON 26 APR
BEGIN HUMID ON 10 MAY
HUMID PERIOD (142 DAYS) ENDS ON 28 SEP
END OF SEASON ON 6 OCT.
TOTAL LENGTH OF SEASON IS 164 DAYS

COUNTRY : ETHIOPIA * STATION : ROBI * NUMBER : 63346
* LATITUDE 10.01 * LONGITUDE : 39.59 * ELEVATION : 1300 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	62	164	72	169	124	178	195	295	92	42	35	40	1468
TEMP AVERAGE	20.3	21.4	23.2	23.9	24.9	27.2	24.4	23.5	23.6	22.7	20.9	19.6	23.0
TEMP MEAN MAX	28.0	28.8	30.8	30.9	32.6	37.3	31.9	30.1	30.6	30.7	29.0	28.0	30.7
TEMP MEAN MIN	12.6	14.0	15.5	16.8	17.1	17.1	16.8	16.9	16.6	14.6	12.7	11.1	15.2
TEMP MEAN DAY	23.1	24.1	25.9	26.4	27.6	30.8	27.1	25.9	26.1	25.5	23.7	22.5	25.7
TEMP MN NIGHT	17.7	18.9	20.5	21.4	22.1	23.5	21.5	21.0	20.9	19.5	17.6	16.2	20.1
VAPOUR PRESS.	13.3	15.8	13.9	17.8	16.4	17.3	16.2	18.8	18.1	15.4	13.1	12.5	15.7
WIND SPEED 2M	0.9	0.9	1.0	1.0	1.2	1.5	1.3	1.0	0.8	0.9	0.9	1.0	1.0
SUNSHINE %	73	74	62	61	64	53	32	49	54	73	83	77	62
TOT RADIATION	456	497	486	495	501	452	375	444	459	504	498	455	468
EVAPOTRANSP.	105	106	137	133	150	160	137	126	121	129	110	103	1317

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 127 INTERM. DAYS : 80 WET DAYS : 158

SEASON NR : 1
SEASON BEGINS ON 13 JAN
BEGIN HUMID ON 29 JAN.
HUMID PERIOD (31 DAYS) ENDS ON 28 FEB.
END OF SEASON ON 10 MAR
TOTAL LENGTH OF SEASON IS 57 DAYS
SEASON NR : 2
SEASON BEGINS ON 24 MAR
BEGIN HUMID ON 1 APR.
HUMID PERIOD (31 DAYS) ENDS ON 1 MAY
BEGIN HUMID ON 2 JUNE
HUMID PERIOD (99 DAYS) ENDS ON 8 SEP
END OF SEASON ON 22 SEP
TOTAL LENGTH OF SEASON IS 183 DAYS

COUNTRY : ETHIOPIA * STATION : AWASA * NUMBER : 63460

* LATITUDE: 7.04 * LONGITUDE : 38.30 * ELEVATION : 1750 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	29	52	60	96	107	91	151	124	133	76	28	14	961
TEMP. AVERAGE	18.8	20.2	20.8	20.7	20.1	19.4	18.9	17.8	18.8	19.0	18.1	17.8	19.2
TEMP MEAN MAX	28.6	29.1	29.3	28.3	27.1	25.7	24.0	21.9	24.8	26.2	27.0	27.9	26.7
TEMP MEAN MIN	9.0	11.3	12.2	13.0	13.0	13.1	13.7	13.2	12.8	11.7	9.2	7.7	11.7
TEMP MEAN DAY	22.3	23.4	23.8	23.4	22.6	21.7	20.7	19.1	20.9	21.5	21.3	21.4	21.8
TEMP MN NIGHT	15.4	17.1	17.8	17.9	17.5	17.1	16.9	15.9	16.5	16.2	14.7	13.9	16.4
VAPOUR PRESS.	12.4	12.8	14.5	15.4	17.4	16.9	17.0	15.7	16.7	15.6	12.0	10.8	14.8
WIND SPEED 2M	1.5	1.5	1.7	1.5	1.5	1.8	1.4	1.4	1.0	0.9	1.1	1.3	1.4
SUNSHINE %	74	71	65	56	59	55	36	43	44	58	76	80	59
TOT RADIATION	479	500	503	473	473	448	381	416	423	460	493	486	461
EVAPOTRANSP.	118	120	142	127	119	107	97	100	98	107	107	110	1352

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 151 INTERM. DAYS : 117 WET DAYS : 97

SEASON NR : 1
SEASON BEGINS ON 28 MAR.
BEGIN HUMID ON 27 JUNE
HUMID PERIOD (98 DAYS) ENDS ON 2 OCT.
END OF SEASON ON 28 OCT.
TOTAL LENGTH OF SEASON IS 215 DAYS

COUNTRY : ETHIOPIA * STATION : TEPI * NUMBER : 63461

* LATITUDE: 7.05 * LONGITUDE : 35.15 * ELEVATION : 1200 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	11	30	53	46	187	175	259	259	199	45	22	6	1292
TEMP. AVERAGE	22.2	21.8	22.2	21.2	21.5	21.1	21.0	21.1	20.7	20.8	20.6	21.6	21.3
TEMP MEAN MAX	30.2	29.4	30.4	28.7	29.5	28.5	28.6	28.1	27.9	28.3	27.9	29.4	28.9
TEMP MEAN MIN	14.1	14.2	14.0	13.7	13.5	13.7	13.4	14.0	13.5	13.2	13.2	13.8	13.7
TEMP MEAN DAY	25.1	24.6	25.2	23.9	24.4	23.8	23.7	23.6	23.3	23.4	23.2	24.4	24.0
TEMP MN NIGHT	19.4	19.2	19.3	18.5	18.6	18.4	18.2	18.4	18.0	17.9	17.7	18.6	18.5
VAPOUR PRESS.	15.8	14.4	15.2	16.4	19.5	20.5	21.4	21.5	20.3	18.7	17.2	16.8	18.1
WIND SPEED 2M	1.5	1.6	1.8	1.7	1.7	1.4	1.4	1.3	1.5	1.5	1.4	1.3	1.5
SUNSHINE %	65	57	55	64	38	40	34	15	40	51	61	67	48
TOT RADIATION	448	450	465	503	395	394	374	312	408	435	442	443	422
EVAPOTRANSP.	128	123	149	132	116	101	99	91	103	115	107	114	1378

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 195 INTERM. DAYS : 17 WET DAYS : 153

SEASON NR : 1
SEASON BEGINS ON 23 APR
BEGIN HUMID ON 1 MAY
HUMID PERIOD (154 DAYS) ENDS ON 1 OCT.
END OF SEASON ON 10 OCT.
TOTAL LENGTH OF SEASON IS 171 DAYS

COUNTRY : ETHIOPIA * STATION : ASMARA * NUMBER : 63021

* LATITUDE: 15.17 * LONGITUDE : 38.55 * ELEVATION : 2325 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	5	3	10	30	21	41	194	162	16	13	25	5	525
TEMP. AVERAGE	15.0	15.9	17.3	18.1	18.5	18.3	16.7	17.0	16.9	15.6	14.8	14.7	16.6
TEMP MEAN MAX	22.7	23.7	24.9	25.1	24.9	25.2	21.8	22.0	23.2	21.5	21.3	21.9	23.2
TEMP MEAN MIN	7.2	8.1	9.7	11.1	12.1	12.2	11.8	11.8	10.8	9.8	8.5	7.5	10.1
TEMP MEAN DAY	17.0	18.7	20.1	20.6	20.8	21.0	18.6	18.7	19.2	17.7	17.1	17.2	19.0
TEMP MN NIGHT	12.4	13.4	14.8	15.7	16.2	16.3	14.9	14.9	14.6	13.3	12.3	11.7	14.2
VAPOUR PRESS.	6.7	7.2	7.7	10.3	10.0	9.6	13.1	13.2	10.8	10.5	10.3	8.9	9.9
WIND SPEED 2M	1.5	1.6	1.7	1.8	2.0	1.9	1.8	1.8	1.7	2.1	1.4	1.3	1.7
SUNSHINE %	93	71	88	88	92	87	73	69	84	93	90	95	85
TOT RADIATION	471	445	556	586	612	589	530	510	551	541	475	459	527
EVAPOTRANSP.	91	98	131	131	141	132	114	113	114	104	78	76	1323

TYPE OF GROWING SEASON : NORMAL GROWING SEASON (WITH DRY PERIOD)
DRY DAYS : 294 INTERM. DAYS : 11 WET DAYS : 60

SEASON NR : 1
SEASON BEGINS ON 23 JUNE
BEGIN HUMID ON 30 JUNE
HUMID PERIOD (61 DAYS) ENDS ON 29 AUG.
END OF SEASON ON 2 SEP.
TOTAL LENGTH OF SEASON IS 72 DAYS

COUNTRY : ETHIOPIA * STATION : MASSAWA * NUMBER : 63023

* LATITUDE: 15.37 * LONGITUDE : 39.27 * ELEVATION : 10 MET.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
PRECIPITATION	30	31	17	14	6	0	5	7	3	19	18	35	181
TEMP. AVERAGE	25.5	25.3	26.7	28.6	30.8	32.8	34.5	34.4	32.9	30.9	28.4	26.5	29.8
TEMP MEAN MAX	28.3	27.9	29.5	31.6	33.8	36.7	37.7	37.8	36.1	33.8	31.5	29.4	32.8
TEMP MEAN MIN	22.7	22.6	23.9	25.7	27.8	29.1	31.2	31.6	29.9	28.1	25.4	23.7	26.8
TEMP MEAN DAY	26.5	26.2	27.7	29.7	31.9	34.3	35.6	35.8	34.1	32.0	29.5	27.5	30.9
TEMP MN NIGHT	24.6	24.4	25.8	27.6	29.7	31.5	33.2	33.5	31.8	29.8	27.2	25.4	28.7
VAPOUR PRESS	24.5	24.5	25.3	28.5	30.1	27.1	28.5	30.5	30.4	28.7	26.7	25.6	27.5
WIND SPEED 2M	2.2	1.4	1.9	2.3	2.0	1.9	1.9	3.2	2.5	2.3	2.0	2.0	2.1
SUNSHINE %	65	60	72	83	78	82	72	76	82	81	79	78	75
TOT RADIATION	380	405	493	568	555	569	526	539	542	496	438	405	493
EVAPOTRANSP.	108	99	143	168	184	194	203	228	195	170	129	112	1933

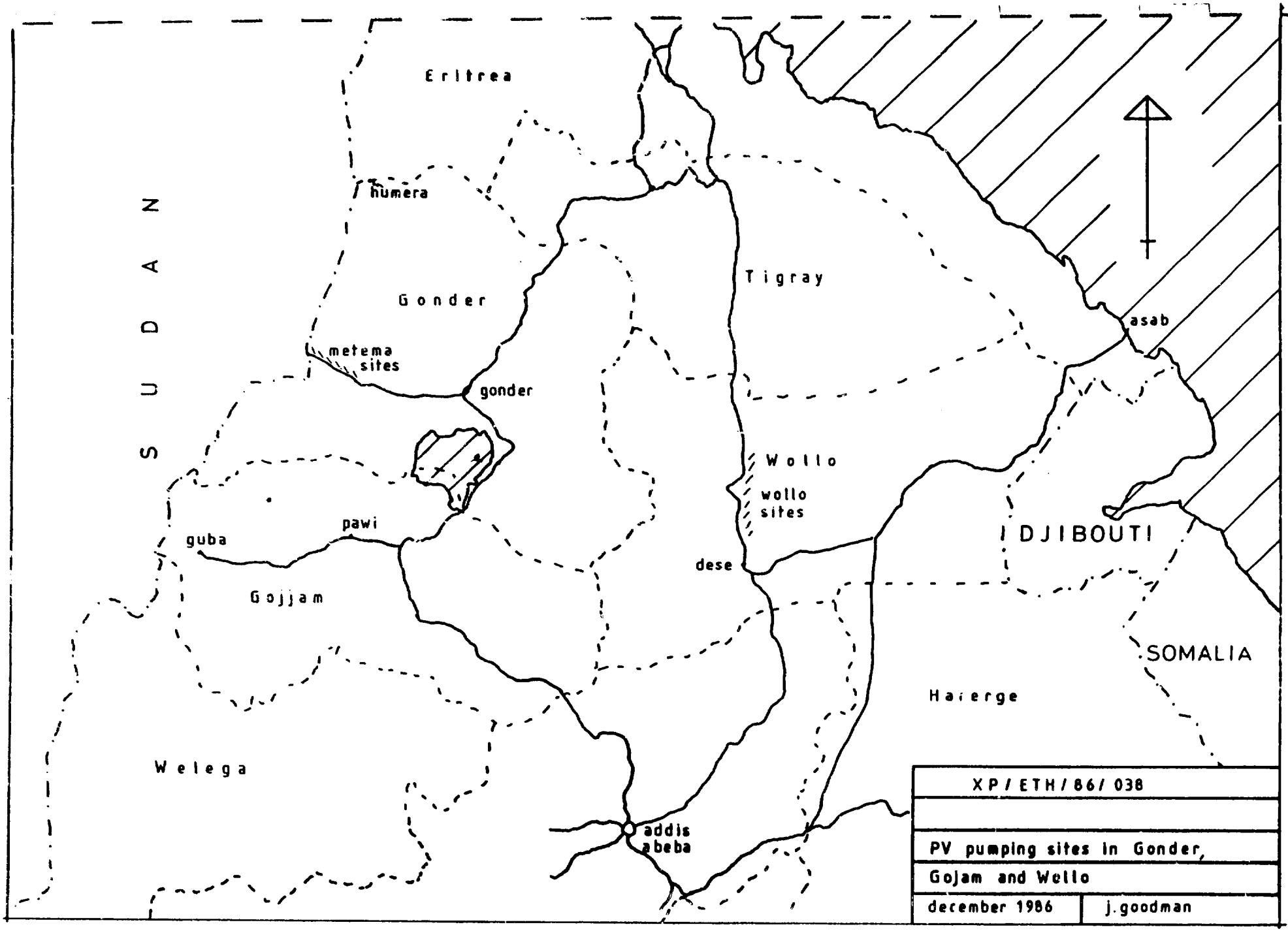
TYPE OF GROWING SEASON : ALL YEAR ROUND DRY

DRY DAYS : 365 INTERM. DAYS : 0 WET DAYS : 0

I.3.3. LIGHTING

This portion of the project is a technical report on solar lighting systems, designs and cost estimates for the OPEC funded 50 schools project. A copy of this section has been submitted to the UNESCO advisor to the OPEC project as a basis for further funding. The UNESCO advisor is also involved in the World Bank evaluation for a further 200 schools and this lighting annex will be included in the evaluation.

Refer to solar powered lighting for schools and 'Basic Development Education Centres', Section C for specifications, designs, and energy outputs for various modules in Asosa, Gambela and Metema.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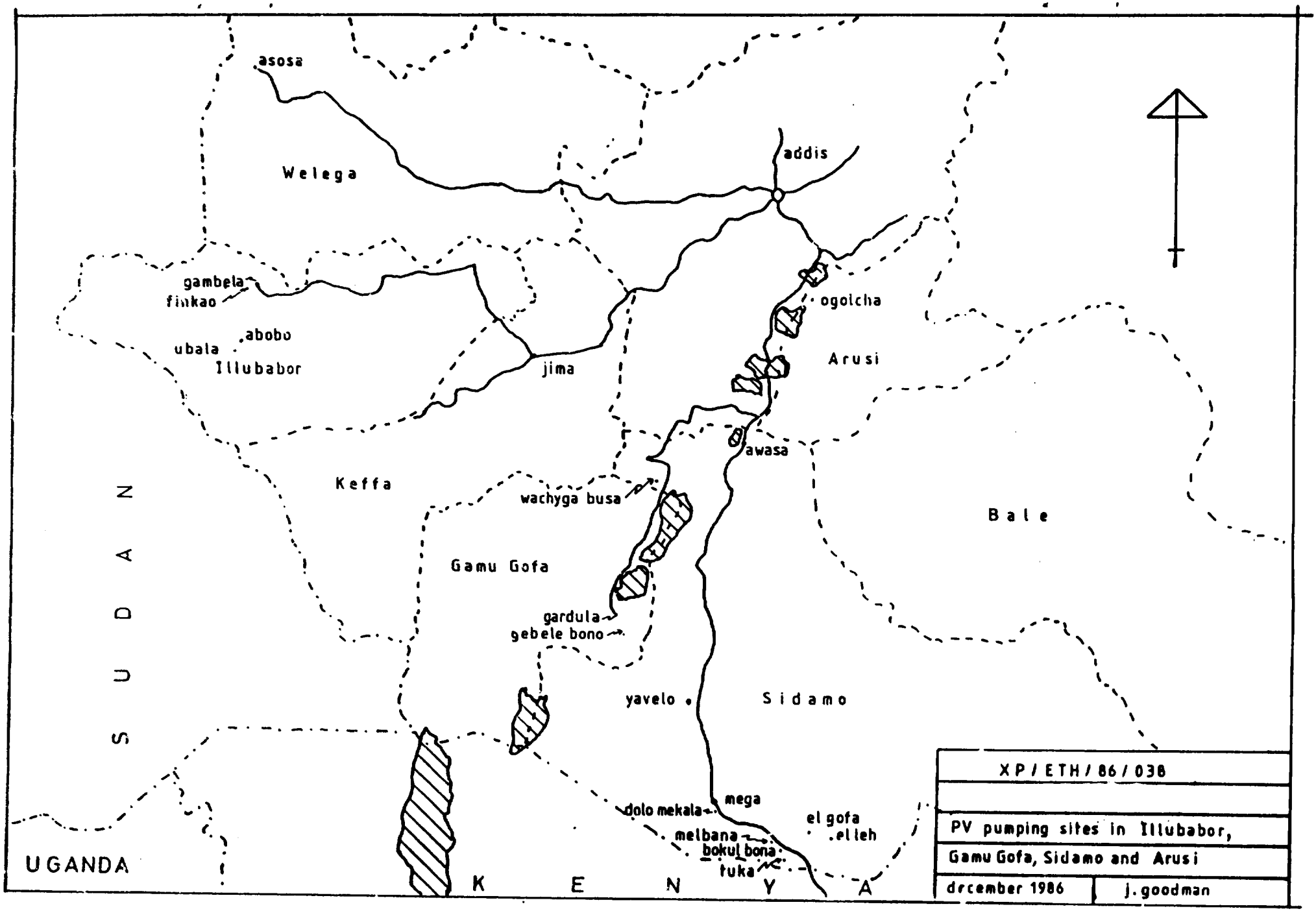
XP/ETH/86/038
PV pumping sites in Gonder,
Gojam and Wello
december 1986
j.goodman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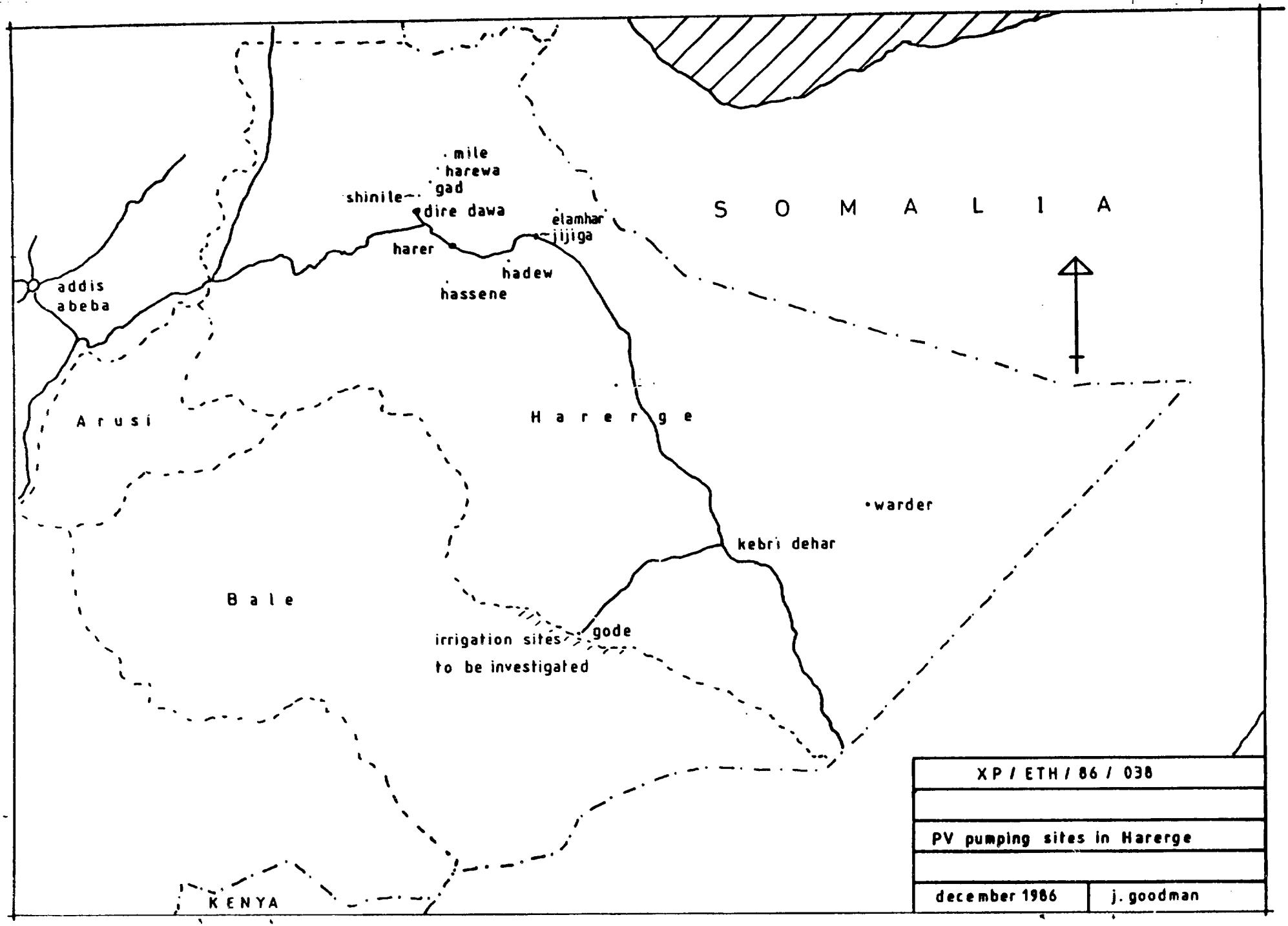
PV pumping sites in Illubabor,
Gamu Gofa, Sidamo and Arusi
december 1986
j.goodman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B a l e
irrigation sites
to be investigated
gode
K E N Y A
XP / ETH / 86 / 038
PV pumping sites in Harerge
december 1986
j. goodman

ANNEX II 1. Survey Summary

REGION	S I T E	POPULATION	SYSTEM HEAD	TRACKING	OUTPUT M^3	PUMP	ARRAY	RADIATION STATION FAO INDEX	LENGTH OF DROP CABLE	BUDGET COST CABLE	BUDGET PUMP COST	BUDGET MODULE COST	BUDGET ARRAY STAND COST	SYSTEM EQUIPMENT TOTAL f.o.b.
GONDER	METEMA Village # 1	1236	80m	FIXED 15° TILT South	9.1	SP1-28	7 x 4	METEMA # 63314	75m	$692.25	$2776	$9015.30	$1100	$13583.55
			"	FIXED 20° TILT South	9.0	"	"			"	"	"	$1100	$13583.55
				FIXED 15° TILT North	8-1	"	"			"	"	"	$1100	$13583.55
				DOUBLE AXIS	12.6	"	"			"	"	"	Manually too complicated	$13583.55
				HORIZ(N-S) AXIS (LIMIT ANGLE 30°)	12.2					"	"	"	$2200	$14583.55
				HORIZ(N-S) AXIS (LIMIT ANGLE 45°)	11.9	"	"			"	$2776	$9015.30	$2200	$14683.55
	METEMA Village # 2	1100	50m	FIXED 15° TILT	19.1	SP2-18	7 x 4 M55	METEMA # 63314	35m	$323.05	$2589	$9015.30	$1100	$13027.35
	"		50m	HORIZ(N-S) AXIS	25.2	"	"		35m	$323.05	$2589	$9015.30	$2200	$14127.35
	METEMA Village # 3	1038	52m	FIXED 15° TILT	18.6	"	"	"	50m	$461.50	$2589	$9015.30	$1100	$13165.80
			52m	HORIZ(N-S) AXIS	24.3	"	"		50m	$461.50	$2589	$9015.30	$2200	$14265.80
	METEMA #4, KOBIT	1079	70m	FIXED 15° TILT	9.4	SP1-28	7 x 4 M55	METEMA	85m	$784.55	$2776	$9015.30	$1100	$13675.85
	" "		70m	HORIZ(N-S) AXIS	12.2	SP1-28	"		85m	$784.55	$2776	$9015.30	$2200	$14775.85
	KIMER	554	17m	FIXED 15° TILT	62.1	SP8-4	7 x 4 M55	METEMA	27m	$249.21	$2539	$9015.30	$1100	$12903.51
	"		17m	HORIZ(N-S) AXIS	58.2	SP8-4	7 x 3 M55		27m	$249.21	$2539	$6761.48	$1650	$11199.69
			17m	" "	81.2	SP8.4	7 x 4 M55		27m	$249.21	$2539	$9015.30	$2200	$14003.57
	JOHANNES METEMA	1500	41.0m	FIXED 15° TILT	22.5	SP2-18	7 x 4 M55	METEMA	45m	$369.20	$2545	$9015.30	$1100	$13029.50
			41.0m	HORIZ(N-S) AXIS	29.0	SP2-18	7 x 4 M55	"	45m	$369.20	$2545	$6761.48	$1650	$11375.68
	SHENDI IRRIGATION		22m	FIXED 15° TILT	45.5	SP4-8	7 x 4 M55		40m	$369.20	$2545	$9015.30	$2200	$14129.50
			"	HORIZ(N-S) AXIS	46.6	SP4-8	7 x 3 M55		40m	$415.35	$2589	$9015.30	$1100	$13075.65
			"	" "	57.8	SP4-8	7 x 4 M55		40m	$415.35	$2589	$9015.30	$2200	$14219.65
GOJAM	GUBA		90m	FIXED 15° TILT	8.5	SP1-28	7 x 4 M55	METEMA	100m	$923.-	$2776	$9015.30	$1100	$13814.30
				HORIZ(N-S) AXIS	11.0	SP1-28	7 x 4		100m	$923.-	$2776	$9015.30	$2200	$14914.30

REGION	S I T E	POPULATION	SYSTEM HEAD	TRACKING	OUTPUT M^3	PUMP	ARRAY SIZE	RADIATION STATION FAO INDEX	LENGTH OF DROP CABLE	BUDGET COST CABLE	BUDGET PUMP COST	BUDGET MODULE COST	BUDGET ARRAY STAND COST	SYSTEM EQUIPMENT TOTAL f.o.b.
ILLUBABOR	BARA ABOL OR FINKAO VILLAGES 5, 6 & 7	#5 : 950 #6 : 1787 #7 : 1240	50m	FIXED 15° TILT	16.6	SP2-18	7 x 4	GAMBELLA # 63377	60m	$553.80	$2589	$9015.30	$1100	$13258.10
			50m	HORIZ(N-S) AXIS	21.6	SP2-18	7 x 4	"	60m	$553.80	$2589	$9015.30	$2200	$14358.10
	UBALA Village #6	800	86	FIXED 15° TILT	7.4	SP1-28	7 x 4	ABOBO # 63445	90m	$830.70	$2776	$9015.30	$1100	$13772.00
			86	HORIZ(N-S) AXIS	9.8	SP1-28	7 x 4		90m	$830.70	$2776	$9015.30	$2200	$14822.00
	UBALA Village 1-5	1500	50m	HORIZ(N-S) AXIS	17.6	SP2-18	7 x 4	ABOBO # 63445	60m	$553.80	$2589	$9015.30	$2200	$14358.10
SHEWA	OCOLCHO - ABURRA	3500	33	FIXED 15° TILT	32.8	SP4-8	7 x 4	OGOLCHA # 63440	45m	$415.35	$2545	$9015.30	$1100	$13075.65
			33	HORIZ(N-S) AXIS	31.5	SP4-8	7 x 3	" "	45m	$415.35	$2545	$6761.48	$1650	$11371.83
			33	" "	43.2	SP4-8	7 x 4	" "	45m	$415.35	$2545	$9015.30	$2200	$14175.65
GAMU GOFA	GEBELE BONO No 1		55	FIXED 15° TILT	16.9	SP2-18	7 x 4	GIDOLE # 63528	53m	$489.19	$2589	$9015.30	$1100	$13193.49
			55	HORIZ(N-S) AXIS	22.6	SP2-18	7 x 4	GIDOLE "	53m	$489.19	$2589	$9015.30	$2200	$14293.49
	GARDULA No 2 (GUMAIDE)		55	FIXED 15° TILT	16.9	SP2-18	7 x 4	GIDOLE "	58m	$535.34	$2589	$9015.30	$1100	$13239.64
			55	HORIZ(N-S) AXIS	22.6	SP2-18	7 x 4	GIDOLE "	58m	$525.34	$2589	$9015.30	$2200	$14339.64
	WACHYGA BUSHA a) Existing Distr	5000	80	FIXED 15° TILT	8.7	SP1-28	7 x 4	SODO # 63484	55m	$507.65	$2776	$9015.30	$1100	$13398.95
			80	HORIZ(N-S) AXIS	11.5	SP1-28	7 x 4	" "	55m	$507.65	$2776	$9015.30	$2200	$1440-
	b) On Point Distr		60	FIXED 15° TILT	14.7	SP2-18	7 x 4	" "	55m	$507.65	$2589	$9015.30	$110(	$13211.9-
			60	HORIZ(N-S) AXIS	19.6	SP2-18	7 x 4	" "	55m	$507.65	$2589	$9015.30	$220(	$14311.95
HARERGE	HASSENE	2-2500	80m	FIXED 15° TILT	9.2	SP1-28	7 x 4	HARER # 63470	75m	$692.25	$2776	$9015.30	$1100	$13583.55
	"		"	HORIZ(N-S) AXIS	12.0	SP1-28	"	" "	75m	$692.25	$2776	"	$2200	$14683.55
	HADEW	1500	46	FIXED 15° TILT	20.2	SP2-18	7 x 4	JIJIGA # 63473	50m	$461.50	$2589	"	$1100	$13165.80
			46	HORIZ(N-S) AXIS	26.3	SP2-18	7 x 4	" "	50m	$461.50	$2589	"	$2200	$14265.80
	ELAMHAR	1000 + Seasonal variation	50	FIXED 15° TILT	18.5	SP2-18	"	JIJIGA "	54m	$498.42	$2589	"	$1100	$13202.72
			50	HORIZ(N-S) AXIS	24.7	SP2-18	"	" "	54m	$498.42	$2589	"	$2200	$14302.72
	SHINILE- UNDER/RCC WELL	3000	34	FIXED 15° TILT	30.9	SP4-8	"	DIRE DAWA # 63471	40m	$369.20	$2545	"	$1100	$13029.50
				HORIZ(N-S) AXIS	40.6	SP4-8	"	" "	40m	$369.20	$2545	"	$2200	$14129.50
	SHINILE	3000	36	FIXED 15° TILT	23.9	SP2-18	"	" "	40m	$369.20	$2589	"	$1100	$13073.50
			36	HORIZ(N-S) AXIS	30.7	SP2-18	"	" "	40m	$369.20	$2589	"	$2200	$14173.50

REGION	S I T E	POPULATION	SYSTEM HEAD	TRACKING	OUTPUT M^3	PUMP	ARRAY	RADIATION STATION FAO INDEX	LENGTH OF DROP CABLE	BUDGET COST CABLE	BUDGET PUMP COST	BUDGET MODULE COST	BUDGET ARRAY STAND COST	SYSTEM EQUIPMENT TOTAL f.o.b.
HARERGE (Contd.)	SHINILE		32	FIXED 15° TILT	33	SP4-8	7 x 4	DIRE DAWA # 63471	40m	$369.20	$2545	$9015.30	$1100	$13029.50
			32	HORIZ(N-S) AXIS	43.3	SP4-8	"	" " "	40m	$369.20	$2545	"	$2200	$14129.50
	GAD	1000 + Nursery	58	FIXED 15° TILT	16.1	SP2-18	"	DIRE DAWA "	85m	$784.55	$2589	"	$1100	$13488.85
			58	HORIZ(N-S) AXIS	21.2	SP2-18	"	" " "	85m	$784.55	$2589	"	$2200	$14588.85
	HILE	1000	30	FIXED 15° TILT	35.1	SP4-8	"	" " "	35m	$323.05	$2545	"	$1100	$12983.35
			30	HORIZ(N-S) AXIS	45.9	SP4-8	"	" " "	35m	$323.05	$2545	"	$2200	$14083.35
	HARENA	1500 + Seasonal Variation	61	FIXED 15° TILT	15.0	SP2-18	"	DIRE DAWA "	70m	$646.10	$2589	"	$1100	$13350.40
			61	HORIZ(N-S) AXIS	20.0	SP2-18	"	" " "	70m	$646.10	$2589	"	$2200	$14450.40
	WARDER WELL #1 (Note open well)	2000	24	FIXED 15° TILT	45.1	SP4-8	7 x 4	KEBRI DEHAR #63492	30m	$276.90	$2545	$9015.30	$1100	$12937.20
			24	HORIZ(N-S) AXIS	58.5	SP4-8	7 x 4	" " "	30m	$276.90	$2545	$9015.30	$2200	$14037.20
	WARDER WELLS 2 & 3	-	"	FIXED 15° TILT	45.1	SP4-8	"	" " "	30m	$276.90	$2545	$9015.30	$1100	$12937.20
			"	HORIZ(N-S) AXIS	58.5	SP4-8	"	" " "	30m	$276.90	$2545	$9015.30	$2200	$14037.30
SIDAMO	DILLO MEKALA No 1	2600 + 1000 cattle	111.5	FIXED 15° TILT	6.4	SP1-28	"	MEGA #63565	77m	$710.71	$2776	$9015.30	$1100	$13602.01
			111.5	HORIZ(N-S) AXIS	8.7	SP1-28	"	" "	77m	$710.71	$2776	$9015.30	$2200	$14702.01
	BOKOL BOLA No 3	Seasonal	80.0	FIXED 15° TILT	8.8	SP1-28	"	MEGA "	78m	$719.94	$2776	$9015.30	$1100	$13611.24
			80.0	HORIZ(N-S) AXIS	11.8	SP1-28	"	" "	78m	$719.94	$2776	$9015.30	$2200	$14711.24
	EL LEH No 1	Seasonal 5700 + 50,000 cattle	28.0	FIXED 15° TILT	36.5	SP4-8	7 x 4	MEGA "	35m	$323.05	$2545	$9015.30	$1100	$12983.35
			28.0	HORIZ(N-S) AXIS	36.4	SP4-8	7 x 3	" "	35m	$323.05	$2545	$6761.48	$1650	$11279.53
			28.0	" " "	48.1	SP4-8	7 x 4	" "	35m	$323.05	$2545	$9015.30	$2200	$14083.35
	EL GOFA No 2	Seasonal Small Permanent Settlement	50.0	FIXED 15° TILT	18.4	SP2-18	7 x 4	MEGA "	45m	$415.35	$2589	$9015.30	$1100	$13119.65
			50.0	HORIZ(N-S) AXIS	24.5	SP2-18	"	" "	45m	$415.35	$2589	$9015.30	$2200	$14219.65
	MELBANA No 1	2000	50.0	FIXED 15° TILT	18.4	SP2-18	"	MEGA "	55m	$507.65	$2589	$9015.30	$1100	$13211.95
			50.0	HORIZ(N-S) AXIS	24.5	SP2-18	"	" "	55m	$507.65	$2589	$9015.30	$2200	$14311.95
	MELBANA No 2	2000	80.0	FIXED 15° TILT	8.8	SP1-28	"	MEGA "	80m	$738.40	$2776	$9015.30	$1100	$13629.70
			80.0	HORIZ(N-S) AXIS	11.8	SP1-28	"	" "	80m	$738.40	$2776	$9015.30	$2200	$14729.70

REGION	SITE	POPULATION	SYSTEM HEAD	TRACKING	OUTPUT M^3	PUMP	ARRAY	RADIATION STATION FAO INDEX	LENGTH OF DROP CABLE	BUDGET COST CABLE	BUDGET PUMP COST	BUDGET MODULE COST	BUDGET ARRAY STAND COST	SYSTEM EQUIPMENT TOTAL f.o.b.
	CHILANGO	Seasonal	89.0	FIXED 15° TILT	8.0	SP1-28	7 x 4	MEGA #63545	75m	$692.25	$2776	$9015.30	$1100	$13583.55
			81.0	HORIZ(N-S) AXIS	10.8	SP1-28	"	" "	75m	$692.25	$2776	$9015.30	$2200	$14683.55
	TUKA No 1	Seasonal Area 20,000	27.0	FIXED 15° TILT	37.7	SP4-8	7 x 4	MEGA "	35m	$323.05	$2545	$9015.30	$1100	$12983.35
			27.0	HORIZ(N-S) AXIS	49.5	SP4-8	7 x 4	" "	"	$323.05	$2545	$9015.30	$2200	$14083.35
			27.0	" "	37.9	SP4-8	7 x 3	" "		$323.05	$2545	$6761.48	$1650	$11279.53

Note 1. The array is made up of ARCO solar MSS modules for this output/cost summary. The figure of 7 x 4 or 7 x 3 represents the number of modules in series (1st figure) multiplied by the number in parallel. Hence, 7 x 4 represents an array of 28 modules with each block of 7 series wired modules wired in parallel.

2. The costs are based on estimates relevant to tender estimates. They account for volume reductions and relevent "markups" (there are no manufacturers who produce both p.v. modules and pumps).

3. The costs are strictly confidential and are for UNIDO internal consumption alone.

4. At every site visited the wells were cased with a minimum if 6" diameter casing (steel or pvc); the wells had also been screened. This uniformity of casing (6" or 10") and the choice of a.c. submersibles up to 1.5 Kw range accounts for the omitting of site casing details.

5. The water outputs are maximised using tracking approach. For sites such as Dolo Mekala, with output of only 8.7 m^3, E.W.W.C.A. - community dialogue must occur before installation. Is minimum daily potable water better than intermittent water (in this case their existing generator has been down for some 3 months with a simple fuse malfunction)?

II.2. NOTES ON N.W. REGION - GONDER AND GOJAM

In Gonder the excellent sites at Metema were visited (see survey records). These sites, remote with serious fuel supply difficulties, are of the first priority in the installation programme. Time constraints precluded a visit to the RCC supported settlements in Humera on the N.W. border with Eritrea and Sudan. Information on the wells here should be provided to E.N.E.C. for evaluation.

In Gojam the large FAI (Fondo Auti Italia) funded settlements of Pawi on the Beles river were visited. This area was well organised with basic services and the substitution of the diesel powered water supply projects by gravity fed pipeline to each village is under way.

It was not possible to visit Guba, west of the Pawi settlement near the Sudan border but hydrogeological information on the well has been obtained and included in this survey.

Although Bichena, ENE of Deber Markos had been included in the initial site survey, prevailing conditions preclude this area. These conditions, strong government financial committment and proximity to Debre Markos, Bahar Dar lay a low priority on this area.

NOTES

Metema

1. All yield information is based on air lift with Q measured by Vee Notch for 2 - 3 hours.

2. The reported drawdown and decline in discharge over a 2 year period in volcanic/metamorphic rocks from Jima has not been checked here. The yields are based on tests executed immediately after completion of the well.

3. To allow for a possible yield reduction due to this phenomena, in design considerations Q is taken as 50% of tested Q for friction loss calculations and daily demand estimates.

4. The standardisation of equipment in the Metema wells is commendable.

5. The main administrative centre at Gandawuha or Shehdi is currently been equipped with a system to supply water, from a well beside the Gandawuha river, to a storage tank on the hills above the army/RCC compound. A well with a good yield, 10 L/S, 45 meter deep and a 2"½" pipeline with Shanzi DVA 1500 generator and Bornemann 14.4m³/hr. pump installed. This centre is rapidly expanding with hospital, administrative buildings, road construction camp, E.W.W.C.A., army; there are also 4 - 5 generators in the town. As a result water demand is too high to be met currently by a solar pump and this case should be reviewed after the population stabilises.

6. Fuel to this area is currently delivered by R.R.C. aeroplane from Gondar to Shehdi. The further difficulty of supplying the villages with fuel from Shehdi is compounded by a poor road system.

Installation sites:

Gonder:

1. Metema village 1
2. " " 2
3. " " 3
4. " " 4, Kobit
5. " " 4, Kobit
6. Kumer
7. Johannes Ketema
8. Shehdi (Gandawuha) irrigation site
9. Kumer irrigation site.

Pump allocation at sites not visited.

1. Guba (Gojam) - hydrogeological and system head data available.
2. Humera - RCC wells, no information available yet.
3. " "

Location		Metema Village No. 1
Radiation station:		Metema
Population:		1236
No. of wells:		1
Wells:	aquifer type	Weathered Basalt
	depth	60m (originally drilled 78m but partial collapse) - pump at 57m
	yield	1.5 L/S.
	drawdown	-
Pumping units:		
	motor	Slanzi DVA 1030
	pump	Bornemann Mono, 7.2m^3/hr
	no. of hours of operation	1 1/2 hrs/day
	fuel consumption	2 litres/day
Distribution:	pipework Ø	2" Ø
	length	240m, elevation + 13.4m
	storage	4m^3 tank (Top 3.6m above G.L.)
Array location:		Some tree clearing required, Foundation on good soi. with aggregate available.
Design:		1 L/S TDH = 57 + 12.4 + 3.6 + 2.4 = 75.4m = 76m

DESIGN PROVIDED BY: ARCO SOLAR EUROPE
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 4.2 12/20/85)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 7DEC86
OPER: DJS

APPLICATION: AC WATER PUMPING

NOTE: VILLAGE NO 1
INSOLATION DATA LOCATION: METEMA ETHIOPIA (User Supplied)

LATITUDE: 12.95 DEG N LONGITUDE: 36.07 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	15 0 DEGREES	Grundfos SP1-28	
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-4	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	9.1 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	80.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	457	528	26.9	NA	9.5
FEB	514	567	29.6	NA	9.9
MAR	535	557	30.1	NA	9.7
APR	554	547	28.9	NA	9.5
MAY	516	491	28.7	NA	8.6
JUN	484	454	27.8	NA	8.0
JUL	477	452	26.1	NA	8.1
AUG	414	405	26.0	NA	7.1
SEP	479	489	26.0	NA	8.9
OCT	511	552	27.3	NA	9.9
NOV	497	567	27.9	NA	10.0
DEC	465	546	27.5	NA	9.7

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: ARCO SOLAR EUROPE
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 4.2 12/20/85)

CUSTOMER: UNIDO SURVEY DATE: 7DEC86
ADDRESS: ETHIOPIA OPER: DJS

APPLICATION: AC WATER PUMPING

NOTE: VILLAGE NO 1
INSOLATION DATA LOCATION: METEMA ETHIOPIA (User Supplied)

LATITUDE: 12.95 DEG N LONGITUDE: 36.07 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
HORIZONTAL (N-S) AXIS TRACKING		Grundfos SP1-28	
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-4	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	11.9 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	80.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	457	601	26.9	NA	11.4
FEB	514	674	29.6	NA	12.5
MAR	535	691	30.1	NA	12.8
APR	554	701	28.9	NA	13.0
MAY	516	642	28.7	NA	12.2
JUN	484	597	27.8	NA	11.5
JUL	477	588	26.1	NA	11.5
AUG	414	507	26.0	NA	9.9
SEP	479	607	26.0	NA	11.9
OCT	511	664	27.3	NA	12.6
NOV	497	654	27.9	NA	12.3
DEC	465	613	27.5	NA	11.4

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT
UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

Location		Metema - Village 2
Radiation station:		Metema
Population:		1100
No. of wells:		1
Wells:	aquifer type	Basalt
	depth	24m (pump at 21m)
	yield	10 L/S.
	drawdown	-
Pumping units:		
	motor	Slanzi DVA 1030
	pump	Bornemann, 7.2m^3/hr (belt driven) (currently bearings broken)
	no. of hours of operation	3 hrs/day (because of no storage)
	fuel consumption	-
Distribution:	pipework Ø	2" Ø
	length	700m, elevation + 8.03 + 7.40 = 15.43
	storage	not yet installed - 4m^3
Array location:		at well head, aggregate available, good foundation.
Design:		Max Q = 5 L/S
		TDH = 21 + 15.43 + 14
		= 50m.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: VILLAGE 2
INSOLATION DATA LOCATION: METEMA (User Supplied)

LATITUDE: 12.95 DEG N LONGITUDE: 36.07 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	15.0 DEGREES	Grundfos SP2-18	
MAX. PWR. CURRENT:	12.2 A.	XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	19.4 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	50.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	457	527	26.9	NA	20.2
FEB	514	566	29.6	NA	20.7
MAR	535	557	30.1	NA	20.3
APR	554	548	28.9	NA	20.0
MAY	516	493	28.7	NA	18.4
JUN	494	465	27.8	NA	17.7
JUL	477	453	26.1	NA	17.6
AUG	414	406	26.0	NA	15.7
SEP	479	489	26.0	NA	19.2
OCT	511	551	27.3	NA	20.9
NOV	497	566	27.9	NA	21.2
DEC	465	545	27.5	NA	20.6

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: VILLAGE 2
INSOLATION DATA LOCATION: METEMA (User Supplied)

LATITUDE: 12.95 DEG N LONGITUDE: 36.07 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		-- -----PUMP SYSTEM---------	
HORIZONTAL (N-S) AXIS TRACKING		Grundfos SP2-18	
MAX. PWR. CURRENT:	12.2 A.	XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	25.2 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	50.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	457	598	26.9	NA	24.4
FEB	514	670	29.6	NA	26.1
MAR	535	686	30.1	NA	26.6
APR	554	696	28.9	NA	27.0
MAY	516	638	28.7	NA	25.5
JUN	494	607	27.8	NA	24.8
JUL	477	584	26.1	NA	24.4
AUG	414	501	26.0	NA	21.2
SEP	479	601	26.0	NA	25.2
OCT	511	660	27.3	NA	26.6
NOV	497	651	27.9	NA	25.9
DEC	465	611	27.5	NA	24.5

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

Location		**Metema - Village No.3**
Radiation station:		**Metema**
Population:		1038
No. of wells:		1
Wells:	**aquifer type**	**Basalt**
	depth	**40m, pump at 36m**
	yield	3 L/S.
	drawdown	-
Pumping units:		
	motor	Slanzi DVA 1030
	pump	Bornemann mono 7.2m^3/hr belt driven
	no. of hours of operation	3 hrs a day direct to fawcetts
	fuel consumption	-
Distribution:	pipework Ø	2" Ø
	length	350 metres, elevation + 8.8m
	storage	-
Array location:		Well is adjacent to river course, a tree will have to be removed.
Design:		Q max = 1.5 L/S. TDH = 36 + 8.8 + 7 = 51.80m

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GGODMAN

APPLICATION: AC WATER PUMPING

NOTE: VILLAGE 3
INSOLATION DATA LOCATION: METEMA (User Supplied)

LATITUDE: 12.95 DEG N LONGITUDE: 36.07 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	15.0 DEGREES	Grundfos SP2-18	
MAX. PWR. CURRENT:	12.2 A.	XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	18.6 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	52.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT PANEL LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	457	527	26.9	NA	19.5
FEB	514	566	29.6	NA	20.0
MAR	535	557	30.1	NA	19.6
APR	554	548	28.9	NA	19.3
MAY	516	493	28.7	NA	17.7
JUN	494	465	27.8	NA	17.0
JUL	477	453	26.1	NA	16.8
AUG	414	406	26.0	NA	15.0
SEP	479	489	26.0	NA	18.4
OCT	511	551	27.3	NA	20.2
NOV	497	566	27.9	NA	20.5
DEC	465	545	27.5	NA	19.9

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 8/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: VILLAGE 3
INSOLATION DATA LOCATION: METEMA (User Supplied)

LATITUDE: 12.95 DEG N LONGITUDE: 36.07 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------
HORIZONTAL (N-S) AXIS TRACKING
MAX. PWR. CURRENT: 12.2 A.
MAXIMUM POWER: 1486.0 W.

AS INC M55 3.05 A. @ 17.4 V.
7 (S) X 4 (P) = 28 TOTAL

---------PUMP SYSTEM---------
Grundfos SP2-18
XX-5
COUPLED TO ARRAY @ 105 VOLTS

AVG. DAILY OUTPUT: 24.3 CU.M
SYSTEM HEAD: 52.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	457	598	26.9	NA	23.5
FEB	514	670	29.6	NA	25.2
MAR	535	686	30.1	NA	25.8
APR	554	696	28.9	NA	26.1
MAY	516	638	28.7	NA	24.6
JUN	494	607	27.8	NA	23.9
JUL	477	584	26.1	NA	23.5
AUG	414	501	26.0	NA	20.2
SEP	479	601	26.0	NA	24.3
OCT	511	660	27.3	NA	25.7
NOV	497	651	27.9	NA	25.0
DEC	465	611	27.5	NA	23.7

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

Location		Metema - Kobit, Village No. 4.
Radiation station:		Metema
Population:		1079
No. of wells:		2
Wells:	aquifer type	Basalt
	depth	65m (pump at 56m)
	yield	2.3 L/S
	drawdown	-
Pumping units:		
	motor	Slanzi DVA 1030
	pump	Bornemann 7.2m^3/hr belt driven
	no. of hours of operation	1 hr/day
	fuel consumption	1 litre/day
Distribution:	pipework Ø	2" Ø
	length	30m elevation - with a proposal for a 200m extension (+ 5m head)
	storage	4m^3
Array location:		North side of road.
Design:		Q = 1.2 L/S TDH = 56 + 5.6 + 5 + 3 = 70m.

Note: There is also a hand pump on a well of depth 48m, yield of 2.5 L/S with 700 metre delivery main.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: VILLAGE 4, KOBIT
INSOLATION DATA LOCATION: METEMA (User Supplied)

LATITUDE: 12.95 DEG N LONGITUDE: 36.07 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT..(ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	15.0 DEGREES	Grundfos SP1-28	
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-4	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	9.4 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	80.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	457	527	26.9	NA	9.8
FEB	514	566	29.6	NA	10.0
MAR	535	557	30.1	NA	9.8
APR	554	548	28.9	NA	9.7
MAY	516	493	28.7	NA	8.9
JUN	494	465	27.8	NA	8.6
JUL	477	453	26.1	NA	8.5
AUG	414	406	26.0	NA	7.8
SEP	479	489	26.0	NA	9.2
OCT	511	551	27.3	NA	10.1
NOV	497	566	27.9	NA	10.2
DEC	465	545	27.5	NA	10.0

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: VILLAGE 4, KOBIT
INSOLATION DATA LOCATION: METEMA (User Supplied)

LATITUDE: 12.95 DEG N LONGITUDE: 36.07 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------
HORIZONTAL (N-S) AXIS TRACKING
MAX. PWR. CURRENT: 12.2 A.
MAXIMUM POWER: 1486.0 W.

AS INC M55 3.05 A. @ 17.4 V.
7 (S) X 4 (P) = 28 TOTAL

---------PUMP SYSTEM---------
Grundfos SP1-28
102 VDC 1500 W XX-4
COUPLED TO ARRAY @ 105 VOLTS

AVG. DAILY OUTPUT: 12.2 CU.M
SYSTEM HEAD: 80.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	457	598	26.9	NA	11.7
FEB	514	670	29.6	NA	12.6
MAR	535	686	30.1	NA	12.9
APR	554	696	28.9	NA	13.1
MAY	516	638	28.7	NA	12.4
JUN	494	607	27.8	NA	12.1
JUL	477	584	26.1	NA	11.9
AUG	414	501	26.0	NA	10.3
SEP	479	601	26.0	NA	12.2
OCT	511	660	27.3	NA	12.8
NOV	497	651	27.9	NA	12.5
DEC	465	611	27.5	NA	11.7

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

Location	Metema - Kumer
Radiation station:	Metema
Population:	554
No. of wells:	1
Wells: aquifer type	Basalt but rig couldn't penetrate below 15m
depth	15m - pump at 12m
yield	1 - 2 L/S.
drawdown	-
Pumping units:	
motor	Slanzi DVA 1030
pump	Bornemann Mono, 7.2m^3/hr (belt driven)
no. of hours of operation	1 hr/day
fuel consumption	1 litre/day
Distribution: pipework Ø	2"
length	162m, elevation + 2.8 included to top of tank.
storage	4m^3
Array location:	15m west of existing pump station Black cotton soil - raft foundation.
Design:	1L/S TDH = 12 + 2.8 + 1.62
	= 16.42m
	= 17m

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: KUMER
INSOLATION DATA LOCATION: METEMA (User Supplied)

LATITUDE: 12.95 DEG N LONGITUDE: 36.07 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------
TILT ANGLE:	15.0 DEGREES	Grundfos SP8-4
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-5
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT: 62.1 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD: 17.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	457	527	26.9	NA	64.9
FEB	514	566	29.6	NA	66.8
MAR	535	557	30.1	NA	65.5
APR	554	548	28.9	NA	64.4
MAY	516	493	28.7	NA	58.9
JUN	494	465	27.8	NA	56.4
JUL	477	453	26.1	NA	56.0
AUG	414	406	26.0	NA	49.5
SEP	479	489	26.0	NA	61.3
OCT	511	551	27.3	NA	67.5
NOV	497	566	27.9	NA	68.3
DEC	465	545	27.5	NA	66.3

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: KUMER
INSOLATION DATA LOCATION: METEMA (User Supplied)

LATITUDE: 12.95 DEG N LONGITUDE: 36.07 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------

HORIZONTAL (N-S) AXIS TRACKING
MAX. PWR. CURRENT: 12.2 A.
MAXIMUM POWER: 1486.0 W.

AS INC M55 3.05 A. @ 17.4 V.
7 (S) X 4 (P) = 28 TOTAL

---------PUMP SYSTEM---------

Grundfos SP8-4
102 VDC 1500 W XX-5
COUPLED TO ARRAY @ 105 VOLTS

AVG. DAILY OUTPUT: 81.2 CU.M
SYSTEM HEAD: 17.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	457	598	26.9	NA	78.6
FEB	514	670	29.6	NA	84.4
MAR	535	686	30.1	NA	86.1
APR	554	696	28.9	NA	87.3
MAY	516	638	28.7	NA	82.4
JUN	494	607	27.8	NA	80.3
JUL	477	584	26.1	NA	78.9
AUG	414	501	26.0	NA	67.4
SEP	479	601	26.0	NA	81.3
OCT	511	660	27.3	NA	85.8
NOV	497	651	27.9	NA	83.5
DEC	465	611	27.5	NA	79.2

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: KUMER
INSOLATION DATA LOCATION: METEMA (User Supplied)

LATITUDE: 12.95 DEG N LONGITUDE: 36.07 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
HORIZONTAL (N-S) AXIS TRACKING		Grundfos SP8-4	
MAX. PWR. CURRENT:	9.1 A.	102 VDC 1500 W XX-5	
MAXIMUM POWER:	1114.5 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	58.2 CU.M
7 (S) X 3 (P) =	21 TOTAL	SYSTEM HEAD:	17.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT PANEL LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	457	598	26.9	NA	56.2
FEB	514	670	29.6	NA	61.8
MAR	535	686	30.1	NA	62.9
APR	554	696	28.9	NA	64.0
MAY	516	638	28.7	NA	58.4
JUN	494	607	27.8	NA	56.1
JUL	477	584	26.1	NA	54.8
AUG	414	501	26.0	NA	44.3
SEP	479	601	26.0	NA	57.7
OCT	511	660	27.3	NA	63.6
NOV	497	651	27.9	NA	61.8
DEC	465	611	27.5	NA	57.1

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

Location		Metema - Johannes Ketema
Radiation station:		Metema
Population:		1500
No. of wells:		1
Wells:	aquifer type	-
	depth	38m (pump at 30m)
	yield	11 L/S
	drawdown	-
Pumping units:		
	motor	Slanzi DVA 1030
	pump	Bornemann 7.2m^3/hr belt dri[illegible].
	no. of hours of operation	3 hrs/day
	fuel consumption	-
Distribution:	pipework Ø	2" Ø
	length	150m elevation + 4m
	storage	None - 4m^3 proposed (+ 3.6m)
Array location:		Large tree due East of B4 Flood protection from down slope.
Design:		Q max = 5 L/S TDH = 30 + 4 + 3 + 3.6 = 40.60m

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: JOHANNES KETEMA
INSOLATION DATA LOCATION: METEMA (User Supplied)

LATITUDE: 12.95 DEG N LONGITUDE: 36.07 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	15.0 DEGREES	Grundfos SP2-18	
MAX. PWR. CURRENT:	12.2 A.	XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	22.5 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	41.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	457	527	26.9	NA	23.3
FEB	514	566	29.6	NA	23.9
MAR	535	557	30.1	NA	23.5
APR	554	548	28.9	NA	23.3
MAY	516	493	28.7	NA	21.6
JUN	494	465	27.8	NA	20.9
JUL	477	453	26.1	NA	20.7
AUG	414	406	26.0	NA	18.9
SEP	479	489	26.0	NA	22.3
OCT	511	551	27.3	NA	24.1
NOV	497	566	27.9	NA	24.3
DEC	465	545	27.4	NA	23.7

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: JOHANNES KETEMA
INSOLATION DATA LOCATION: METEMA (User Supplied)

LATITUDE: 12.95 DEG N LONGITUDE: 36.07 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
HORIZONTAL (N-S) AXIS TRACKING		Grundfos SP2-18	
MAX. PWR. CURRENT:	12.2 A.	XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	29.0 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	41.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	457	598	26.9	NA	27.9
FEB	514	670	29.6	NA	29.8
MAR	535	686	30.1	NA	30.5
APR	554	696	28.9	NA	30.9
MAY	516	638	28.7	NA	29.4
JUN	494	607	27.8	NA	28.8
JUL	477	584	26.1	NA	28.4
AUG	414	501	26.0	NA	25.0
SEP	479	601	26.0	NA	29.0
OCT	511	660	27.3	NA	30.3
NOV	497	651	27.9	NA	29.5
DEC	465	611	27.4	NA	28.1

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

IRRIGATION SITES IN METEMA

At the request of the local administration several irrigation sites were investigated as to their suitability for solar powered irrigation.

1. Shehdi or Gandawuha demonstration site

Source: Gandawuha river. This is a seasonal river with an approx. 6 metre variation in river level; the river has no surface flow for a small part of the year but there are deep pools and subsurface flow along the river which have been used in the past for irrigation with diesel pumps. The diesel pumps were removed from the river side during the rainy seasons, due to high flood levels.

Proposel: A hand dug well (1 meter with perforated concrete culvert casing) installed, to a depth of approx. 13 metre below max. flood level, during the dry season (to minimise dewatering equipment capacity) in the alluvial deposits at the site. A solar pump installed here would then pump to a storage/distribution tank beside the agriculture training school on the hill which would command the whole area.

Max head (without friction losses)	19 metre
Length of pipe	150 metre
Pipe diameter	2" - 3"

See printout for average monthly output.

2. Shehdi irrigation site adjacent to existing water supply well.

This area of just 1 ha has a similar situation to the demonstration site at Shehdi although the required TDH is 14 meter with approx. 150 of pipework to command point. The proximity of site to the Shehdi settlement water supply borehole suggests:

a) Monitoring well for performance during dry season and

then b) using the town supply system for irrigation water.

3. Kumer

Along the same Gandawuha river as the first teo projects, a 2 ha site with a wide variety of vegetables fruit being grown. Again a large pool which never dries (i.e. sub-surface flow) with max. head in dry season of 13.5 meter with pipework requirements of 50 m. Due to flooding a hand dug well would be necessary.

It was notived during the site investigation that, particularly in the small basin irrigation plots there is a evidence of salination. The recommendation for an irrigation advisor be posted to Shehdi for some months to assist the agricultural officer in training in irrigation techniques and to investigate further the water and soil properties was suggested to the senior Gomdar regional administrator.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: SHEHDI IRRIGATION SITE
INSOLATION DATA LOCATION: METEMA (User Supplied)

LATITUDE: 12.95 DEG N LONGITUDE: 36.07 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	15.0 DEGREES	Grundfos SP4-8	
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	45.5 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	22.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	457	527	26.9	NA	46.7
FEB	514	566	29.6	NA	47 6
MAR	535	557	30.1	NA	47.4
APR	554	548	28.9	NA	47.2
MAY	516	493	28.7	NA	44.3
JUN	494	465	27.8	NA	42.9
JUL	477	453	26.1	NA	42.6
AUG	414	406	26.0	NA	39.0
SEP	479	489	26.0	NA	45.2
OCT	511	551	27.3	NA	48.0
NOV	497	566	27.9	NA	48.3
DEC	465	545	27.5	NA	47.3

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY DATE: 8TH DECEMBER 1986
ADDRESS: ETHIOPIA OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: SHEHDI IRRIGATION SITE
INSOLATION DATA LOCATION: METEMA (User Supplied)

LATITUDE: 12.95 DEG N LONGITUDE: 36.07 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
HORIZONTAL (N-S) AXIS TRACKING		Grundfos SP4-8	
MAX. PWR. CURRENT:	9.1 A.	102 VDC 1500 W XX-5	
MAXIMUM POWER:	1114.5 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	46.6 CU.M
7 (S) X 3 (P) =	21 TOTAL	SYSTEM HEAD:	22.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	457	598	26.9	NA	44.9
FEB	514	670	29.6	NA	48.3
MAR	535	686	30.1	NA	49.3
APR	554	696	28.9	NA	49.9
MAY	516	638	28.7	NA	47.2
JUN	494	607	27.8	NA	46.0
JUL	477	584	26.1	NA	45.3
AUG	414	501	26.0	NA	39.3
SEP	479	601	26.0	NA	46.7
OCT	511	660	27.3	NA	49.2
NOV	497	651	27.9	NA	47.8
DEC	465	611	27.5	NA	45.3

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: SHEHDI IRRIGATION SITE
INSOLATION DATA LOCATION: METEMA (User Supplied)

LATITUDE: 12.95 DEG N LONGITUDE: 36.07 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
HORIZONTAL (N-S) AXIS TRACKING		Grundfos SP4-8	
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	57.8 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	22.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	457	598	26.9	NA	55.9
FEB	514	670	29.6	NA	59.2
MAR	535	686	30.1	NA	60.5
APR	554	696	28.9	NA	61.2
MAY	516	638	28.7	NA	58.7
JUN	494	607	27.8	NA	57.6
JUL	477	584	26.1	NA	56.9
AUG	414	501	26.0	NA	51.2
SEP	479	601	26.0	NA	58.1
OCT	511	660	27.3	NA	60.0
NOV	497	651	27.9	NA	58.5
DEC	465	611	27.5	NA	56.1

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: KUMER
INSOLATION DATA LOCATION: METEMA (User Supplied)

LATITUDE: 12.95 DEG N LONGITUDE: 36.07 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
HORIZONTAL (N-S) AXIS TRACKING		Grundfos SP8-4	
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	81.2 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	17.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	457	598	26.9	1	78.6
FEB	514	670	29.6	0	84.4
MAR	535	686	30.1	0	86.1
APR	554	696	28.9	1	87.3
MAY	516	638	28.7	67	82.4
JUN	494	607	27.8	160	80.3
JUL	477	584	26.1	209	78.9
AUG	414	501	26.0	211	67.4
SEP	479	601	26.0	187	81.3
OCT	511	660	27.3	45	85.8
NOV	497	651	27.9	4	83.5
DEC	465	611	27.5	0	79.2

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA
DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: GUBA
INSOLATION DATA LOCATION: METEMA (User Supplied)

LATITUDE: 12.95 DEG N LONGITUDE: 36.07 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	15.0 DEGREES	Grundfos SP1-28	
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-4	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	8.5 CU.M
7 'S) X	4 (P) = 28 TOTAL	SYSTEM HEAD:	90.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT PANEL LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	457	527	26.9	NA	8.8
FEB	514	566	29.6	NA	9.1
MAR	535	557	30.1	NA	8.9
APR	554	548	28.9	NA	8.7
MAY	516	493	28.7	NA	8.0
JUN	494	465	27.8	NA	7.6
JUL	477	453	26.1	NA	7.6
AUG	414	406	26.0	NA	6.7
SEP	479	489	26.0	NA	8.3
OCT	511	551	27.3	NA	9.2
NOV	497	566	27.9	NA	9.4
DEC	465	545	27.5	NA	9.0

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY DATE: 8TH DECEMBER 1986
ADDRESS: ETHIOPIA OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: GUBA
INSOLATION DATA LOCATION: METEMA (User Supplied)

LATITUDE: 12.95 DEG N LONGITUDE: 36.07 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
HORIZONTAL (N-S) AXIS TRACKING		Grundfos SP1-28	
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-4	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	11.0 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	90.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	457	598	26.9	NA	10.5
FEB	514	670	29.6	NA	11.4
MAR	535	686	30.1	NA	11.7
APR	554	696	28.9	NA	11.9
MAY	516	638	28.7	NA	11.2
JUN	494	607	27.8	NA	10.9
JUL	477	584	26.1	NA	10.7
AUG	414	501	26.0	NA	9.2
SEP	479	601	26.0	NA	11.0
OCT	511	660	27.3	NA	11.7
NOV	497	651	27.9	NA	11.3
DEC	465	611	27.5	NA	10.6

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

II.3. SUMMARY AND NOTES ON S.W. REGION WELLS, ILLUBABOR AND WELEGA

Only the wells in the settlement villages in Gambella were visited where the well drilling programme is now formally closed. New areas, with a large proposed drilling programme, are to be developed on the southern border with Gamu Gofa. The well log records should be forwarded to ENEC for evaluation and inclusion in this project.

There is currently a large programme 60 Km. S.W. of Jima; however the proximity of Jima mitigated against investigation.

In Welega there are extensive development plans for the construction of hydroelectric schemes and extension of the grid into development areas. Of particular interest to this project is the progress of the mini-hydro scheme north of Asosa. This area has been the focus of a large well drilling programme, extensive settlement and expansion of services but the future, in this remote N.W. corner of the province on the Sudan border, depends on the mini hydro. The personnel at E.W.W.C.A. in Jima were strongly in favour of the utilisation of solar water pumping because of the real difficulty in providing maintenance in the area. If the hydro scheme becomes a reality then electric submersibles should be installed otherwise re-evaluation of the wells W.R.T. p.v. installations will be considered.

NOTES:

Illubabor

1. In metamorphic and volcanic rocks in the Jime /Gambela area, wells decline in discharge by 60% over 2 years. This is the conclusion from step drawdown tests conducted by E.W.W.C.A. in the region, over a 2-3 years period. This phenomena has been recorded in similar formations in Sweden and Canada and reported in several publications.

"Well monitoring"

and "Groundwater Journal".

The phenomena occurs when drilling in areas with no other boreholes and where there appears to be an initially higher water table, and thus greater yield, than the eventual equilibrium state of groundwater recharge can account for.

Hence in design considerations to account for this drop in yield - assume 40% of initial yield.

2. Original yield tests in Illubabor were either done by step drawdown tests or airlift tests, using a compressor for 3 hours, with discharge measured by Vee Notch.

As the well drilling programme for this project is formally closed, records in Jimma were not available; however an assumption of 40% Q leaves a margin of safety.

Installation Sites:

1. Bara Abol (Finkao) village # 5

2. Bara Abol (Finkao) village # 6

3. Bara Abol (Finkao) village # 7

4. Ubala village # 1

5. Ubala village # 2

6. Ubala village # 3

7. Ubala village # 4

8. Ubala village # 5

9. Ubala village # 6

Location		Baro Abol or Finkao Village No. 5
Radiation station:		Gambella
Population:		950
No. of wells:		2
Wells:	aquifer type	Basalt
	depth	35 - 60m (for design purposes 50m)
	yield	3 L/S
	drawdown	-
Pumping units:		Hand Pump.
	motor	-
	pump	-
	no. of hours of operation	6 8 hrs/day each.
	fuel consumption	-
Distribution:	pipework Ø	
	length	None
	storage	None
Array location:		Next to well

Design:

Note: With 2 wells, one fitted with solar and one remaining as hand pump is ideal fail safe solution.

Location		Bara Abol or Finkao Village No. 6
Radiation station:		Gambella
Population:		1787
No. of wells:		2
Wells:	aquifer type	Basalt
	depth	35 - 60m (for design 50m)
	yield	3 L/S.
	drawdown	-
Pumping units:		Hand pump
	motor	-
	pump	-
	no. of hours of operation	6 - 8 hrs/day.
	fuel consumption	-
Distribution:	pipework Ø	None
	length	None
	storage	None
Array location:		Next to well

Design:

Note: As for village 5.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: BARA ABOL OR FINKAO VILLAGES NO.5,6,7
INSOLATION DATA LOCATION: GAMBELA (User Supplied)

LATITUDE: 8.25 DEG N LONGITUDE: 34.58 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	15.0 DEGREES	Grundfos SP2-18	
MAX. PWR. CURRENT:	12.2 A.	XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	16.6 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	50.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	468	527	28.0	NA	19.9
FEB	474	511	29.2	NA	19.3
MAR	448	459	30.5	NA	17.4
APR	486	475	29.7	NA	18.1
MAY	398	379	27.4	NA	14.3
JUN	380	358	26.6	NA	13.3
JUL	370	351	26.8	NA	13.0
AUG	314	307	26.3	NA	10.7
SEP	407	410	26.7	NA	16.0
OCT	439	464	27.0	NA	18.2
NOV	440	488	26.1	NA	19.2
DEC	455	519	27.2	NA	19.9

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

Location		Bara Abol, or Finkao Village No. 7
Radiation station:		Gambella
Population:		1140
No. of wells:		2
Wells:	aquifer type	Basalt
	depth	35 - 60m
	yield	2 - 3 L/S
	drawdown	-
Pumping units:		2 Hand pumps
	motor	
	pump	
	no. of hours of operation	
	fuel consumption	
Distribution:	pipework Ø	
	length	None
	storage	None
Array location:		Next to well.

Design:

Note: As for village 3.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY DATE: 8TH DECEMBER 1986
ADDRESS: ETHIOPIA OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: BARA ABOL OR FINKAO VILLAGES NO.5,6,7
INSOLATION DATA LOCATION: GAMBELA (User Supplied)

LATITUDE: 8.25 DEG N LONGITUDE: 34.58 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------

HORIZONTAL (N-S) AXIS TRACKING
MAX. PWR. CURRENT: 12.2 A.
MAXIMUM POWER: 1486.0 W.

AS INC M55 3.05 A. @ 17.4 V.
7 (S) X 4 (P) = 28 TOTAL

---------PUMP SYSTEM---------

Grundfos SP2-18
XX-5
COUPLED TO ARRAY @ 105 VOLTS

AVG. DAILY OUTPUT: 21.6 CU.M
SYSTEM HEAD: 50.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	468	604	28.0	NA	24.4
FEB	474	605	29.2	NA	24.4
MAR	448	559	30.5	NA	22.8
APR	486	603	29.7	NA	24.6
MAY	398	481	27.4	NA	20.0
JUN	380	457	26.6	NA	19.0
JUL	370	443	26.8	NA	18.3
AUG	314	368	26.3	NA	14.2
SEP	407	499	26.7	NA	21.0
OCT	439	552	27.0	NA	23.1
NOV	440	562	26.1	NA	23.5
DEC	455	588	27.2	NA	24.1

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT
UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

Location		Ubala, Villages1 - 5
Radiation station:		Abobo
Population:		1500
No. of wells:		1
Wells:	aquifer type	Basalt
	depth	50m.
	yield	2 - 3 L/S
	drawdown	-
Pumping units:		Hand pump
	motor	-
	pump	-
	no. of hours of operation	12 hours/day
	fuel consumption	-
Distribution pipework Ø		None
	length	None
	storage	None
Array location:		next to well
Design:		-

Note: The queues at all village hand pump locations and the general complaint of the amount of time waiting for water (an opportunity time cost) warrant pump. With deep wells it is more difficult for older people and with 400 families on average taking 2 minutes minimum, that is 13.3 hrs/day.

DESIGN PROVIDED BY: ARCO SOLAR EUROPE
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 4.2 12/20/85)

CUSTOMER: UNIDO SURVEY DATE: 7DEC86
ADDRESS: ETHIOPIA OPER: DJS

APPLICATION: AC WATER PUMPING

NOTE: UBALA VILLAGES 1-5
INSOLATION DATA LOCATION: ABOBO ETHIOPIA (User Supplied)

LATITUDE: 7.80 DEG N LONGITUDE: 34.40 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------
HORIZONTAL (N-S) AXIS TRACKING
MAX. PWR. CURRENT: 12.2 A.
MAXIMUM POWER: 1486.0 W.

\S INC M55 3.05 A. @ 17.4 V.
7 (S) X 4 (P) = 28 TOTAL

---------PUMP SYSTEM---------
Grundfos SP2-18
XX-5
COUPLED TO ARRAY @ 105 VOLTS

AVG. DAILY OUTPUT: 17.6 CU.M
SYSTEM HEAD: 58.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	469	608	24.5	9	20.8
FEB	469	603	26.4	40	20.4
MAR	449	567	28.3	69	19.1
APR	493	619	27.5	93	21.0
MAY	389	474	25.1	139	15.2
JUN	381	463	25.9	126	14.6
JUL	375	455	25.4	345	14.3
AUG	313	374	25.4	258	10.3
SEP	404	502	24.2	225	16.7
OCT	433	549	24.4	184	18.8
NOV	440	566	25.4	57	19.4
DEC	457	593	23.9	3	20.5

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT
UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

Location		Ubala, Village No. 6 (labelled UB 14)
Radiation station:		Abobo
Population:		800
No. of wells:		1 with motor, 2 handpumps.
Wells:	aquifer type	Basalt
	depth	86m
	yield	3 - 4 L/S
	drawdown	-
Pumping units:		
	motor	Kirloskar RD-2, 12.5 KVA
	pump	Submersible
	no. of hours of operation	1 hr/day
	fuel consumption	-
Distribution:	pipework Ø	2" Ø, 4 No. 90° bends
	length	24m
	storage	4000 litre, 4 metres top elevation above borehole.
Array location:		Immediately adjacent to B.H.

Design:

Note: 6 villages in UBALA all fitted with IMII except UB14. min. depth 24m, max depth 86m (UB14) average 40 - 50m, yield 2-3 L/S.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: UBALA VILLAGE NO.6 (UB 14 EWWCA)
INSOLATION DATA LOCATION: ABOBO (User Supplied)

LATITUDE: 7.80 DEG N LONGITUDE: 34.60 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	15.0 DEGREES	Grundfos SP1-28	
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-4	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	7.4 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	86.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	469	527	24.5	NA	9.3
FEB	469	504	26.4	NA	8.7
MAR	449	459	28.3	NA	8.0
APR	493	481	27.5	NA	8.3
MAY	389	371	25.1	NA	6.0
JUN	381	358	25.9	NA	5.6
JUL	375	355	25.4	NA	5.6
AUG	313	305	25.4	NA	4.4
SEP	404	406	24.2	NA	7.2
OCT	433	456	24.4	NA	8.2
NOV	440	487	25.4	NA	8.7
DEC	457	520	23.9	NA	9.3

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

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STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: UBALA VILLAGE NO.6 (UB 14 EWWCA)
INSOLATION DATA LOCATION: ABORO (User Supplied)

LATITUDE: 7.80 DEG N LONGITUDE: 34.60 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
HORIZONTAL (N-S) AXIS TRACKING		Grundfos SP1-28	
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-4	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	9.8 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	86.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	469	605	24.5	NA	11.3
FEB	469	598	26.4	NA	11.1
MAR	449	560	28.3	NA	10.5
APR	493	613	27.5	NA	11.4
MAY	389	469	25.1	NA	8.7
JUN	381	458	25.9	NA	8.4
JUL	375	450	25.4	NA	8.2
AUG	313	367	25.4	NA	6.1
SEP	404	494	24.2	NA	9.4
OCT	433	543	24.4	NA	10.4
NOV	440	562	25.4	NA	10.6
DEC	457	590	23.9	NA	11.2

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

II.4 ARUSI PROVINCE

Location		Aburra Village or Ogolcha
Radiation station:		Ogolcha
Population:		3500
No. of wells:		1
Wells:	aquifer type	-
	depth	63m
	yield	5.8 L/S for 24 hours
	drawdown	1m
Pumping units:		Broken hand pump.
	motor	
	pump	
	No. of hours of operation	
	Fuel consumption	
Distribution:	pipework Ø	1" Ø
	length	200 m.
	storage	1 m^3 This will be removed and a storage tank to elevation of 4m. placed beside the B.H. and gravity feed to school and village.
Array locations:		Besides B. H.
Design:		Q = 2.5 L/S TDH = 33m.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: OGOLCHO-ABURRA VILLAGE
INSOLATION DATA LOCATION: OGOLCHO (User Supplied)

LATITUDE: 8.06 DEG N LONGITUDE: 39.03 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	15.0 DEGREES	Grundfos SP4-8	
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	32.8 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	33.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	505	569	18.3	NA	37.9
FEB	524	565	19.4	NA	37.6
MAR	520	532	20.1	NA	35.7
APR	501	489	20.9	NA	32.7
MAY	484	457	20.7	NA	30.3
JUN	474	440	20.2	NA	29.0
JUL	403	381	19.5	NA	24.4
AUG	433	419	19.1	NA	27.8
SEP	422	425	18.8	NA	28.4
OCT	504	533	19.3	NA	35.9
NOV	501	557	17.9	NA	37.4
DEC	472	539	17.5	NA	36.4

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: OGOLCHO-ABURRA VILLAGE
INSOLATION DATA LOCATION: OGOLCHO (User Supplied)

LATITUDE: 8.06 DEG N LONGITUDE: 39.03 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
HORIZONTAL (N-S) AXIS TRACKING		Grundfos SP4-8	
MAX. PWR. CURRENT:	9.1 A.	102 VDC 1500 W XX-5	
MAXIMUM POWER:	1114.5 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	31.5 CU.M
7 (S) X 3 (P) =	21 TOTAL	SYSTEM HEAD:	33.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	505	656	18.3	NA	35.1
FEB	524	675	19.4	NA	36.3
MAR	520	660	20.1	NA	35.3
APR	501	624	20.9	NA	32.9
MAY	484	597	20.7	NA	31.1
JUN	474	583	20.2	NA	30.3
JUL	403	487	19.5	NA	23.2
AUG	433	529	19.1	NA	26.6
SEP	422	519	18.8	NA	25.9
OCT	504	642	19.3	NA	34.3
NOV	501	648	17.9	NA	34.7
DEC	472	612	17.5	NA	32.4

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
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CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: OGOLCHO-ABURRA VILLAGE
INSOLATION DATA LOCATION: OGOLCHO (User Supplied)

LATITUDE: 8.06 DEG N LONGITUDE: 39.03 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------

HORIZONTAL (N-S) AXIS TRACKING
MAX. PWR. CURRENT: 12.2 A.
MAXIMUM POWER: 1466.0 W.

AS INC M55 3.05 A. @ 17.4 V.
7 (S) X 4 (P) = 28 TOTAL

---------PUMP SYSTEM---------

Grundfos SP4-8
102 VDC 1500 W XX-5
COUPLED TO ARRAY @ 105 VOLTS

AVG. DAILY OUTPUT: 43.2 CU.M
SYSTEM HEAD: 33.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	505	656	18.3	NA	46.6
FEB	524	675	19.4	NA	47.8
MAR	520	660	20.1	NA	47.1
APR	501	624	20.9	NA	44.8
MAY	484	597	20.7	NA	43.1
JUN	474	583	20.2	NA	42.2
JUL	403	487	19.5	NA	34.9
AUG	433	529	19.1	NA	38.5
SEP	422	519	18.8	NA	37.8
OCT	504	642	19.3	NA	46.1
NOV	501	648	17.9	NA	46.3
DEC	472	612	17.5	NA	44.0

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

II.5. SUMMARY AND NOTES ON SOUTHERN REGION WELLS

- Sidamo, Gamu-Gofa, Bale.

Southern Sidamo is a vast area inhabited by nomads who move seasonally across the province visiting the traditional wells, ellas, en route. Many of the new wells drilled by the EWWCA/Canadian aid team are situated in these traditional well locations where there are some small permanent settlements such as El leh and EL.Gofa The seasonal demand for water varies enormously as the cattle herds pass through. This fluctuation in seasonal demand cannot be met by existing solar pumps; if it could it would be economically inadvisable. The traditional wells are maintained by the inhabitants and provide the extra seasonal demand; the solar pumps sized for these areas allow for some stock watering, potable water for the local people and some surplus for small scale irrigation as is occuring at EL Gofa. Storage facilities at these sites could be greatly extended, initially utilizing the cattle troughs which are not very well designed for stock watering (0.3m wide walls are too wide for sheep and goats).

No population figure was available for Chilango, and with a system head of 89 metres TDH and output of 10.8 m^3 this is a marginal site unless there are traditional wells nearby. Dolo Mekala No. 1, where the diesel pump has been out of action for months, the system head at 111.5m TDH is very high with an output of 8.7 m^3/day with tracking. However, if onsite storage and distribution system is provided, the TDH reduces to 95m and output increases to 10.2m^3/day. There are traditional wells here.

All information on the current well drilling programme should be obtained by ENEC from EWWCA for evaluation in this and future projects.

NOTES - SIDAMO, GAMU GOFA, BALE

1. In Sidamo region there is an ongoing programme of well drilling by E.W.W.C.A. with 3 wells which have just been drilled at:

   Kidale No. 1) 7 Km north of Yavello
   Chalkasa)
   Derdoto) all in Arero

   Information on these wells should be obtained by the Ministry (well data, populations served) and system sized for viability.

2. In Gamu-Gofa, only the wells south of Arba Minch were reviewed (apart from Wachyga Busha).

   a) Kolosi No.1; town supply with booster station.

   b) Gato No. 1; 120m well depth produced artesian flow.

   c) Gardula No. 4 or TISHEMELE (10 km south of Gato).

      aquifer: All fine sands + Silts with some clays (i.e. alluvials)

      depth: 82m

      S.W.L.: 5.4m

      Airlift test: 108 L/Min for 7 hours.

   d) GARDULA No. 2

      (Gumaide No. 2)
      acquifer type: Broken basalt
      depth 70m
      S.W.L. 34.08 PWL. 43m
      Drawdown: 9m at Q = 150 L/Min. after 9 hrs pumping
      Specific capacity: 16.7 L/Min./hr.
      Safe yield: ? 1.5 L/S assume
      Recommended pump level 45m.
      Population: approx. 5000

Installation: Mono lift pumping with Lister diesel and 4m³ storage.

Design: Q ; 1.5 L/S, TDH = 55m

Note: See survey.

5. In BALE province, where 21% of the population now have access to potable water, the highest percentage in Ethiopia, there are no deep boreholes. EWWCA is heavily involved in the highlands, where spring development and hand dug wells with hand pumps are the basis of this encouraging committment.

Installation Sites:

Sidamo

1. El Leh No. 1
2. El Gofa No. 2
3. Melbana No. 1
4. Melbana No. 2
5. Chilango - to be reviewed by EWWCA.
6. Bokul Bona No. 3
7. Dolo Mekala No. 1
8. Tuka No. 1

Gamu Gofa

1. Gebele Bono No. 1
2. Gardula No. 2
3. Wachyga Busha (on point distribution and well surged)

Location		El Leh No. 1
Radiation station:		Moyale/Mega
Population:		Small permanent settlement nearby: 5700 people and approx. 50,000 cattle.
No. of wells:		I.B.H. and several traditional wells.
Wells:	aquifer type	Alluvial & Elluviall over burden
	depth	42.5m S.W.L. 18.16m P.W.L. 20.80m
	yield	90 L/min, specific capacity 97.3 L/min/metre
	drawdown	2.64 after 19 hrs pumping at 114 L/min.
Pumping units:		
	motor	Farymann Diesel single cylinder (5 H.P.)
	pump	Mono flow way pump, belt driven rated 90 L/min (The engine has been replaced once in 3 years operation)
	no. of hours of operation	4 hours a day 21.60m^3/day but max seasonal demand 90m^3/day
	fuel consumption	200 - 250 litre/month.
Distribution:	pipework Ø	2" Ø
	length	40m
	storage	8m^3, 6m elevation serving 1 trough 12m^3 capacity and 2 tap stands.
Array location:		O.K., adjacent to B.H. in existing garden
Design:		Q = 1.5 L/Sec TDH = 20.9 + 6 + 0.9 = 27.7m

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY DATE: 8TH DECEMBER 1986
ADDRESS: ETHIOPIA OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: EL LEH NO.1
INSOLATION DATA LOCATION: MEGA (User Supplied)

LATITUDE: 4.08 DEG N LONGITUDE: 38.33 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	15.0 DEGREES	Grundfos SP4-8	
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	36.5 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	28.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	518	574	20.9	NA	43.6
FEB	527	560	19.5	NA	42.8
MAR	518	524	20.6	NA	40.6
APR	484	468	19.6	NA	37.0
MAY	383	362	18.2	NA	28.2
JUN	442	406	16.9	NA	32.0
JUL	410	382	16.3	NA	30.0
AUG	373	359	16.9	NA	28.1
SEP	498	495	17.9	NA	38.9
OCT	442	460	18.3	NA	36.8
NOV	475	518	18.8	NA	40.6
DEC	456	510	20.4	NA	39.9

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY DATE: 8TH DECEMBER 1986
ADDRESS: ETHIOPIA OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: EL LEH NO.1
INSOLATION DATA LOCATION: MEGA (User Supplied)

LATITUDE: 4.08 DEG N LONGITUDE: 38.33 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
HORIZONTAL (N-S) AXIS TRACKING		Grundfos SP4-8	
MAX. PWR. CURRENT:	9.1 A.	102 VDC 1500 W XX-5	
MAXIMUM POWER:	1114.5 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	36.4 CU.M
7 (S) X 3 (P) =	21 TOTAL	SYSTEM HEAD:	28.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	518	667	20.9	NA	42.5
FEB	527	673	19.5	NA	43.0
MAR	518	654	20.6	NA	42.0
APR	484	603	19.6	NA	38.8
MAY	383	465	18.2	NA	27.8
JUN	442	546	16.9	NA	34.7
JUL	410	502	16.3	NA	31.1
AUG	373	450	16.9	NA	26.5
SEP	498	624	17.9	NA	40.3
OCT	442	551	18.3	NA	35.2
NOV	475	604	18.8	NA	39.0
DEC	456	582	20.4	NA	37.1

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: EL LEH NO.1
INSOLATION DATA LOCATION: MEGA (User Supplied)

LATITUDE: 4.08 DEG N LONGITUDE: 38.33 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT.. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------
HORIZONTAL (N-S) AXIS TRACKING
MAX. PWR. CURRENT: 12.2 A.
MAXIMUM POWER: 1486.0 W.

AS INC M55 3.05 A. @ 17.4 V.
7 (S) X 4 (P) = 28 TOTAL

---------PUMP SYSTEM---------
Grundfos SP4-8
102 VDC 1500 W XX-5
COUPLED TO ARRAY @ 105 VOLTS

AVG. DAILY OUTPUT: 48.1 CU.M
SYSTEM HEAD: 28.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	518	667	20.9	NA	53.8
FEB	527	673	19.5	NA	54.5
MAR	518	654	20.6	NA	53.6
APR	484	603	19.6	NA	50.4
MAY	383	465	18.2	NA	39.8
JUN	442	546	16.9	NA	46.5
JUL	410	502	16.3	NA	43.1
AUG	373	450	16.9	NA	38.4
SEP	498	624	17.9	NA	51.9
OCT	442	551	18.3	NA	47.0
NOV	475	604	18.8	NA	50.4
DEC	456	582	20.4	NA	48.7

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

Location		EL Gofa No. 2
Radiation station:		Moyale/Mega
Population:		Small permanent settlement, seasonal grazing
No. of wells:		I.B.H. and several additional wells (ellas)
Wells:	aquifer type	Alluvium
	depth	48m S.W.L. 27.36, P.W.L. 27.76
	yield	2.5 L/Sec Specific capacity 810.8 L/min/metre.
	drawdown	0.4m after 9 hrs pumping at Q = 300 L/min.
Pumping units:		
	motor	12.4 H.P. Lister, 10KVA
	pump	7.5 H.P. Pleuger submersible rated 109 1/min. at 150m head. Pump set 38m. below ground.
	no. of hours of operation	Full storage but would pump 12 hrs a day if cattle around. Max Demand 86m^3/day.
	fuel consumption	-
Distribution:	pipework Ø	2" Ø
	length	64m.
	storage	8m^3, 6m elevation serving 2 t p stands and 1 cattle trough (1 1/2 m X 20m X 0.4m)
Array location:		Would have to be placed south of the storage tank - pump house and B.H. are north of storage.
Design:		Q = 2 L/Sec max.
		TDH = 38 + 6 + 6 = 50m

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: EL GOFA NO.2
INSOLATION DATA LOCATION: MEGA (User Supplied)

LATITUDE: 4.08 DEG N LONGITUDE: 38.33 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	15.0 DEGREES	Grundfos SP2-18	
MAX. PWR. CURRENT:	12.2 A.	XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	18.4 CU.M
7 (S) X	4 (P) = 28 TOTAL	SYSTEM HEAD:	50.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	518	574	20.9	NA	22.3
FEB	527	560	19.5	NA	21.9
MAR	518	524	20.6	NA	20.7
APR	484	468	19.6	NA	18.7
MAY	383	362	18.2	NA	13.8
JUN	442	406	16.9	NA	15.9
JUL	410	382	16.3	NA	14.8
AUG	373	359	16.9	NA	13.8
SEP	498	495	17.9	NA	19.8
OCT	442	460	18.3	NA	18.6
NOV	475	518	18.8	NA	20.7
DEC	456	510	20.4	NA	20.3

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: EL GOFA NO.2
INSOLATION DATA LOCATION: MEGA (User Supplied)

LATITUDE: 4.08 DEG N LONGITUDE: 38.33 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
HORIZONTAL (N-S) AXIS TRACKING		Grundfos SP2-18	
MAX. PWR. CURRENT:	12.2 A.	XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	24.5 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	50.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	518	667	20.9	NA	27.7
FEB	527	673	19.5	NA	28.0
MAR	518	654	20.6	NA	27.5
APR	484	603	19.6	NA	25.8
MAY	383	465	18.2	NA	19.8
JUN	442	546	16.9	NA	23.6
JUL	410	502	16.3	NA	21.6
AUG	373	450	16.9	NA	19.0
SEP	498	624	17.9	NA	26.5
OCT	442	551	18.3	NA	23.8
NOV	475	604	18.8	NA	25.8
DEC	456	582	20.4	NA	24.9

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

Location		Melbana No. 1 - not visited.
Radiation station:		Mega/Moyale
Population:		2000 people
No. of wells:		I.B.H.
Wells:	aquifer type	-
	depth	46m
	yield	100 L/min airlift test.
	drawdown	-
Pumping units:		-
	motor	-
	pump	-
	no. of hours of operation	-
	fuel consumption	-
Distribution:	pipework Ø	-
	length	-
	storage	$5m^3$ storage at 4 metre elevations
Array location:		-
Design:		Q = 1 L/S
		TDH = 50m.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: MELBANA NO.1
INSOLATION DATA LOCATION: MEGA (User Supplied)

LATITUDE: 4.08 DEG N LONGITUDE: 38.33 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	15.0 DEGREES	Grundfos SP2-18	
MAX. PWR. CURRENT:	12.2 A.	XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	18.4 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	50.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	518	574	20.9	NA	22.3
FEB	527	560	19.5	NA	21.9
MAR	518	524	20.6	NA	20.7
APR	484	468	19.6	NA	18.7
MAY	383	362	18.2	NA	13.8
JUN	442	406	16.9	NA	15.9
JUL	410	382	16.3	NA	14.8
AUG	373	359	16.9	NA	13.8
SEP	498	495	17.9	NA	19.8
OCT	442	460	18.3	NA	18.6
NOV	475	518	18.8	NA	20.7
DEC	456	510	20.4	NA	20.3

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: MELEANA NO.1
INSOLATION DATA LOCATION: MEGA (User Supplied)

LATITUDE: 4.08 DEG N LONGITUDE: 38.33 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------
HORIZONTAL (N-S) AXIS TRACKING		Grundfos SP2-18
MAX. PWR. CURRENT:	12.2 A.	XX-5
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT: 24.5 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD: 50.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	518	667	20.9	NA	27.7
FEB	527	673	19.5	NA	28.0
MAR	518	654	20.6	NA	27.5
APR	484	603	19.6	NA	25.8
MAY	383	465	18.2	NA	19.8
JUN	442	546	16.9	NA	23.6
JUL	410	502	16.3	NA	21.6
AUG	373	450	16.9	NA	19.0
SEP	498	624	17.9	NA	26.5
OCT	442	551	18.3	NA	23.8
NOV	475	604	18.8	NA	25.8
DEC	456	582	20.4	NA	24.9

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

Location	Melbana No. 2	- not visited.
Radiation station:	Mega/Moyale	
Population:	2000	
No. of wells:	-	
Wells: aquifer type	-	
depth	pump installed at 70m.	
yield	2 L/S (airlift test)	
drawdown	-	
Pumping units:	-	
motor		
pump	Belt driven Moyno.	
no. of hours of operation	-	
fuel consumption	-	
Distribution: pipework Ø		
length	-	
storage	$4m^3$ elevated storage adjacent to B.H.	
Array location:		
Design:	Q = 1.5 L/S.	
	TDH = 70r .	

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: MELBANA NO.2
INSOLATION DATA LOCATION: MEGA (User Supplied)

LATITUDE: 4.08 DEG N LONGITUDE: 38.33 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	15.0 DEGREES	Grundfos SP1-28	
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-4	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	8.8 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	80.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	518	574	20.9	NA	10.8
FEB	527	560	19.5	NA	10.6
MAR	518	524	20.6	NA	10.0
APR	484	468	19.6	NA	9.0
MAY	383	362	18.2	NA	6.4
JUN	442	406	16.9	NA	7.5
JUL	410	382	16.3	NA	7.0
AUG	373	359	16.9	NA	6.4
SEP	498	495	17.9	NA	9.6
OCT	442	460	18.3	NA	9.0
NOV	475	518	18.8	NA	10.0
DEC	456	510	20.4	NA	9.8

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION [illegible] ARY DEPENDENT
UPON WEATHER CONDITIONS AND ACCURACY OF [illegible] ION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: MELBANA NO.2
INSOLATION DATA LOCATION: MEGA (User Supplied)

LATITUDE: 4.08 DEG N LONGITUDE: 38.33 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
HORIZONTAL (N-S) AXIS TRACKING		Grundfos SP1-28	
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-4	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	11.8 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	80.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	518	667	20.9	NA	13.4
FEB	527	673	19.5	NA	13.5
MAR	518	654	20.6	NA	13.3
APR	484	603	19.6	NA	12.5
MAY	383	465	18.2	NA	9.4
JUN	442	546	16.9	NA	11.4
JUL	410	502	16.3	NA	10.4
AUG	373	450	16.9	NA	9.0
SEP	498	624	17.9	NA	12.8
OCT	442	551	18.3	NA	11.5
NOV	475	604	18.8	NA	12.5
DEC	456	582	20.4	NA	12.0

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

Location		Chilango
Radiation station:		Mega
Population:		Seasonal demand
No. of wells:		I.B.H. + traditional wells.
Wells:	aquifer type	Soft clay rich limestone.
	depth	105m. S.W.L. 50m
	yield	20 L/min. 1/3 L/Sec spec capacity 4.27 L/min/m
	drawdown	-
Pumping units:		16 KW Petter generator
	motor	8 HP ESP with 20 stages
	pump	Install pump at 83m.
	no. of hours of operation	
	fuel consumption	
Distribution: pipework Ø		
	length	
	storage	$4m^3$ 4.5m above G.L.
Array location:		
Design:		Max Q = 1/3 L/Sec TDH = 83 + 4.5 + 1.5 = 89m.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: CHILANGO
INSOLATION DATA LOCATION: MEGA (User Supplied)

LATITUDE: 4.08 DEG N LONGITUDE: 38.33 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	15.0 DEGREES	Grundfos SP1-28	
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-4	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	8.0 CU.M
/ (S) X	4 (P) = . 28 TOTAL	SYSTEM HEAD:	89.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT PANEL LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	518	574	20.9	NA	10.0
FEB	527	560	19.5	NA	9.8
MAR	518	524	20.6	NA	9.2
APR	484	468	19.6	NA	8.2
MAY	383	362	18.2	NA	5.7
JUN	442	406	16.9	NA	6.7
JUL	410	382	16.3	NA	6.2
AUG	373	359	16.9	NA	5.7
SEP	498	495	17.9	NA	8.7
OCT	442	460	18.3	NA	8.1
NOV	475	518	18.8	NA	9.2
DEC	456	510	20.4	NA	9.0

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: CHILANGO
INSOLATION DATA LOCATION: MEGA (User Supplied)

LATITUDE: 4.08 DEG N LONGITUDE: 38.33 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
HORIZONTAL (N-S) AXIS TRACKING		Grundfos SP1-28	
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-4	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	10.8 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	89.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	518	667	20.9	NA	12.4
FEB	527	673	19.5	NA	12.6
MAR	518	654	20.6	NA	12.3
APR	484	603	19.6	NA	11.4
MAY	383	465	18.2	NA	8.5
JUN	442	546	18.9	NA	10.3
JUL	410	502	16.3	NA	9.4
AUG	373	450	16.9	NA	8.1
SEP	498	624	17.9	NA	11.8
OCT	442	551	18.3	NA	10.4
NOV	475	604	18.8	NA	11.4
DEC	456	582	20.4	NA	10.9

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

Location		Bokulbona No. 3
Radiation station:		Mega.
Population:		50,000 nomads and 10,000 cattle seasonally.
No. of wells:		1 Borehole, 2 Boreholes in Army camp a small settlement 1 Km away, seasonal demand.
Wells:	aquifer type	Sand, weatnering product of granite.
	depth	71m, S.W.L. 39.5, Drawdown 2.59m at R = 200 L/min (67 hours pump test)
	yield	200 L/Min or 3.3 L/Sec
	drawdown	2.59m at yield in January.
Pumping units:		
	motor	Lister 12 HP, 10.6 KVA
	pump	7.5 HP Pluger rated 200 L/Min at 100 - 120m pump installed at 68.3m below G.L.
	no. of hours of operation	Army take up to $10m^3$/day; during peak stocking seasons up to 8 hrs a day pumping $100m^3$ with fuel consumption
	fuel consumption	25 litres/day. The cattle owners pay for the diesel.
Distribution:	pipework Ø	2" Ø
	length	Total 100m
	storage	$8m^3$
Array location:		Storage tank is immediately South of pump house and borehole so array location to be South of storage.
Design:		Q = 3.3 L/S max TDH = 68 + 6 + 6 = 80m in worst time of year.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: BOKUL BONA NO.3
INSOLATION DATA LOCATION: MEGA (User Supplied)

LATITUDE: 4.08 DEG N LONGITUDE: 38.33 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	15.0 DEGREES	Grundfos SP1-28	
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-4	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	8.8 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	80.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	518	574	20.9	NA	10.8
FEB	527	560	19.5	NA	10.6
MAR	518	524	20.6	NA	10.0
APR	484	468	19.6	NA	9.0
MAY	383	362	18.2	NA	6.4
JUN	442	406	16.9	NA	7.5
JUL	410	382	16.3	NA	7.0
AUG	373	359	16.9	NA	6.4
SEP	498	495	17.9	NA	9.6
OCT	442	460	18.3	NA	9.0
NOV	475	518	18.8	NA	10.0
DEC	456	510	20.4	NA	9.8

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY DATE: 8TH DECEMBER 1986
ADDRESS: ETHIOPIA OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: BOKUL BONA NO.3
INSOLATION DATA LOCATION: MEGA (User Supplied)

LATITUDE: 4.08 DEG N LONGITUDE: 38.33 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
HORIZONTAL (N-S) AXIS TRACKING		Grundfos SP1-28	
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-4	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	11.8 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	80.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	518	667	20.9	NA	13.4
FEB	527	673	19.5	NA	13.5
MAR	518	654	20.6	NA	13.3
APR	484	603	19.6	NA	12.5
MAY	383	465	18.2	NA	9.4
JUN	442	546	16.9	NA	11.4
JUL	410	502	16.3	NA	10.4
AUG	373	450	16.9	NA	9.0
SEP	498	624	17.9	NA	12.8
OCT	442	551	18.3	NA	11.5
NOV	475	604	18.8	NA	12.5
DEC	456	582	20.4	NA	12.0

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

Location		Dolo Mekala No.1
Radiation station:		Mega
Population:		2600 + 10,000 cattle.
No. of wells:		1 borehole and traditional wells (ellas)
Wells:	aquifer type	Fractured Zones basement rock
	depth	131m, S.W.L. 42.5, P.W.L. 66.6
	yield	24.1m at 75 L/min. after 25 hrs
	drawdown	High Fe content 0.7mg/l almost double allowable
Pumping units:		
	motor	Mitsui Deutz 32 HP, 16KVA (contactor is broken)
	pump	8 H.P. Andoli submersible rated 200l/min at 135 - 160m installed at depth of 86m.
	no. of hours of operation	8 hrs/day, seasonal
	fuel consumption	25 litre/day at peak.
Distribution:	pipework Ø	2" Ø
	length	270 metre total
	storage	$8m^3$
Array location:		No problems
Design:		Q = 2.45 L/Sec max TDH = 84 + 1.7 + 5.82 + 3.5 + 13.5 = 111.52 at Q max.

Note: If storage removed to B.H. site near trough, head would be 95m (this is more realistic).

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: DOLO MEKALA NO.1
INSOLATION DATA LOCATION: MEGA (User Supplied)

LATITUDE: 4.08 DEG N LONGITUDE: 38.33 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	15.0 DEGREES	Grundfos SP1-28	
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-4	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	6.4 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	111.5 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	518	574	20.9	NA	8.2
FEB	527	560	19.5	NA	8.1
MAR	518	524	20.6	NA	7.5
APR	484	468	19.7	NA	6.4
MAY	383	362	18.2	NA	4.3
JUN	442	406	16.9	NA	5.1
JUL	410	382	16.3	NA	4.7
AUG	373	359	16.9	NA	4.2
SEP	498	495	17.9	NA	7.0
OCT	442	460	18.3	NA	6.4
NOV	475	518	18.8	NA	7.5
DEC	456	510	20.4	NA	7.3

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: DOLO MEKALA NO.1
INSOLATION DATA LOCATION: MEGA (User Supplied)

LATITUDE: 4.08 DEG N LONGITUDE: 38.33 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
HORIZONTAL (N-S) AXIS TRACKING		Grundfos SP1-28	
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-4	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	8.7 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	111.5 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	518	667	20.9	NA	10.3
FEB	527	673	19.5	NA	10.4
MAR	518	654	20.6	NA	10.2
APR	484	603	19.7	NA	9.3
MAY	383	465	18.2	NA	6.5
JUN	442	546	16.9	NA	8.2
JUL	410	502	16.3	NA	7.2
AUG	373	450	16.9	NA	6.2
SEP	498	624	17.9	NA	9.7
OCT	442	551	18.3	NA	8.4
NOV	475	604	18.8	NA	9.4
DEC	456	582	20.4	NA	8.9

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

Location		Tuka No. 1
Radiation station:		Moyale/Mega
Population:		20,000
No. of wells:		2, the second well is sealed
Wells:	aquifer type	In a seasonal river bed.
	depth	22m
	yield	1 L/Sec
	drawdown	-
Pumping units:		
	motor	10 HP Lister
	pump	14 stage suction pump belt driven giving 1/3 L/Sec (measured).
	no. of hours of operation	4 hrs/day
	fuel consumption	200 litres/month
Distribution:	pipework Ø	No Distribution
	length	
	storage	No Storage (proposed at old road camp site) 2" Ø, 80m, elevation + 6m.
Array location:		East of Borehole on slope above flood level
Design:		Q = 1 L/Sec.
		TDH = 20 + 6 + 0.7 = 26.7m

Note: The casing protrudes 1.5m out of ground and is welded on at an angle. This would have to be removed.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: TUKA NO.1
INSOLATION DATA LOCATION: MEGA (User Supplied)

LATITUDE: 4.08 DEG N LONGITUDE: 38.33 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	15.0 DEGREES	Grundfos SP4-8	
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-F	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 10. .OLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPU	37.7 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	27.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	518	574	20.9	NA	44.9
FEB	527	560	19.5	NA	44.1
MAR	518	524	20.6	NA	41.8
APR	484	468	19.6	NA	38.1
MAY	383	362	18.2	NA	29.3
JUN	442	406	16.9	NA	33.2
JUL	410	382	16.3	NA	31.2
AUG	373	359	16.9	NA	29.3
SEP	498	495	17.9	NA	40.1
OCT	442	460	18.3	NA	37.9
NOV	475	518	18.8	NA	41.8
DEC	456	510	20.4	NA	41.1

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: TUKA NO.1
INSOLATION DATA LOCATION: MEGA (User Supplied)

LATITUDE: 4.08 DEG N LONGITUDE: 38.33 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------
HORIZONTAL (N-S) AXIS TRACKING
MAX. PWR. CURRENT: 12.2 A.
MAXIMUM POWER: 1486.0 W.

AS INC M55 3.05 A. @ 17.4 V.
7 (S) X 4 (P) = 28 TOTAL

---------PUMP SYSTEM---------
Grundfos SP4-8
102 VDC 1500 W XX-5
COUPLED TO ARRAY @ 105 VOLTS

AVG. DAILY OUTPUT: 49.5 CU.M
SYSTEM HEAD: 27.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	518	667	20.9	NA	55.2
FEB	527	673	19.5	NA	55.9
MAR	518	654	20.6	NA	55.0
APR	484	603	19.6	NA	51.8
MAY	383	465	18.2	NA	41.3
JUN	442	546	16.9	NA	47.9
JUL	410	502	16.3	NA	44.5
AUG	373	450	16.9	NA	39.8
SEP	498	624	17.9	NA	53.2
OCT	442	551	18.3	NA	48.3
NOV	475	604	18.8	NA	51.8
DEC	456	582	20.4	NA	50.0

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: TUKA NO.1
INSOLATION DATA LOCATION: MEGA (User Supplied)

LATITUDE: 4.08 DEG N LONGITUDE: 38.33 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
HORIZONTAL (N-S) AXIS TRACKING		Grundfos SP4-8	
MAX. PWR. CURRENT:	9.1 A.	102 VDC 1500 W XX-5	
MAXIMUM POWER:	1114.5 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	37.9 CU.M
7 (S) X 3 (P) =	21 TOTAL	SYSTEM HEAD:	27.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	518	667	20.9	NA	43.9
FEB	527	673	19.5	NA	44.4
MAR	518	654	20.6	NA	43.4
APR	484	603	19.6	NA	40.2
MAY	383	465	18.2	NA	29.3
JUN	442	546	16.9	NA	36.2
JUL	410	502	16.3	NA	32.6
AUG	373	450	16.9	NA	23.0
SEP	498	624	17.9	NA	41.7
OCT	442	551	18.3	NA	36.7
NOV	475	604	18.8	NA	40.4
DEC	456	582	20.4	NA	38.6

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: GEBELE BONO NO.1
INSOLATION DATA LOCATION: GIDOLE (User Supplied)

LATITUDE: 5.62 DEG N LONGITUDE: 37.48 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	15.0 DEGREES	Grundfos SP2-18	
MAX. PWR. CURRENT:	12.2 A.	XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	16.9 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	55.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG CU.M/DAY
JAN	510	568	16.4	NA	20.6
FEB	532	569	17.1	NA	20.5
MAR	452	459	17.6	NA	16.7
APR	497	482	17.3	NA	17.5
MAY	435	410	17.8	NA	14.3
JUN	466	429	15.4	NA	15.1
JUL	397	373	15.4	NA	12.5
AUG	380	367	15.8	NA	12.4
SEP	445	445	16.8	NA	16.1
OCT	465	487	16.9	NA	17.8
NOV	492	541	16.8	NA	19.7
DEC	498	563	16.4	NA	20.4

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: GEBELE BONO NO.1
INSOLATION DATA LOCATION: GIDOLE (User Supplied)

LATITUDE: 5.62 DEG N LONGITUDE: 37.48 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------
HORIZONTAL (N-S) AXIS TRACKING
MAX. PWR. CURRENT: 12.2 A.
MAXIMUM POWER: 1486.0 W.

AS INC M55 3.05 A. @ 17.4 V.
7 (S) X 4 (P) = 28 TOTAL

---------PUMP SYSTEM---------
Grundfos SP2-18
XX-5
COUPLED TO ARRAY @ 105 VOLTS

AVG. DAILY OUTPUT: 22.6 CU.M
SYSTEM HEAD: 55.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	510	658	16.4	NA	25.5
FEB	532	683	17.1	NA	26.3
MAR	452	563	17.6	NA	22.1
APR	497	620	17.3	NA	24.3
MAY	435	534	17.8	NA	20.8
JUN	466	576	15.4	NA	22.6
JUL	397	482	15.4	NA	18.4
AUG	380	458	15.8	NA	17.2
SEP	445	551	16.8	NA	21.6
OCT	465	585	16.9	NA	23.0
NOV	492	631	16.8	NA	24.6
DEC	498	643	16.4	NA	25.0

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT
UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: GARDULA NO.2 (GUMAIDE)
INSOLATION DATA LOCATION: GIDOLE (User Supplied)

LATITUDE: 5.62 DEG N LONGITUDE: 37.48 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
HORIZONTAL (N-S) AXIS TRACKING		Grundfos SP2-13	
MAX. PWR. CURRENT:	12.2 A.	XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	22.6 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	55.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	510	658	16.4	NA	25.5
FEB	532	683	17.1	NA	26.3
MAR	452	563	17.6	NA	22.1
APR	497	620	17.3	NA	24.3
MAY	435	534	17.8	NA	20.8
JUN	466	576	15.4	NA	22.6
JUL	397	482	15.3	NA	18.4
AUG	380	458	15.8	NA	17.2
SEP	445	551	16.8	NA	21.6
OCT	465	585	16.8	NA	23.0
NOV	492	631	16.8	NA	24.6
DEC	498	643	16.4	NA	25.0

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: GARDULA NO.2 (GUMAIDE)
INSOLATION DATA LOCATION: GIDOLE (User Supplied)

LATITUDE: 5.62 DEG N LONGITUDE: 37.48 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM D/ ----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	15.0 DEGREES	Grundfos SP2-18	
MAX. PWR. CURRENT:	12.2 A.	XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	16.9 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	55.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	510	568	16.4	NA	20.6
FEB	532	569	17.1	NA	20.5
MAR	452	459	17.6	NA	16.7
APR	497	482	17.3	NA	17.5
MAY	435	410	17.8	NA	14.3
JUN	466	429	15.4	NA	15.1
JUL	397	373	15.3	NA	12.5
AUG	380	367	15.8	NA	12.4
SEP	445	445	16.8	NA	16.1
OCT	465	487	16.8	NA	17.8
NOV	492	541	16.8	NA	19.7
DEC	498	563	16.4	NA	20.4

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

Location		Wachyga Busha
Radiation station:		Sodo
Population:		5000
No. of wells:		1 B.H. and some shallow seasonal wells
Wells:	aquifer type	Clinkers between lava flows
	depth	100m S.W.L. 30.54m, P.W.L. 40.78m
	yield	Specific capacity 23.44 l/min/metre but seasonal variation.
	drawdown	10.24m after 22 hrs at Q = 4 L/Min.
Pumping units:		
	motor	Lister 3 H.P.
	pump	Belt driven robbins & meyer Mono pump. pumping at 50m for test, instal at 70m.
	no. of hours of operation	4 - 6 hr/day.
	fuel consumption	There is no money for fuel.
Distribution:	pipework Ø	2" Ø
	length	375m
	storage	$8m^3$ storage, 7m elevation serving 3 points with fawcetts.
Array location:		Beside B.H.
Design:		Q = 1 L/S max. TDH = 50 + 17.42 + 3 = 70.42 If storage moved to site with no distribution then TDH = 50 + 7 + 1 say 60m

Note: The well needs cleaning or surging - origional gravel for screen was not washed and a high clay content was reported in drilling Log.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE. WACHYGA BUSHA (EXISTING DISTRIBUTION SYSTEM)
INSOLATION DATA LOCATION: SODO (User Supplied)

LATITUDE: 6.83 DEG N LONGITUDE: 37.72 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	15.0 DEGREES	Grundfos SP1-28	
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-4	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	8.7 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	80.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	479	536	21.2	NA	10.2
FEB	488	523	21.9	NA	10.0
MAR	504	514	21.4	NA	9.8
APR	488	475	20.8	NA	9.1
MAY	438	414	19.8	NA	7.8
JUN	421	392	18.5	NA	7.2
JUL	347	329	17.2	NA	5.5
AUG	374	363	17.4	NA	6.5
SEP	430	431	19.1	NA	8.4
OCT	476	501	20.0	NA	9.6
NOV	510	564	21.1	NA	10.6
DEC	473	537	21.0	NA	10.2

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: WACHYGA BUSHA (EXISTING DISTRIBUTION SYSTEM)
INSOLATION DATA LOCATION: SODO (User Supplied)

LATITUDE: 6.83 DEG N LONGITUDE: 37.72 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------
HORIZONTAL (N-S) AXIS TRACKING
MAX. PWR. CURRENT: 12.2 A.
MAXIMUM POWER: 1486.0 W.

AS INC M55 3.05 A. @ 17.4 V.
7 (S) X 4 (P) = 28 TOTAL

---------PUMP SYSTEM---------
Grundfos SP1-28
102 VDC 1500 W XX-4
COUPLED TO ARRAY @ 105 VOLTS

AVG. DAILY OUTPUT: 11.5 CU.M
SYSTEM HEAD: 80.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	479	617	21.2	NA	12.5
FEB	488	623	21.9	NA	12.6
MAR	504	636	21.4	NA	12.9
APR	488	607	20.8	NA	12.5
MAY	438	536	19.8	NA	11.2
JUN	421	513	18.5	NA	10.7
JUL	347	413	17.2	NA	7.9
AUG	374	449	17.4	NA	9.0
SEP	430	530	19.1	NA	11.1
OCT	476	602	20.0	NA	12.3
NOV	510	658	21.1	NA	13.1
DEC	473	611	21.0	NA	12.4

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: WACHYGA BUSHA (WITH ON POINT DISTRIBUTION SYSTEM)
INSOLATION DATA LOCATION: SODO (User Supplied)

LATITUDE: 6.83 DEG N LONGITUDE: 37.72 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	15.0 DEGREES	Grundfos SP2-18	
MAX. PWR. CURRENT:	12.2 A.	XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	14.7 CU.M
7 (S) X	4 (P) = 28 TOTAL	SYSTEM HEAD:	60.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	479	536	21.2	NA	17.6
FEB	488	523	21.9	NA	17.1
MAR	504	514	21.4	NA	16.8
APR	488	475	20.8	NA	15.3
MAY	438	414	19.8	NA	12.7
JUN	421	392	18.5	NA	11.7
JUL	347	329	17.2	NA	8.3
AUG	374	363	17.4	NA	10.5
SEP	430	431	19.1	NA	13.7
OCT	476	501	20.0	NA	16.4
NOV	510	564	21.1	NA	18.4
DEC	473	537	21.0	NA	17.6

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: WACHYGA BUSHA (WITH ON POINT DISTRIBUTION SYSTEM)
INSOLATION DATA LOCATION: SODO (User Supplied)

LATITUDE: 6.83 DEG N LONGITUDE: 37.72 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
HORIZONTAL (N-S) AXIS TRACKING		Grundfos SP2-18	
MAX. PWR. CURRENT:	12.2 A.	XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	19.6 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	60.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	479	617	21.2	NA	21.6
FEB	488	623	21.9	NA	21.9
MAR	504	636	21.4	NA	22.5
APR	488	607	20.8	NA	21.4
MAY	438	536	19.8	NA	18.7
JUN	421	513	18.5	NA	17.7
JUL	347	413	17.2	NA	12.8
AUG	374	449	17.4	NA	14.6
SEP	430	530	19.1	NA	18.5
OCT	476	602	20.0	NA	21.3
NOV	510	658	21.1	NA	23.0
DEC	473	611	21.0	NA	21.4

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

II. NOTES ON HARERGE WELLS

The E.W.W.C.A. is extremely well organised in this region, a region charecterised in the remoter areas by too many people with too few boreholes. This is particularly true of the Ogaden region where the town water supplies have been well rationalised but the settlements, a central water point often serves for 3 - 4 communities with their stock. However, the UNHCR funded, WUSC executed, rehabilitation project is placing major emphasis on water supply with two new drilling rigs about to start operation and a good relationship has been setablished with E.W.W.C.A.

The sites along the DJIBOUTI - DIRE DAWA rail-road area, after the Metema sites in Gondar, top priority. Remote and fairly inaccessible and re-lying to an extent on the enterprise and goodwill of individuals in the community to purchase fuel in Dire Dawa and sell the water to cover the costs.

Maintenance problems are severe and have overloaded the EWWCA resulting in broken equipment at many of the sites.

Installation Sites

1. Hassene
2. Hadew
3. Elamhar
4. Warder Well 1
5. Shinile RRC/UNHCR WEU
6. Shinile
7. GAD
8. Mile
9. Harewa

Location		Hassene
Radiation station:		Harer
Population:		2 - 2500 (nearly villages use this point when river dries)
No. of wells:		1
Wells:	aquifer type	Probably limestone - cool air is constantly expelled from borehole
	depth	118m, SWL 38m, PWL. -
	yield	1.5 L/Sec.
	drawdown	-
Pumping units:		
	motor	lister ST3, 10.8 KW.
	pump	Okamoto, 11 KW
	no. of hours of operation	6 hrs/day, demand is highat $40m^3$
	fuel consumption	12 litres/day
Distribution:	pipework Ø	2" Ø
	length	60m
	storage	$15m^3$ masonary, elevation 4m
Array location:		Besides well, good foundation
Design:		TDH = 70m

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: HASSENE
INSOLATION DATA LOCATION: HARER (User Supplied)

LATITUDE: 9.20 DEG N LONGITUDE: 42.07 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	15.0 DEGREES	Grundfos SP1-28	
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-4	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	9.2 CU.M
7 (S) X	4 (P) = 28 TOTAL	SYSTEM HEAD:	80.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	478	541	18.4	NA	10.4
FEB	476	515	20.0	NA	9.9
MAR	488	501	20.5	NA	9.6
APR	487	477	20.0	NA	9.2
MAY	476	451	20.1	NA	8.6
JUN	449	420	19.0	NA	7.9
JUL	432	408	19.6	NA	7.7
AUG	428	416	17.9	NA	7.9
SEP	448	452	18.3	NA	8.8
OCT	479	508	18.6	NA	9.8
NOV	471	526	18.5	NA	10.1
DEC	458	525	18.1	NA	10.1

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: HASSENE
INSOLATION DATA LOCATION: HARER (User Supplied)

LATITUDE: 9.20 DEG N LONGITUDE: 42.07 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------
HORIZONTAL (N-S) AXIS TRACKING
MAX. PWR. CURRENT: 12.2 A.
MAXIMUM POWER: 1486.0 W.

AS INC M55 3.05 A. @ 17.4 V.
7 (S) X 4 (P) = 28 TOTAL

---------PUMP SYSTEM---------
Grundfos SP1-28
102 VDC 1500 W XX-4
COUPLED TO ARRAY @ 105 VOLTS

AVG. DAILY OUTPUT: 12.0 CU.M
SYSTEM HEAD: 80.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	478	620	18.4	NA	12.6
FEB	476	610	20.0	NA	12.5
MAR	488	616	20.5	NA	12.6
APR	487	604	20.0	NA	12.5
MAY	476	586	20.1	NA	12.1
JUN	449	548	19.0	NA	11.4
JUL	432	525	19.6	NA	11.0
AUG	428	521	17.9	NA	10.9
SEP	448	553	18.3	NA	11.6
OCT	479	609	18.6	NA	12.5
NOV	471	608	18.5	NA	12.4
DEC	458	594	18.1	NA	12.2

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

Location		Hadew
Radiation station:		Jijiga
Population:		1500
No. of wells:		1
Wells:	aquifer type	-
	depth	45m, SWL. 6m, PWL. 40m
	yield	3 L/Sec.
	drawdown	-
Pumping units:		
	motor	Mitsui Deutz, 17.6KW
	pump	Pluger 8.5 KW
	no. of hours of operation	8 hrs/day (including nursery irrigation) - $25m^3$/day demand.
	fuel consumption	N/A.
Distribution:	pipework Ø	2" Ø
	length	18m
	storage	$4m^3$ storage at 4m elevation
Array location:		Besides well
Design:		TDH = 40 + 4 + 2 = 46

Note: The Harer - jijiga 45 KVA transmission line runs within 1 Km of Hadew but it is unlikely that electricity for Hadew well be a priority.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: HADEW
INSOLATION DATA LOCATION: JIJIGA (User Supplied)

LATITUDE: 9.33 DEG N LONGITUDE: 42.72 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. .(ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	15.0 DEGREES	Grundfos SP2-18	
MAX. PWR CURRENT:	12.2 A.	XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	20.2 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	46.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	487	552	16.9	NA	23.0
FEB	469	507	17.7	NA	21.6
MAR	488	501	19.4	NA	21.2
APR	472	463	20.3	NA	19.7
MAY	484	459	21.0	NA	19.4
JUN	442	414	20.9	NA	17.5
JUL	432	408	20.0	NA	17.3
AUG	424	412	20.0	NA	17.6
SEP	452	456	20.1	NA	19.6
OCT	475	504	18.3	NA	21.4
NOV	470	525	17.0	NA	22.2
DEC	461	529	16.5	NA	22.4

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: HADEW
INSOLATION DATA LOCATION: JIJIGA (User Supplied)

LATITUDE: 9.33 DEG N LONGITUDE: 42.72 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------
HORIZONTAL (N-S) AXIS TRACKING
MAX. PWR. CURRENT: 12.2 A.
MAXIMUM POWER: 1486.0 W.

AS INC M55 3.05 A. @ 17.4 V.
7 (S) X 4 (P) = 28 TOTAL

---------PUMP SYSTEM---------
Grundfos SP2-18
XX-5
COUPLED TO ARRAY @ 105 VOLTS

AVG. DAILY OUTPUT: 26.3 CU.M
SYSTEM HEAD: 46.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	487	633	16.9	NA	28.0
FEB	469	600	17.7	NA	27.1
MAR	488	616	19.4	NA	27.7
APR	472	584	20.3	NA	26.6
MAY	484	596	21.0	NA	27.0
JUN	442	539	20.9	NA	24.7
JUL	432	525	20.0	NA	24.2
AUG	424	516	20.0	NA	23.8
SEP	452	561	20.1	NA	25.7
OCT	475	604	18.3	NA	27.2
NOV	470	606	17.0	NA	27.2
DEC	461	599	16.5	NA	26.8

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

Location		Elamhar.
Radiation station:		Jijiga
Population:		1000 with seasonal variation
No. of wells:		1 borehole, 5 traditional wells used for stock watering
Wells:	aquifer type	-
	depth	54m, S.W.L. 11.6m, pump level 44m
	yield	0.8 L/S.
	drawdown	-
Pumping units:		
	motor	Lister ST1
	pump	Mono BNK 1
	no. of hours of operation	4 hrs/day
	fuel consumption	4 litres/day
Distribution:	pipework Ø	2" Ø
	length	20m
	storage	$4m^3$ steel tank at 4m elevation
Array location:		Besides well
Design:		TDH = 44 + 4 + 2 = 50m

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: ELAMHAR
INSOLATION DATA LOCATION: JIJIGA (User Supplied)

LATITUDE: 9.33 DEG N LONGITUDE: 42.72 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	15.0 DEGREES	Grundfos SP2-18	
MAX. PWR. CURRENT:	12.2 A.	XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	18.9 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	50.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	487	552	16.9	NA	21.7
FEB	469	507	17.7	NA	20.2
MAR	488	501	19.4	NA	19.9
APR	472	463	20.3	NA	18.4
MAY	484	459	21.0	NA	18.0
JUN	442	414	20.9	NA	16.1
JUL	432	408	20.0	NA	16.0
AUG	424	412	20.0	NA	16.3
SEP	452	456	20.1	NA	18.2
OCT	475	504	18.3	NA	20.1
NOV	470	525	17.0	NA	20.9
DEC	461	529	16.4	NA	21.0

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: ELAMHAR
INSOLATION DATA LOCATION: JIJIGA (User Supplied)

LATITUDE: 9.33 DEG N LONGITUDE: 42.72 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT.. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
HORIZONTAL (N-S) AXIS TRACKING		Grundfos SP2-18	
MAX. PWR. CURRENT:	12.2 A.	XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	24.7 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	50.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	487	633	16.9	NA	26.5
FEB	469	600	17.7	NA	25.5
MAR	488	616	19.4	NA	26.0
APR	472	584	20.3	NA	24.9
MAY	484	596	21.0	NA	25.3
JUN	442	539	20.9	NA	23.1
JUL	432	525	20.0	NA	22.6
AUG	424	516	20.0	NA	22.2
SEP	452	561	20.1	NA	24.1
OCT	475	604	18.3	NA	25.6
NOV	470	606	17.0	NA	25.6
DEC	461	599	16.4	NA	25.3

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT
UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

Location	Warder Well No. 1.
Radiation station:	Kebri Dehar
Population:	2000
No. of wells:	3 open wells
Wells: aquifer type	
depth	No. 1 25m SWL 18
yield	ALL 2 L/S
drawdown	-
Pumping units:	
motor	Lister ST2 18 H.P.
pump	Mono
no. of hours of operation	-
fuel consumption	-
Distribution: pipework Ø	2" Ø
length	60m
storage	80m^3 open masonary
Array location:	Not visited
Design:	TDH = 24m

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: WARDER WELL
INSOLATION DATA LOCATION: KEBRI DEHAR (User Supplied)

LATITUDE: 6.67 DEG N LONGITUDE: 44.30 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	15.0 DEGREES	Grundfos SP4-8	
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	45.1 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	24.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	555	623	26.3	NA	49.6
FEB	548	588	27.3	NA	47.8
MAR	578	589	28.2	NA	47.6
APR	557	540	28.0	NA	44.8
MAY	491	461	26.5	NA	40.2
JUN	510	469	26.2	NA	40.5
JUL	478	445	26.1	NA	39.2
AUG	534	511	26.2	NA	43.5
SEP	579	579	27.1	NA	47.4
OCT	493	519	26.4	NA	44.3
NOV	520	575	26.1	NA	47.4
DEC	541	616	25.8	NA	49.2

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: WARDER WELL
INSOLATION DATA LOCATION: KEBRI DEHAR (User Supplied)

LATITUDE: 6.67 DEG N LONGITUDE: 44.30 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT.. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------

HORIZONTAL (N-S) AXIS TRACKING
MAX. PWR. CURRENT: 12.2 A.
MAXIMUM POWER: 1486.0 W.

AS INC M55 3.05 A. @ 17.4 V.
7 (S) X 4 (P) = 28 TOTAL

---------PUMP SYSTEM---------

Grundfos SP4-8
102 VDC 1500 W XX-5
COUPLED TO ARRAY @ 105 VOLTS

AVG. DAILY OUTPUT: 58.5 CU.M
SYSTEM HEAD: 24.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	555	723	26.3	NA	60.4
FEB	548	706	27.3	NA	59.7
MAR	578	739	28.2	NA	61.4
APR	557	702	28.0	NA	60.0
MAY	491	608	26.5	NA	55.3
JUN	510	634	26.2	NA	56.7
JUL	478	590	26.1	NA	54.3
AUG	534	668	26.2	NA	58.6
SEP	579	736	27.1	NA	61.8
OCT	493	625	26.4	NA	56.1
NOV	520	672	26.1	NA	58.2
DEC	541	705	25.8	NA	59.5

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: WARDER WELL
INSOLATION DATA LOCATION: KEBRI DEHAR (User Supplied)

LATITUDE: 6.67 DEG N LONGITUDE: 44.30 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------
HORIZONTAL (N-S) AXIS TRACKING
MAX. PWR. CURRENT: 9.1 A.
MAXIMUM POWER: 1114.5 W.

AS INC M55 3.05 A. @ 17.4 V.
7 (S) X 3 (P) = 21 TOTAL

---------PUMP SYSTEM---------
Grundfos SP4-8
102 VDC 1500 W XX-5
COUPLED TO ARRAY @ 105 VOLTS

AVG. DAILY OUTPUT: 47.3 CU.M
SYSTEM HEAD: 24.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	555	723	26.3	NA	49.4
FEB	548	706	27.3	NA	48.6
MAR	578	739	28.2	NA	50.1
APR	557	702	28.0	NA	48.7
MAY	491	608	26.5	NA	44.0
JUN	510	634	26.2	NA	45.5
JUL	478	590	26.1	NA	42.9
AUG	534	668	26.2	NA	47.4
SEP	579	736	27.1	NA	50.5
OCT	493	625	26.4	NA	44.9
NOV	520	672	26.1	NA	47.2
DEC	541	705	25.8	NA	48.6

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

Location	Warder Wells No. 2 & 3.
Radiation station:	Kebri Dehar
Population:	
No. of wells:	3 open wells.
Wells: aquifer type	-
depth	No. 2 25m, S.W.L. 17m, No.3 27m, S.W.L. 18m
yield	2 L/S.
drawdown	-
Pumping units:	
motor	Both lister ST1, 6HP
pump	Mono BNK 1
no. of hours of operation	-
fuel consumption	-
Distribution: pipework Ø	
length	-
storage	-
Array location:	Not visted
Design:	TDH = 24m

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: WARDER WELLS NO.2 AND 3
INSOLATION DATA LOCATION: KEBRI DEHAR (User Supplied)

LATITUDE: 6.67 DEG N LONGITUDE: 44.30 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	15.0 DEGREES	Grundfos SP4-8	
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	45.1 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	24.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT PANEL LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	555	623	26.3	NA	49.6
FEB	548	588	27.3	NA	47.8
MAR	578	589	28.2	NA	47.6
APR	557	540	28.0	NA	44.8
MAY	491	461	26.5	NA	40.2
JUN	510	469	26.2	NA	40.5
JUL	478	445	26.1	NA	39.2
AUG	534	511	26.1	NA	43.5
SEP	579	579	27.1	NA	47.4
OCT	493	519	26.4	NA	44.3
NOV	520	575	26.1	NA	47.4
DEC	541	616	25.8	NA	49.2

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: WARDER WELLS NO.2 AND 3
INSOLATION DATA LOCATION: KEBRI DEHAR (User Supplied)

LATITUDE: 6.67 DEG N LONGITUDE: 44.30 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
HORIZONTAL (N-S) AXIS TRACKING		Grundfos SP4-8	
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	58.5 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	24.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT PANEL LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	555	723	26.3	NA	60.4
FEB	548	706	27.3	NA	59.7
MAR	578	739	28.2	NA	61.4
APR	557	702	28.0	NA	60.0
MAY	491	608	26.5	NA	55.3
JUN	510	634	26.2	NA	56.7
JUL	478	590	26.1	NA	54.3
AUG	534	668	26.1	NA	58.6
SEP	579	736	27.1	NA	61.8
OCT	493	625	26.4	NA	56.1
NOV	520	672	26.1	NA	58.2
DEC	541	705	25.8	NA	59.5

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

Location		Shinile - uNHCR/RRC well.
Radiation station:		Dire Dawa
Population:		3000
No. of wells:		3 B.H.
Wells:	aquifer type	-
	depth	30m, S.W.L. 15m.
	yield	2 L/S.
	drawdown	-
Pumping units:		
	motor	Lister
	pump	Mono
	no. of hours of operation	(Has not functioned for 3 months) - operated 6 hrs/day.
	fuel consumption	
Distribution:	pipework Ø	2"
	length	200m
	storage	6m3 at 6m elevation
Array location:		Beside well, on wadi bank.
Design:		TDH = 34m.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: SHINILE-UNHCR/RRC WELL
INSOLATION DATA LOCATION: DIRE DAWA (User Supplied)

LATITUDE: 9.60 DEG N LONGITUDE: 41.87 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	15.0 DEGREES	Grundfos SP4-8	
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	30.9 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	34.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	453	513	21.4	NA	33.6
FEB	466	505	22.6	NA	32.9
MAR	484	498	24.6	NA	32.1
APR	479	470	26.3	NA	29.9
MAY	493	467	27.3	NA	29.3
JUN	460	430	28.1	NA	26.3
JUL	446	421	26.3	NA	25.9
AUG	473	458	25.7	NA	29.1
SEP	466	471	25.9	NA	30.2
OCT	472	502	25.0	NA	32.3
NOV	473	529	22.4	NA	34.4
DEC	460	529	21.3	NA	34.6

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric Internationa'
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: SHINILE-UNHCR/RRC WELL
INSOLATION DATA LOCATION: DIRE DAWA (User Supplied)

LATITUDE: 9.60 DEG N LONGITUDE: 41.87 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
HORIZONTAL (N-S) AXIS TRACKING		Grundfos SP4-8	
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	40.6 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	34.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT PANEL LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	453	586	21.4	NA	40.7
FEB	466	596	22.6	NA	41.4
MAR	484	611	24.6	NA	42.2
APR	479	593	26.3	NA	40.9
MAY	493	608	27.3	NA	41.5
JUN	460	563	28.1	NA	38.3
JUL	446	544	26.3	NA	37.4
AUG	473	582	25.7	NA	40.2
SEP	466	581	25.9	NA	40.1
OCT	472	600	25.0	NA	41.3
NOV	473	611	22.4	NA	42.2
DEC	460	598	21.3	NA	41.4

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

Location		Shinile
Radiation station:		Dire Dawa
Population:		3000
No. of wells:		3Bore holes
Wells:	aquifer type	-
	depth	30.1m SWL 18m
	yield	3 L/S
	drawdown	-
Pumping units:		
	motor	Lister ST3 6KW
	pump	Aturia 2.3
	no. of hours of operation	5 hrs/day
	fuel consumption	-
Distribution:	pipework ø	a. 2" ø b. 1" 2" ø
	length	10m 164m
	storage	$4m^3$ at 4m elevation $4m^3$ at 6.2m elevation.
Array location:		Besides borehole if storage replaced.
Design:		a. TDH = 32m b. TDH = 36m. 2 storage tanks relocated 30m from borehole with 2" pipework.

Note. On point storage leaking badly; distribution by siphon hosepipe. All fawcetts broken at 2nd storage.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: SHINILE
INSOLATION DATA LOCATION: DIRE DAWA (User Supplied)

LATITUDE: 9.60 DEG N LONGITUDE: 41.87 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT..(ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	15.0 DEGREES	Grundfos SP4-8	
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	33.0 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	32.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	453	513	21.4	NA	35.7
FEB	466	505	22.6	NA	35.0
MAR	484	498	24.6	NA	34.2
APR	479	470	26.3	NA	32.1
MAY	493	467	27.3	NA	31.5
JUN	460	430	28.1	NA	28.5
JUL	446	421	26.3	NA	28.1
AUG	473	458	25.7	NA	31.2
SEP	466	471	25.9	NA	32.3
OCT	472	502	25.0	NA	34.4
NOV	473	529	22.4	NA	36.5
DEC	460	529	21.3	NA	36.6

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

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STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: SHINILE
INSOLATION DATA LOCATION: DIRE DAWA (User Supplied)

LATITUDE: 9.60 DEG N LONGITUDE: 41.87 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
HORIZONTAL (N-S) AXIS TRACKING		Grundfos SP4-8	
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	43.3 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	32.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	453	586	21.4	NA	43.4
FEB	466	596	22.6	NA	44.1
MAR	484	611	24.6	NA	44.8
APR	479	593	26.3	NA	43.5
MAY	493	608	27.3	NA	44.1
JUN	460	563	28.1	NA	40.9
JUL	446	544	26.3	NA	40.0
AUG	473	582	25.7	NA	42.8
SEP	466	581	25.9	NA	42.7
OCT	472	600	25.0	NA	43.9
NOV	473	611	22.4	NA	44.8
DEC	460	598	21.3	NA	44.1

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

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STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: SHINILE
INSOLATION DATA LOCATION: DIRE DAWA (User Supplied)

LATITUDE: 9.60 DEG N LONGITUDE: 41.87 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	15.0 DEGREES	Grundfos SP2-18	
MAX. PWR. CURRENT:	12.2 A.	XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	23.9 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	36.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	453	513	21.4	NA	25.3
FEB	466	505	22.6	NA	24.9
MAR	484	498	24.6	NA	24.6
APR	479	470	26.3	NA	23.4
MAY	493	467	27.3	NA	23.1
JUN	460	430	28.1	NA	21.5
JUL	446	421	26.3	NA	21.3
AUG	473	458	25.7	NA	22.9
SEP	466	471	25.9	NA	23.5
OCT	472	502	25.0	NA	24.6
NOV	473	529	22.4	NA	25.7
DEC	460	529	21.3	NA	25.8

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

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(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: SHINILE
INSOLATION DATA LOCATION: DIRE DAWA (User Supplied)

LATITUDE: 9.60 DEG N LONGITUDE: 41.87 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------
HORIZONTAL (N-S) AXIS TRACKING
MAX. PWR. CURRENT: 12.2 A.
MAXIMUM POWER: 1486.0 W.

AS INC M55 3.05 A. @ 17.4 V.
7 (S) X 4 (P) = 28 TOTAL

---------PUMP SYSTEM---------
Grundfos SP2-18
XX-5
COUPLED TO ARRAY @ 105 VOLTS

AVG. DAILY OUTPUT: 30.7 CU.M
SYSTEM HEAD: 36.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	453	586	21.4	NA	30.5
FEB	466	596	22.6	NA	31.0
MAR	484	611	24.6	NA	31.6
APR	479	593	26.3	NA	30.9
MAY	493	608	27.3	NA	31.3
JUN	460	563	28.1	NA	29.6
JUL	446	544	26.3	NA	29.0
AUG	473	582	25.7	NA	30.5
SEP	466	581	25.9	NA	30.5
OCT	472	600	25.0	NA	31.0
NOV	473	611	22.4	NA	31.3
DEC	460	598	21.3	NA	30.8

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

Location	Gad
Radiation station:	Dire Dawa
Population:	1000 (on railroad) with small irrigation scheme and stock watering
No. of wells:	1 B.H.
Wells: aquifer type	-
depth	62m, SWL - PWL -
yield	3 L/Sec.
drawdown	-
Pumping units:	
motor	Lister ST1 6.3 H.P.
pump	Mono BNK 1
no. of hours of operation	- Demand 16 -30m^3/day
fuel consumption	2 L/day
Distribution: pipework Ø	
length	15m
storage	4m^3 at - metre elevation
Array location:	In party compound 30m east of B.H.
Design:	TDH = 58m

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: GAD
INSOLATION DATA LOCATION: DIRE DAWA (User Supplied)

LATITUDE: 9.60 DEG N LONGITUDE: 41.87 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	15.0 DEGREES	Grundfos SP2-18	
MAX. PWR. CURRENT:	12.2 A.	XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	16.1 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	58.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	453	513	21.4	NA	17.6
FEB	466	505	22.6	NA	17.2
MAR	484	498	24.6	NA	16.7
APR	479	470	26.3	NA	15.5
MAY	493	467	27.3	NA	15.2
JUN	460	430	28.1	NA	13.5
JUL	446	421	26.3	NA	13 3
AUG	473	458	25.7	NA	15.0
SEP	466	471	25.9	NA	15.6
OCT	472	502	25.0	NA	16.9
NOV	473	529	22.4	NA	18.0
DEC	460	529	21.3	NA	18.1

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: GAD
INSOLATION DATA LOCATION: DIRE DAWA (User Supplied)

LATITUDE: 9.60 DEG N LONGITUDE: 41.87 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
HORIZONTAL (N-S) AXIS TRACKING		Grundfos SP2-18	
MAX. PWR. CURRENT:	12.2 A.	XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	21.2 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	58.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG MM)	AVG. CU.M/DAY
JAN	453	586	21.4	NA	21.3
FEB	466	596	22.6	NA	21.7
MAR	484	611	24.6	NA	22.1
APR	479	593	26.3	NA	21.4
MAY	493	608	27.3	NA	21.7
JUN	460	563	28.1	NA	19.9
JUL	446	544	26.3	NA	19.4
AUG	473	582	25.7	NA	21.0
SEP	466	581	25.9	NA	20.9
OCT	472	600	25.0	NA	21.6
NOV	473	611	22.4	NA	22.2
DEC	460	598	21.3	NA	21.7

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

Location	Mile
Radiation station:	Dire Dawa
Population:	1000
No. of wells:	1 B.H. and traditional wells in river 3 km away
Wells: aquifer type	-
depth	27.4m, SWL 2m PWL -
yield	1 L/Sec
drawdown	-
Pumping units:	
motor	Lister ST3, 10 KW
pump	Submersible
no. of hours of operation	3 hrs a day, demand 8 - 20m^3
fuel consumption	8 litres/day
Distribution: pipework Ø	2" Ø
length	15m
storage	4m^3 at 4m elevation
Array location:	Beside B.H.
Design:	TDH = 30m

Note: At present an individual purchases fuel in Dire Dawa and then sell the water.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: MILE
INSOLATION DATA LOCATION: DIRE DAWA (User Supplied)

LATITUDE: 9.60 DEG N LONGITUDE: 41.87 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	15.0 DEGREES	Grundfos SP4-8	
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	35.1 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	30.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	453	513	21.4	NA	37.8
FEB	466	505	22.6	NA	37.1
MAR	484	498	24.6	NA	36.3
APR	479	470	26.3	NA	34.2
MAY	493	467	27.3	NA	33.6
JUN	460	430	28.1	NA	30.7
JUL	446	421	26.3	NA	30.3
AUG	473	458	25.7	NA	33.4
SEP	456	471	25.9	NA	34.4
OCT	472	502	25.0	NA	36.5
NOV	473	529	22.4	NA	38.6
DEC	460	529	21.3	NA	38.7

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
(SASY/M Ver 5.0 6/20/86)

CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: MILE
INSOLATION DATA LOCATION: DIRE DAWA (User Supplied)

LATITUDE: 9.60 DEG N LONGITUDE: 41.87 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
HORIZONTAL (N-S) AXIS TRACKING		Grundfos SP4-8	
MAX. PWR. CURRENT:	12.2 A.	102 VDC 1500 W XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	45.9 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	30.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	453	586	21.4	NA	46.0
FEB	466	596	22.6	NA	46.7
MAR	484	611	24.6	NA	47.5
APR	479	593	26.3	NA	46.1
MAY	493	608	27.3	NA	46.8
JUN	460	563	28.1	NA	43.6
JUL	446	544	26.3	NA	42.6
AUG	473	582	25.7	NA	45.5
SEP	466	581	25.9	NA	45.4
OCT	472	600	25.0	NA	46.6
NOV	473	611	22.4	NA	47.5
DEC	460	598	21.3	NA	46.7

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

Location	Harewa
Radiation station:	Dire Dawa
Population:	1500 with seasonal variation
No. of wells:	2 B.H. one being property of railroad
Wells: aquifer type	-
depth	74m, S.W.L. 34m, P.W.L. -
yield	3 L/S.
drawdown.	-
Pumping units:	
motor	Lister ST 1, 8.1 H.P.
pump	Mono BNK 1
no. of hours of operation	5 hrs/day
fuel consumption	4 l/day
Distribution: pipework Ø	2" Ø
length	15m
storage	$8m^3$ at 6.8 elevation
Array location:	The water compound 15 X 8m with 230° bearing on long axis, storage tank will shade array - compound to be extended
Design:	TDH = 61m.

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CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: HAREWA
INSOLATION DATA LOCATION: DIRE DAWA (User Supplied)

LATITUDE: 9.60 DEG N LONGITUDE: 41.87 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
TILT ANGLE:	15.0 DEGREES	Grundfos SP2-18	
MAX. PWR. CURRENT:	12.2 A.	XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	15.0 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	61.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	453	513	21.4	NA	16.6
FEB	466	505	22.6	NA	16.2
MAR	484	498	24.6	NA	15.7
APR	479	470	26.3	NA	14.5
MAY	493	467	27.3	NA	14.2
JUN	460	430	28.1	NA	12.5
JUL	446	421	26.3	NA	12.3
AUG	473	458	25.7	NA	14.0
SEP	466	471	25.9	NA	14.6
OCT	472	502	25.0	NA	15.9
NOV	473	529	22.4	NA	17.0
DEC	460	529	21.3	NA	17.1

NOTE: ARRAY TO FACE TRUE SOUTH

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

DESIGN PROVIDED BY: Solar Electric International
STAND-ALONE SYSTEM DESIGN PROGRAM (PV/WATER PUMP)
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CUSTOMER: UNIDO SURVEY
ADDRESS: ETHIOPIA

DATE: 8TH DECEMBER 1986
OPER: J GOODMAN

APPLICATION: AC WATER PUMPING

NOTE: HAREWA
INSOLATION DATA LOCATION: DIRE DAWA (User Supplied)

LATITUDE: 9.60 DEG N LONGITUDE: 41.87 DEG E
GROUND REFLECTANCE: .20 (J)

----------SELECTED SYSTEM DATA----------

WIRING INFORMATION: 60 FT. (ROUND TRIP) OF 8 GAUGE WIRE

----------ARRAY----------		---------PUMP SYSTEM---------	
HORIZONTAL (N-S) AXIS TRACKING		Grundfos SP2-18	
MAX. PWR. CURRENT:	12.2 A.	XX-5	
MAXIMUM POWER:	1486.0 W.	COUPLED TO ARRAY @ 105 VOLTS	
AS INC M55	3.05 A. @ 17.4 V.	AVG. DAILY OUTPUT:	20.0 CU.M
7 (S) X 4 (P) =	28 TOTAL	SYSTEM HEAD:	61.0 M.

----------SYSTEM DESIGN ANALYSIS----------

MONTH	FLAT LANG	PANEL LANG	MEAN AIR TEMP (C)	RAINFALL (AVG. MM)	AVG. CU.M/DAY
JAN	453	586	21.4	NA	20.1
FEB	466	596	22.6	NA	20.5
MAR	484	611	24.6	NA	20.9
APR	479	593	26.3	NA	20.1
MAY	493	608	27.3	NA	20.5
JUN	460	563	28.1	NA	18.6
JUL	446	544	26.3	NA	18.1
AUG	473	582	25.7	NA	19.7
SEP	466	581	25.9	NA	19.7
OCT	472	600	25.0	NA	20.4
NOV	473	611	22.4	NA	20.9
DEC	460	598	21.3	NA	20.5

NOTE: TRACKER LIMIT ANGLE IS 45.0 DEGREES FROM THE VERTICAL POSITION.

PERFORMANCE OF SYSTEM AT INSTALLATION SITE WILL VARY DEPENDENT UPON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.

II.7. SUMMARY AND NOTES ON WOLLO WELLS

The rural water supply systems in Wollo are currently under review as life returns to normal after the drought. There are many relief agencies operating in the region with their own development programme; OXFAM is heavily involved with EWWCA in well drilling and system installation. An EEC funded programme to rehabilitate a number of wells and install new pumping systems both diesel and hand pump, will commence soon.

Wollo is the closest region to fuel point of entry (Asab) into Ethiopia and hence the cheapest Government policy is encouraging settlements alongside the main N - S road providing easy access to services and supplies. Unfortunately due to time and security constraints the sites east of the main road could not be visited.

Once the review and rationalisation of the water systems has been complete this region should be reviewed. For this project 5 pumps will be allocated for some of the sites along the main road e.g. Addis Tesfa where an encouraging village irrigation scheme is suffering from lack of fuel funds. These would be introduced through projects like KAADP (Kobo and Alamata Development Project).

ANNEX III

ECONOMIC ASSESSMENT

III.1. The time factor

As outlined in the general appraisal, waiting an inordinate length of time for water (queues at hand pumps or diesel systems) has an economic consequence:

If one member of each four active family members in a 400 family community spends 1 hour waiting for water each day, this represents 3% of the total community man hours in a 10 hour working day. Including the organizational demands on the water committee in the timing and supervision of this distribution, a figure of 5% of the total productive man-hours is spent waiting for water.

To quantify an economic value on this: Each family has 5 members of which 4 are active in production (children, elders and the infirm account for 20%). If the average household per capita is $ 100 per year and if it is assumed that production is spread evenly over the year this represents a production loss per community per annum of $ 2000, a sizable sum.

III.2. Pumping Systems

Of the quantifiable economic parameters of solar pumps, the life of the array, representing the major capital cost component,

is the most important. Economic assessment must take this into account and the life cycle cost technique is the most appropriate approach because all future expenses are accounted for and expressed in present day values.

As neither PV pumps or diesel powered pumps are manufactured in Ethiopia, capital and replacement cost discounting and inflation rates are assumed as those on international tender markets. However, the fuel and maintenance costs discount and inflation rates reflect those pertaining in the planned economy of Ethiopia.

III.2. a) PV PUMP SYSTEM CHARACTERISTISCS

System Head, metres	35m.
Average daily water output	30 m^3
Insolation	5 Kwh/m^2/day
Array	1.113 Kwp
Pumping system capital cost (F.O.B. cost)	$ 10/Wp
Pumping system availability	95%
Array life	20 years
Pump life	5 years
Nominal discount rate (world market)	10%
Inflation rate (world market)	5 %
Volume of water pumped over life cycle at 95% availability	208,050 m^3

Maintenance is assumed at $ 100 per annum which allows for broken modules and inverter replacement in the life cycle.

Net present value unit cost of water $/$m^3$:

at 10% discount rate, no inflation	$ 0.07/m^3
at 10% discount rate, 5% inflation	$ 0.09/m^3

Note: In the range of a.c. P.V. water pumps recommended up to the 90 - 100 meter system head range (producing 12m^3 day), there is an initial capital cost increase of $ 3127, with no other costs. This is an extra $ 0.04/m^3 water for this 12m^3 output.

III.2. b) DIESEL PUMP SYSTEM

System head	35m
Average daily water output	$30m^3$
Diesel generator power rating	3.0 Kw.
Average load factor	45%
Diesel fuel cost	$ 0.50/litre
Pumping system capital cost (not installed)	$ 1.60/W
Pumping system availability	90%
Generator set life	6 years
Pump life	5 years
Nominal discount rate (world market)	10%
Ethiopia	5 %
Inflation rate (world market)	5 %
Ethiopia	2 %

Volume of water pumped over life cycle at 90% availability	$197,100m^3$
Average daily fuel consumption	4.2 litres/day
Diesel engine is overhauled in the 6th. year.	

Diesel NPV unit cost of water;

at 10% discount, no inflation and fuel cost $ 0.50/litre (1.03 Birr/litre)	$ 0.10/m^3
at 10% discount rate, no inflation and fuel cost $ 0.75/litre (1.55 Birr/litre)	$ 0.15/m^3

III.2. c) Discussion on Analysis

This analysis of pv and diesel life cycle costs for a 20 year period assumes the following:

i) The dominant p.v. cost is the initial capital cost. The figures of 0.09 USD/m^3 and 0.7 US$/$m^3$ are the NPV values of pumped water with and without inflation rate (5%) at a discount rate of 10%. The inflation rate of 5% is realistic assumption today and future pv price reduction and inflation increases should keep an even rate applicable over the life cycle.

ii) The dominant diesel system cost and the most sensitive is the fuel price: an increase of diesel price from S 0.50 to S 0.75 (1.03 - 1.55 Birr) increase the NPV unit cost by S 0.05/m^3, a substantial increase. Note that these figures are derived from a discount rate of 10% with no inflation component i.e. it is the absolute minimum unit cost of water at that rate.

iii) The inflation rate over the 20 years for the diesel life cycle costs are impossible to ascertain. Looming fuel shortages in the 1990's, hidden inflation in the Ethiopian economy, fluctuations in exchange rates due to increased borrwing from international banks all compound the rate. Hence the figures for (ii) represent the absolute minimum unit cost of water.

iv) The true cost to the Govt. of delivering the fuel to the site cannot be quantified. However, the rate more closely reflects the figure of $ 0.75/litre than $ 0.50/litre if all hidden costs could be included.

v) Given the worst p.v. case (10% discount and 5% inflation) and the best diesel case (10% discount, no inflation) it is more economic to install p.v. pumps in certain areas up to a certain capacity. That limit at present, is in the range 700 - 1000 m^4 where m^4 is volume (m^3) multiplied by head (m).

As outlined in the report it is only recommended that a.c. submersible p.v. systems up to 1.5 Kw range be considered. Although larger systems exist with surface mounted pumps they are not recommended for this present proposal.

vi) The government contribution of installation, storage and distribution construction costs is justified purely on the grounds of time as outlined in Annex III.1. In terms of increased production from relieving time on waiting for water the government will be repaid in less than 4 years. All other benefits are a bonus.

III.3 VACCINE REFRIGERATOR SYSTEMS

Vaccine refrigeration:

	PV System	Kerosene System
SYSTEM CONFIGURATION	large 80 litre refrigerator 168 Wp PV arrry 3.6 kWh Battery storage	large 68 ltr. refrigerator Fuel consumption 0.7 litres/day
FINANCIAL		
f.o.b. Capital cost	$ 4,781	. 458
Recurring capital cost	$ 540 every 5 years. $ 2,897 every 10 years	$ 458 (every 5 yrs)
Maintenance & Repair	1% per year	10% per year
Fuel costs	NA	$ 179 p.a. (represents 1.45 Birr/lt)
Vaccine wastage	2.6 litres	26 litres
RESULTS:		
NPV of 20 yrs cash flow	$ 10,757	$ 10,569
Vaccine storage capacity	80 litres	68 litres

Source: Meridian Corporation - Evaluation of International Photovoltaic Projects.

Notes:

1. These figures are based on high insolation levels. 5.5 - 7.0 kWh/m²/day. For areas with lower insolation, array size and hence initial capital cost will be increased. The importance of adequate sizing is fundamental to good operation.

2. Cost of vaccine is $ 19/litre.

3. There is not a clear cut financial preference between pv and kerosene refrigerators. In this analysis the annual fuel costs have been allowed an annual discount and inflation rate of 5% in calculating N.P.V.

4. The largest cost for kerosene refrigerators is related to vaccine wastege due to low operating availability. This has a fincial consequence as wastage has to be replaced by a pure cash outlay.

5. The dominant cost for pv powered systems are replacement costs which indicate particularly the importance of battery life and warranty.