Ministry of Non-Conventional Energy Sources

Govt. of India, New Delhi

Model Detailed Project Report

Solar Photovoltaic Based Electric Power Project (2x25 kW)

Electrification of Village Magra

District : Udaipur, Rajsthan

Category Remote Hilly Area (217 HH)

Prepared by:

Alternate Hydro Energy Centre
Indian Institute of Technology
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FOREWORD

(This Foreword is not part of the Model DPR)

The Ministry of Non-Conventional Energy Sources, Government of India (MNES) have identified over 24,000 remote villages which are proposed to be electrified through small renewable energy sources e.g. Small Hydro Power, Biomass Gasification and Solar Photovoltaic Technology, so as to improve the well being of population living in the far flung isolated areas.

To make the Remote Village Electrification (RVE) programme successful, it is necessary that the planning, design, execution and operation and maintenance of RVE projects is efficient and reliable and also economical in the long run. MNES, vide letters number 13/5/2005 – 06 RVE dated 23.12.2005 and even number dated 09.03.2006 has asked the alternate Hydro Energy Centre, IIT, Roorkee (AHEC) to prepare model detailed project reports (DPRs) for the following four categories :

1. Category "A – 1" Village with 40 households in the hilly area.
2. Category "A – 2" Village with 40 households in the plain area.
3. Category "B – 1" Village with 200 households in the hilly area.
4. Category "B – 2" Village with 200 households in the plain area.

The villages are to be selected from the States of Chhattisgarh, Maharastra, Jharkhand and Rajasthan to make the DPRs more versatile and practical so that these model DPRs can be used with slight site specific changes by even those users who may not have much technical expertise.

This Document has been prepared for RVE through Solar Photo Voltaic Electric Power Plant for the Category "B-1" village: Magra (Block & Tehsil: Kherwoda, Distt.: Udaipur, State Rajasthan) and also to serve as a Model Document recommended for use as a guide for RVE of similar category villages (including those ones having some variation in number of house holds) with plant and site specific modification. Any suggestions from institutions, organizations, users and interested individuals are welcome. Suggestions should be addressed to:

Head,
Alternate Hydro Energy Centre,
Indian Institute of Technology,
Roorkee – 247667, Uttaranchal, India.

E-mail: ahec@iitr.ernet.in
Fax: +91 – 1332 – 273517.

EXECUTIVE SUMMARY

With the rapid changing scenario of fast depleting conventional energy sources, the future of conventional electric power system is getting uncertain. This has led to world wide thrust on development and use of non-conventional energy sources for electric power generation & use. This coupled with almost no chances of extending the electric power grids to the remote hilly villages and particularly these located deep in the forest due to problems associated with drawing power lines through it and their O & M, use of non-conventional energy sources remains the only alternative for providing reliable electricity to such remote villages.

Magra (Distt. Udaipur, Rajasthan) is a hilly tribal village comprising 2 Settlements, namely: Khajuri Falan and Badli Falan situated in the deep forests. The habitants are poor. Only a few families own plots of agriculture land. The production of food grains from these plots of agriculture land is low and therefore, they also have to buy the required balance quantity of food grains from the market.

Most of the village people are below poverty line. Some of them are jobless. The Solar Photo Voltaic based Electric Power Plant (SPV) proposed for this village will be helpful for:

i. Improving the living conditions of the village people.
ii. Generating new opportunities for over all upliftment.
iii. Providing light for study and promote education amongst children promising them better future.
iv. Providing required drinking water facility in the village.
v. Creating awareness about the renewable sources of energy and using them for entrepreneurship like micro-cottage industries etc. thereby improving economic conditions.
vi. Saving Kerosine and forest wood presently being used for lighting.
vii. Creating environmental awareness amongst the people and help control avoidable destruction of the forest.

The project is envisaged to be constructed in a period of 12 months from the date of contract agreement. The proposed period takes care of the adverse conditions e.g. monsoon season etc.

There being almost no paying capacity of most of the villagers, a low one time contribution of Rs. 1000 per house hold has been proposed towards initial construction of the plant (which, though insignificant, will create a sense of belongingness thereby help make the scheme successful and send good message to others to follow suit) and a monthly payment of Rs. 50/- per month towards O&M (which they will be able to pay as they will have a monthly saving on cost of kerosene). The balance cost of O & M will have to be managed by the Nodal Agency. Source of funding for construction of plant & the system is proposed to be as:

i.	Incentive subsidy by MNES	:	Rs. 152.470 lacs.
ii.	One time contribution by villagers	:	Rs. 2.17 lacs.
iii.	Balance to be paid by Nodal Agency	:	Rs. 46.622 lacs.

The estimated cost of the proposed 50 kW electric power project works out to Rs. 201.262 lacs. The cost of generation works out to Rs 37.744 per kWh & Rs. 50.325 per kWh without subsidy at 80% and 60% LF respectively and Rs. 19.251 & Rs. 25.667 per kWh with subsidy at 80% & 60% LF respectively which is reasonable.

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1.1 GENERAL

i.	**Name of the Project**		:	SPV based Project, for Magra Village
ii.	**Location**			
	a.	Village	:	Magra comprising of 2 settements namely; i. Nichala Magra and ii. Upla Magra Comprising of 2 Falan i.e. hamlets, viz: a. Khajuri Falan and b. Badli Falan
	b.	Block & Tehsil	:	Kherwada
	c.	District	:	Udaipur
	d.	State	:	Rajasthan
iii.	**Access**			
	a.	Rail	:	Udaipur
	b.	Road	:	7 km long Kachcha forest road taking-off on the right side from the Village Jalpaka situated on the Kasaria ji-Sagwada road (Kesaria ji being a town located at 65 km from Udaipur on Udaipur- Ahamadabad National High Way)..
iii.	**Geographical Co-ordinates**			
	a.	Latitude	:	Between 24 deg. 35 min. North.
	b.	Longitude	:	Between 73 deg 42 min. East
iv	**Climatic Condition**			
	a.	Annual Average Temperature	:	24.15 ^{0} C
	b.	Annual Average Wind Speed	:	5.00 m/s
	c.	Annual Average Relative humidity	:	61.33%
	d.	Period of Rainfall	:	June 20 to September 15.
v.	**Land for Project Construction**		**:**	To be provided by the village / Forest Department.
vi.	**Location of proposed Plant Site**		**:**	With in the village.

1.2 CIVIL STRUCTURES (Date given here are Tentative only)

Proposed Sizes:

i.	SPV Array		:	60.0 m x 40.0 m
ii.	SPV Plant Building:			
	a.	Battery Room	:	15.0 m x 4.0m x 4.0 m
	b.	Control Room	:	3.7 m x 3.4 m x 3.6 m
	c.	Store Room	:	3.4 m x 3.0 m x 3.6 m
	d.	General Facilities	:	Drinking water facility, Toilets, Fencing, Gate, Sewerage system etc.

1.3 POWER EVACUATION AND DISTRIBUTION SYSTEM

Distribution System shall be made as per the site conditions and location of various house holds and other user points.

a.	No. of House Holds	:	217
b.	L.T. Distribution Line		
	• No. of Lines	:	3
	• Voltage	:	415 V, 3 – Phase
	• Length of Line	:	14 km (Approx.)
c.	No. of Street Light Points	:	40

1.6 ESTIMATED COST OF THE PROJECT

i.	Cost of the Plant	:	Rs. 201.262 Lacs
ii.	5 Years' Operation & Maintenance Cost	:	Rs. 28.765 Lacs

1.7 ESTIMATED COST OF GENERATION

i. Without Subsidy

At 80% of LF	:	Rs. 37.744/ kWh.
At 60% of LF	:	Rs. 50.325 / kWh.

ii. With Subsidy

At 80% of LF	:	Rs. 19.251/ kWh.
At 60% of LF	:	Rs. 25.667 / kWh.

CHAPTER – 1

BACK GROUND AND BASIC DATA

1.1 INTRODUCTION

There is acute shortage of electric power generation in the country so much so that the areas already connected to the power grids are subjected to frequent power cuts. The available fuel resources being used for electricity generation are getting fast depleted. This problems and sensitivity coupled with problems in drawing the Electric Power lines through deep forest, the cost involved in extending the power grids and cost and problems in O & M of such line etc. make it almost impossible to make grid electricity reach the remote hilly village Magra (Distt. Udaipur, Rajsthan).

The economic and social conditions of the inhabitants of Magra are poor. Electricity being one of the basic infrastructural requirements for development and progress, the only hope in the above scenario is the use of renewable energy sources to generate and supply electricity to this remote village. In an effort towards this end, this project has been conceived for immediate implementation.

1.2 PROJECT SPONSOR

MNES, GOI has come up to subsidize the cost of RVE project to a large extent. The balance cost is to be met by the Nodal Agency and the people of the village.

1.3 NODAL AGENCY & ASSOCIATED ORGANIZATIONS

Rajsthan Renewable Energy Corporation, Limited (RRECL), Jaipur has been assigned to carry out energy development work through non-conventional energy sources by the Government of Rajsthan. Discussions were held with the officers and staff of the RRECL**,** Village Panchayat etc. particularly:

I. Rajsthan Renewable Energy Corporation, Limited (RRECL), Jaipur

i. Sri A.K. Pathak, General Manager
ii. Sri Devendra Mantri, SDO

II. Village Panchayat and Others

i. Sri Devi Ram, Sarpanch,
ii. Sri Lakshmadla, Ward Panch,
iii. Sri Magan Lal Meedan

1.4 SELECTION OF VILLAGE FOR MODEL DPR

Reconnaissance tours were undertaken to various remote villages located in the District of Udaipur forest areas hills for selection of village(s) in co-ordination with RRECL, gathering information and data, interaction with the local people and the village level organizations e.g. Gram Panchayat, etc. and visual survey and assessment of various

aspects related to the project to be undertaken. After detailed studies, remote village Magra (District of Udaipur) located in the Aravali hills in the deep forest area has been selected for preparation of this Model Detailed Project Report.

1.5 ABOUT VILLAGE MAGRA

1.5.1 Location

Magra is a remote village located in the plains in evergreen forest of Aravali hills (Fig. 1.1).The approach to the village is through a 7 km long Kachcha forest road taking-off on the right side from the Village Jalpaka situated on the Kasaria ji-Sagwada road (Kesaria ji being a town located at 65 km from Udaipur on Udaipur- Ahamadabad Natonal High Way) .

1.5.2 General Information and Basic Data

General information gathered from documents, discussions with the officers and staff, from Village Panchayat people and the villagers is given below:

PHOTO - 1 : PRIMARY SCHOOL BUILDING : DISCUSSIONS HELD WITH THE PANCH OF THE VILLAGE PANCHAYAT & VILLAGERS

PHOTO - 2 : HOUSE HOLDS SPREAD OVER AREA : NICHLA MAGRA

PHOTO - 3 : A VIEW OF HEMLET NICHLA MAGRA.

PHOTO - 4 : HOUSE HOLD SPREAD OVER AREA : HEMLET NICHLA MAGRA.

PHOTO - 5 : A VIEW OF HOUSE HOLDS OF NICHLA MAGRA.

PHOTO - 6 : HOUSE HOLDS OF NICHALA MAGRA

PHOTO - 7 : A VIEW OF HOUSE HOLDS AT THE ENTRY SIDE OF NICHLA MAGRA.

PHOTO - 8 : HOUSE HOLDS OF NICHALA MAGRA ON THE RIGHT OF ENTRY SIDE OF ROAD

PHOTO - 9 : HOUSE HOLDS SPRED OVER AREA : HEMLET KHAJURI FALAL (UPLA MAGRA)

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PHOTO - 12 : A VIEW OF HEMLET BADLI FALAN (MAGRA) TOWARDS LIFT OF SHOP

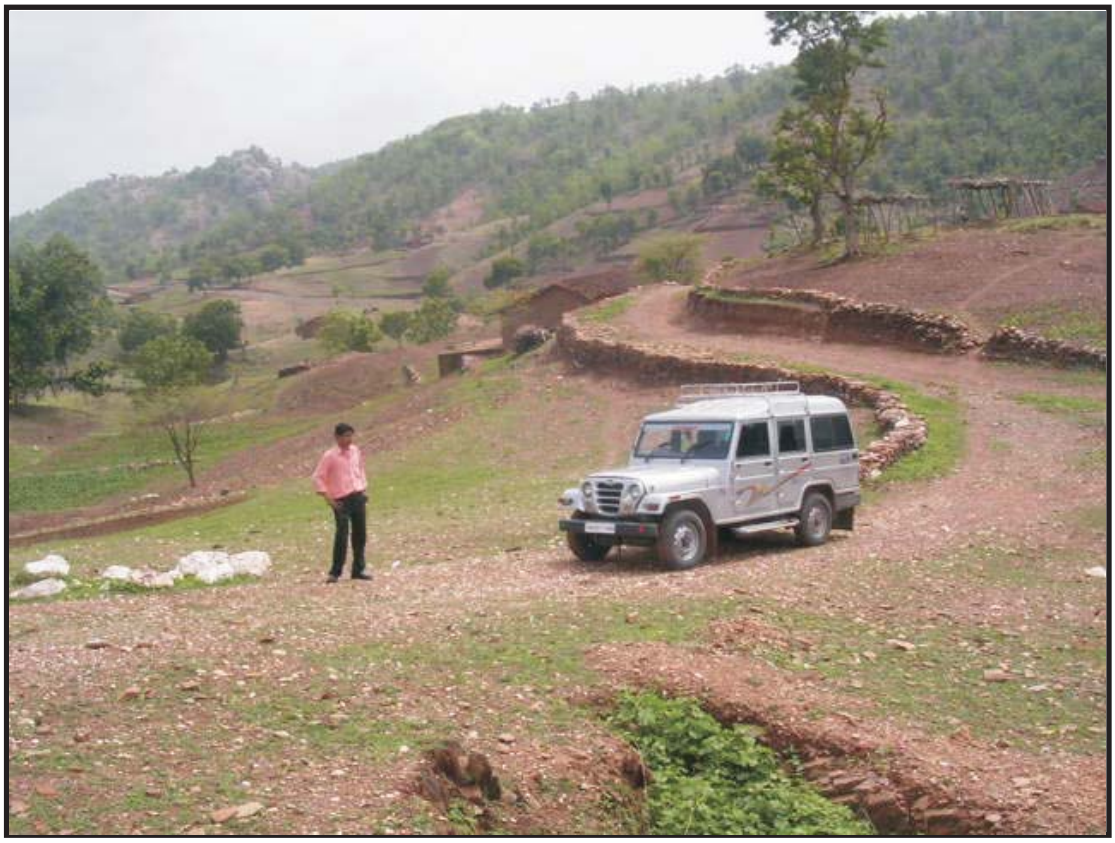


PHOTO - 13 : A VIEW OF VILLAGE MAGRA (HEMLET UPLA MAGRA)

PHOTO - 14 : A VIEW OF HEMLET BADLI FALAN (MAGRA) TOWARDS RIGHT OF SHOP

PHOTO - 15 : A VIEW OF VILLAGE MAGRA (HEMLET UPLA MAGRA)

i. The Village

Magra is a tribal village (under Block & Tehsil – Kherwada, District – Udaipur, Rajsthan) and under the Gram Panchayat Jalpaka (village).

ii. The Forest Cover

Magra Comprises 2 main settlements, namely: Nichala Magra & Upla Magra. Upla Magra has 2 Falan (Hemlets), viz: i. Khajuri Falan and ii. Badli Falan. Magra village is surrounded by ever green forest on all the sides in the Aravali hill ranges of Rajsthan.

iii. Population

There are 217 households, some house holds having agriculture land, some landless with population of about 1250 (about 650 male and 600 female).

iv. Economic Status

All the residents are Tribals (Adivasis), about 90% of them being below poverty line.

v. Level of Education

The number of educated persons in the village is small. The number of children studying is reported to be as 55 in the primary school (local) and 30 in the secondary (high) school (the high school being located at Dungarpur- about 40 km from Magra), and 1 in higher education (at Dungarpur).

vi. Profession

It includes agriculture (5 HH having 10 bighas, some having 2 to 3 bighas of agriculture land), cattle breeding (30 HH have large number of cattles), collection of Tendu leaves for selling to Forest Department, Ata Chakki (1No.), Kirana shop (1No.) and labour in neighbouring towns.

vii. Domestic Animals

Most of the families keep domestic animals (Cows, Buffalos, Oxen, Goats, Hens). 30 HH have 1 to 2 oxen, 20 HH have 1 to2 cows, 20 HH have 1to2 baffalows, almost all have goats (1to 5 Nos.), 40 HH have hens.

viii. Agriculture Production

The agriculture production mainly include Maize and Tuar (pulse). The produce is not sufficient to meet their own requirement and some families have to buy food grains from market. Some mango trees are there.

ix. Water Availability

There are 4 hand pumps, some wells, 1 big pond having good quantity of water during July to March and 2 seasonal rivulets.

x. Animal fodder

The requirement is met from the forest and from agriculture.

xi. Institutions

There is 1 Primary School and 1 Anganwadi (building under construction) in the village.

xii. Roads & Means of Transport

The village is connected by means of single lane metalled road (up to Khajuri Falan only (the road having been constructed under Prime Minister' Gramid Sadak Yojna recently) to the town of Kesariya ji (situated on Udaipur- Ahamdabad NH). No transport facility is available at the village at present.

xiii. Forest Area Assigned to Magra

Magra has been assigned some low-density forest area by the Maharastra Forest Department for their use. It has natural and unnatural forest both extending in N-S as well as E-W direction.

xvi. Lighting

The villagers get about 2 to 3 litres of Kerosine per month at subsidized rates, which is used by them for lighting for an hour or so per day. Since the quantity of Kerosine falls

short of requirement, they also use fire wood, which they bring from the forest, for lighting purpose..

xiv. Use of Wood etc. for Cooking

The villagers get Bamboos and Ballies (Logs) from the Forest Department and collect some head loads of wood for own use in a year. The quantity of cow-dung (cakes) and agriculture waste is low. Forest wood is also being used for lighting as the availability and affordability of Kerosine is limited.

xv. Forest Produce in the Assigned Forest Area

It comprises Sagon, Bamboo, Tendu etc. The villagers get some income from collection of Tendu leaves which is paid for by the Forest Department.

xvi Climatic Conditions near village Magra

a. Temperature (ºC) : 10 m above Earth surface as below:

Lat 20.1 Long 74	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
10 Year Average	15.70	18.7	23.70	28.40	31.15	30.45	27.25	26.05	26.15	24.65	20.55	17.10	24.15

b. Wind Speed (m/s) : 10 m above Earth Surface as below:

Lat 20.1 Long 74	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Monthly mean wind speed (m/s)	4.41	4.24	4.30	4.80	6.50	7.85	6.47	6.10	3.85	3.65	3.50	4.36	5.00

c. Average Relative Humidity : 10 m above Earth Surface as below (%):

Lat 20.1 Long 74	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
10 – Year Average	65	57	45	37	42	65	79	82	76	62	60	66	61.33

d. Median Value of Hourly Solar Radiation (kWh / sq.m)

	Hours L.A.T. Ending at													
Month	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**Daily Total**
Jan.	.00	.00	.15	.33	.54	.67	.71	.71	.67	.54	.32	.14	.00	6.81
Feb.	.00	.00	.19	.43	.62	.75	.81	.82	.75	.60	.42	.19	.00	7.32
March	.00	.00	.30	.54	.70	.83	.92	.92	.82	.69	.50	.28	.00	7.18
April	.00	.14	.36	.58	.78	.91	.95	.95	.90	.76	.55	.32	.17	6.60
May	.00	.18	.41	.61	.79	.91	.95	.95	.91	.78	.58	.38	.17	6.01
June	.00	.18	.39	.57	.74	.85	.92	.92	.85	.73	.56	.37	.15	5.23
July	.00	.14	.31	.50	.64	.75	.81	.81	.76	.65	.51	.31	.00	4.34
Aug.	.00	.00	.27	.46	.60	.71	.77	.77	.72	.62	.47	.28	.00	4.51
Sept.	.00	.00	.29	.51	.67	.80	.87	.86	.79	.67	.49	.28	.00	4.69
Oct.	.00	.00	.22	.44	.65	.78	.82	.82	.77	.63	.43	.20	.00	4.25
Nov.	.00	.00	.17	.37	.55	.68	.73	.73	.68	.55	.34	.17	.00	4.70
Dec.	.00	.00	.00	.31	.50	.63	.68	.68	.62	.49	.31	.00	.00	5.71

e. Daily Total Average Solar Radiation (kWh / sq. m)

Lat 18.55 Lon 73.85	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May.**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	**Annual Average**
Daily Total Avg. Solar Radiation (kWh / sq. m)	3.908	4.707	4.937	5.357	5.25	3.956	1.880	1.878	3.215	4.596	4.453	3.687	3.98

CHAPTER – 2

POWER / ENERGY REQUIREMENT AND INSTALLED CAPACITY

2.1 GENERAL

2.1.1 Vocation of Remote Electrification

The electrification of remote village is intended here to use of limited quantity of electricity to the isolated area not connected with electrical power grid.

2.1.2 The Type of Use of Electricity

The use of electric power is proposed for:

i. Domestic Uses
ii. Public Lighting
iii. Drinking Water Pumping
iv. Multi-purpose Uses
v. Meet out future expansion/growth in the next 10 years' period.

2.1.3 Use Requirement

The use of electricity is proposed to be limited to:

i. 1 kWh of electricity per household per day (up to a period of 7 hours per day say, 3 hours in the morning and 4 hours in the evening).
ii. Public lighting up to 40 points @ 18 watts (CFL) per point for up to 4 hours in the evening.
iii. Drinking water pumping.
iv. Multipurpose uses e.g. meeting out the irrigation needs, lighting of public buildings - school & Anganwadi, lighting of community centre, needs of agro-based cottage industries, lighting of places of worship, battery charging, needs of shops, clinics etc. which may come up in later get motivated/educated on realization of benefits of electric power availability.
v. Future expansion: assumed as 20% during the period of 10 years.

2.2 POWER / ENERGY REQUIREMENT

The requirement has been worked out as per the consideration above and the criteria discussed below and summarized in Table- 2.1: Typical Power Supply Programme (Future Vision) shown in Fig.- 2.1.

i. Domestic Uses

a. Connected load per H.H- 200 watts (assumed: 2 Nos. 11 W CFLs, 1 No. 60 W Fan, any other load up to 118 W)
b. Diversity factor:
   - CFL: 100% (some CFLs may fuse and some households may use more numbers).
   - Other load: 200% (Diversity factor may be higher initially but

Will decrease in due course (due to change in attitude and habits of the
people – particularly the younger ones).

c. Actual load per HH. : 2x11 + 178/2 =111 Watts.
d. Supply hours : 7/day (3, hrs.morning, 4 hrs.evening).

e. Total power needed for 217 H.H. : 111x217= 24087W= 24.087 kW
f. Energy consumption per H.H. / day : up to 111 x 7 Wh = 777 Wh.
or say, 0.80 kWh.

f. Total energy consumption / day for 217 H.H. = 0.80 x 217 kWh
=173.60 kWh.

ii. Public Lighting

It is proposed that public lighting may be only for 4 hours in the evening initially. The final operation and maintenance is conceived to be in the hands of the local body of the village when public lighting and other loads will be managed by them as per their choice, may be for more number of hours.

a. No. of light points : Up to 40.
b. Type of lighting : 18 Watts CFL.
c. Lighting hours : 4 hours in the evening.
d. Power required : Up to 18x40 = 720 W or 0.72 kW.
e. Energy consumption : Up to 0.72 x 4 W hrs. = 2.88 kWh.

iii. Drinking Water Pumping

a. Water requirement per HH : Up to 180 liters (Assuming 30 liters / person and 6 persons / house hold).
b. Total water pumping required : 180 x217 =39060 liters = 39.06cu m.
f. Pumping power needed (assuming pumping height of 50 m & pump efficiency as 60% :
9.81 x (39.06 / 3600) x 50 x 0.60 = 3.193 kW, Say, 5 HP = 3.73W.
d. Pumping period : Assumed up to 1 hour.
e. Energy consumption : up to 1 x 3.73 = 3.73 kWh.

iv. Multipurpose Uses

Depending on requirement and willingness of the people, the plant can be operated for the required number of hours between 9 a.m. to 5 p.m. The power availability for multipurpose use will be limited to about 40 kW only.
Presently, power can be used for up to 12 kW only and energy consumption as 12 x 7 = 84 kWh

v. PH Installation Capacity

Assuming power house consumption and system @ 10 % and the future growth @ 20 % in next 10 years, the PH installation capacity is worked out below:

a. Domestic load = 24.087 kW
b. Public Lighting = 0.72 kW
c. Drinking Water Pumping = 3.73 kW
d. Multipurpose Use = 12.00 kW
e. Future Growth = 0.2 x 24.087
= 4.8174 kW
Sub-Total (a to e) = 45.354 kW
f. P.H. consumption/system losses = 0.1 x 45.354
= 4.535 kW
Total = 49.889 kW
Say, = 50 kW

vi. Energy Consumption per Day

a. Domestic load : = 173.60 kWh
b. Public lighting : = 2.88 kWh
c. Water pumping : = 3.73 kWh
d. Multipurpose use : = 84.00 kWh
e. PH consumption : = 31.75 kWh
Total = 295.96 kWh
Say, = 296.00 kWh

The proposed daily use requirement of power and energy consumption is summarized in Table 2.1 below:

Table : 2.1 – Proposed Daily Use Requirement

Sl. No.	Use	Daily Use of	
		Power (kW)	Energy (kWh)
1	2	3	4
1.	Domestic Use	24.087	173.60
2.	Public Lighting	0.72	2.88
3.	Drinking Water Pumping (Hilly Region)	3.73	3.73
4.	Multipurpose Use: assumed 5 hour working	12.00	84.00
	Sub Total (Item 1 to 4)	40.537	264.21
5.	Future Expansion @ 20% of item 1.	4.817	Not added
6.	PH Consumption, Losses etc. @ 10%	4.535	31.75
	Total	49.889	295.96
	Say,	**50.00**	**296.00**

2.3 RESOURCE AVAILABILITY

2.3.1 Access

i. It should have a simple workable access or possibility of making such access at low cost.
ii. The area should be safe for the people to work at site.
iii. There should be availability of suitable raw material for construction of civil works.

2.3.2 Operation and Maintenance

i. Availability of local persons/persons from nearby area having reasonable reading and writing skills, suitable intellectual capacity and willingness to work as operator/ maintenance staff.
ii. Required facility to provide an on- situ training to the above persons.
iii. Required tools and plants, gadgets, safety equipment, etc. as required for maintaining the SPV plant and distribution system.
iv Availability of spare parts for successful operation of plant for 10 years period.

2.3.3 Availability of Monetary Resource

The scheme is to be funded:

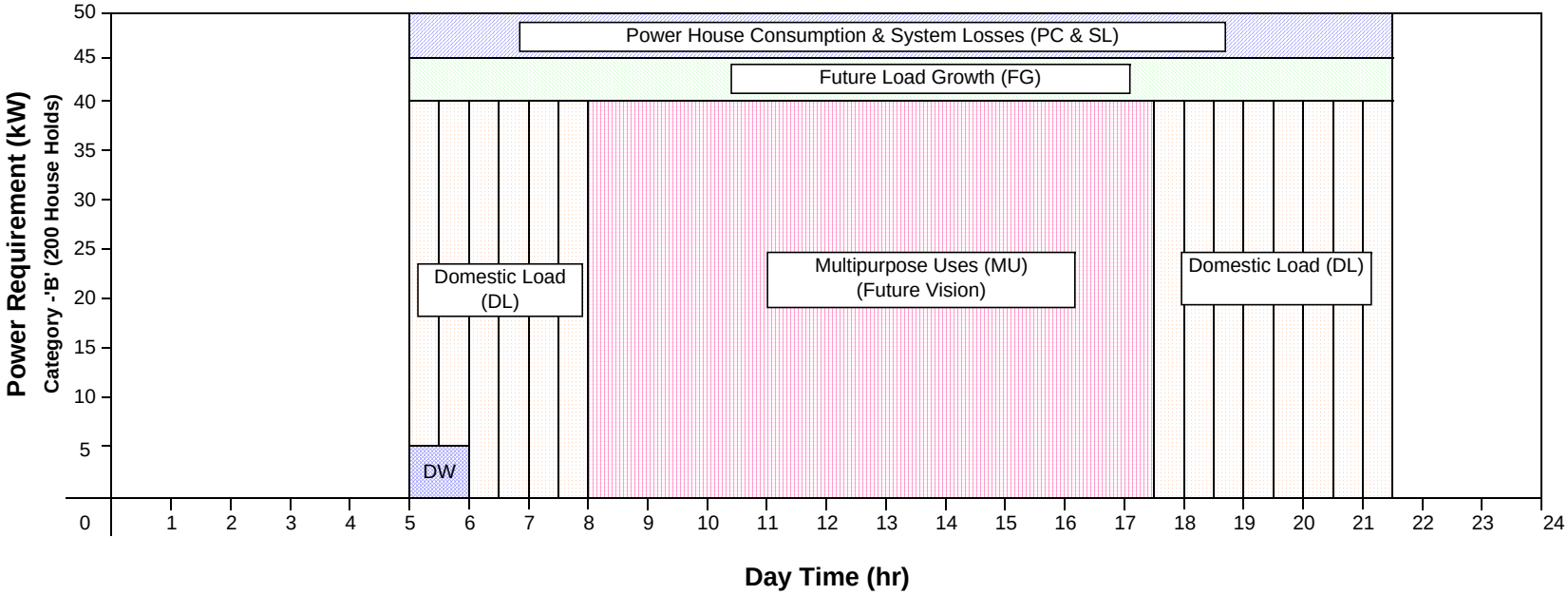
i. Partially by the MNES.
ii. By initial lump sum contribution by the village people.
iii. The rest by the Nodal Agency.

2.4 NODAL AGENCY FOR INSTALLTION OF THE PLANT AND O&M

Supervision, Planning, Designing, Processing the purchase case, Placement of order, Supervising construction, Liaison etc. is to be carried out by the Nodal agency i.e. the Rajsthan Renewable Energy Development Authority, Jaipur (Rajsthan).
The Nodal Agency is also proposed to co-ordinate and arrange for O&M of the plant and regular supervision (Chapter-10).

2.5 O & M ACTIVITIES

The management, operation and maintenance of the plant (including distribution system) is to be carried out by the contractor for initial 5 years period and thereafter by the Village Panchayat, Magra.



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DL- Domestic Load Lighting, Fan, Radio, T.V. etc.

DW- Drinking water pumping

MU- Multipurpose uses (cottage industries, Agricultural value-adding industries, Loads of community centre, School, Clinics, Shops etc.)

BC- DC Battery Charging

AN Agricultural Needs eg. Water Pumping for Irrigation

PC- Power house

& SL Consumption & System losses

FG - Future Load Growth

Note:

To enable Power availability during more number of hours in future as shown in this figure, the installed Capacity will have to be suitably increased.

Fig. 2.1:- Typical Power Supply Programme (Future Vision)-Timings are Adjustable on Seasonal Basis and other Requirements, if any.

CHAPTER - 3

CIVIL WORKS

3.1 INTRODUCTION

The civil structures related to the Solar Photo Voltaic Power Plant (SPV) are proposed to comprise:

i. SPV Array Yard.
ii. SPV Plant Building comprising mainly:
    a. Battery Room.
    b. Control Room.
    c. Store Room.
    d. General Facilities.
iii. Water Supply System and Room
iv. Sewerage system.
v. Fencing, Gate etc.

3.2 SOLAR PV PLANT CIVIL WORKS

The main structures are described below. Any other structure required is also to be made. The dimensions stated are approximate and tentative only.

3.2.1 SPV Array Yard

A SPV Array Yard of approximate size 60 m x 40 m may be required. It is proposed to be located in front of the SPV building facing south.

3.2.2 SPV Plant Building

3.2.3

i. Battery Room.

A Battery room of size 15.0 m x 4.0 m x 4.0 m approximately may be required to house the DC Batteries. This room may be constructed with 250 mm thick stone or brick walls and RCC roofing. (Drg. No. AHEC/C-337-2)

ii. Control Room

The control room may have a size of 3.7 m x 3.4 m x 3.6 m and located by the side of the Battery Room. It may be constructed with 250 mm thick brick walls and RCC roofing. The battery charger is to be housed in the control room. (Drg. No. AHEC/C-337-2)

iii. Store Room

Store Room may have a size of 3.4 m x 3.0 m x 3.6 m and may be constructed with 250 mm thick brick walls and RCC roofing. (Drg. No. AHEC/C-337-2)

iv. General Facilities

Drinking water facility, toilets, etc may be provided.

3.2.3 Water Supply System Room and Storage Tank

A room of size 3 m x 2.5 m x 3.6 m made of 250 mm thick stone / brick walls and covered with CGI sheets may be constructed to house the motor, controls etc and lifting arrangement at the top.

3.3 CONSTRUCTION

i. Adequate arrangement for proper ventilation shall be provided. It shall include exhaust fans and smoke exhaust pipe located in a manner to ensure removal of smoke in direction away from the building.
ii. The control room shall be made of good quality mosaic with best quality white cement and marble chips.
iii. Inside brick wall shall be plastered and white wash distempered.
iv. Windows/ventilators shall be fixed to ensure natural lighting inside the buildings.
v. Proper equipment fitting facility shall be provided.
vi. Proper lighting arrangement shall be made both inside and outside the buildings / SPV Array Yard and approach road.

The construction is to be done as per the Approved drawings. The structural design shall be done based on soil test, stability and safety etc. The construction is to be carried out as per the National Building Code of India, unless otherwise approved. Any other arrangement required as per site condition shall be made to ensure proper functioning of the plant and the system.

3.4 MODULE MOUNTING STRUCTURE

3.4.1 Design of Structure

i. The structure shall be designed for simple mechanical and electrical installation and therefore, it shall support SPV modules shall be supported at a given orientation, absorb and transfer the mechanical loads to the ground properly.
ii. There shall be no requirement of welding or complex machinery shall not be required at site.
iii. The structure shall be designed to allow easy replacement of any module.
iv. Each structure shall have provision for tilt angle (to the horizontal) mounting with. Provision shall be made for tilting from 5 to 35 degrees in steps of 5 degree in order to get maximum output from the SPV panel.
v. Appropriate size stainless steel nuts & bolts shall be used.

3.4.2 The Structure Foundation

The legs of the structures made with hot dip GI angles will be fixed and grouted in the RCC foundation columns made with 1:2:4 cement concrete. The minimum ground clearance from the lowest part of any module shall be 500mm. Due consideration will be given to weight of module assembly while making foundation designs.

The structure should be capable of withstanding wind speed of 150 km per hour after grouting and installation. Necessary excavation, concreting, back filling, shoring & shuttering etc shall be carried out.

3.4.3 Material to be Used

The made of Hot dip galvanized MS angles of size not less than 35mm X 35mm X 5 mm shall be used to make the array structure size. The minimum thickness of galvanization shall be not less than 80 microns. All nuts & bolts shall be made of very good quality of stainless steel. The minimum ground clearance of the lowest part of the module structure shall be 500 mm.

3.5 WATER SUPPLY SYSTEM AND ROOM

3.5.1 Setting up of Water Supply System

i. Installation of a 5 HP submersible type motor-pump unit, the motor being of Siemens /NGEF / Cromton / Jyoti / Kirloskar make operable on 230 V, 50 Hz, 0.8 PF AC supply.
ii. Boring and installation of tube well.
iii. Water piping system including bends, sockets, valves, clamps, civil works etc.
iv. Room for the above system.

3.5.2 Boring etc.

Boring of tube well up to required depth and of required diameter by water jet system through any type of soil strata and including scaffolding, lowering of pipes, strainers, blind pipes including bucket washing, T&P etc.

3.5.3 Storage Tank

Making a 5000 litres PVC water storage tank of Sintex /Palton or equivalent Approved make to be installed on the roof of the SPV building.

3.6 MISCELLANEOUS WORKS

3.6.1 Gate

The main gate is proposed to be 4 m (wide) x 1.80 m (high) comprising 2 panels made of MS angle frame and rods with guide Track etc. supported on 2 numbers 400 mm x 400 mm RCC pillars on both sides.

3.6.2 Fencing

Pre-cast RCC posts, 2 m high with 0.3 m bend at the top, is to be erected and chain link fencing (50 mm x 50 mm x 8 SWG size) fixed with the RCC posts by means of galvanized clips to a grid of horizontal strands of galvanized high tensile spring 12 SWG steel wire.

3.6.3 Approach Road

Suitable approach road shall be provided for the required services.

3.6.4 Environmental Provisions

Necessary provisions are to be made as per the requirement of environmental rules and regulations in force.

3.7 MATERIALS, CONSTRUCTION, FINISHING, TESTING AND COMMISSIONING

These are recommended to be as per the relevant Indian Standards and the construction etc. in accordance with drawings to be approved by the Nodal Agency.

3.8 MILD STEEL OR IRON WORK IN SMALL SIZES AND SECTIONS

3.8.1 Materials

The materials to be used, fabrication and construction method, supplying and fixing mild steel or iron work in small sizes and sections such as holding down bolts, holdfasts, tie rods, gratings etc. should be as per the relevant Indian Standards.

3.8.2 Painting

Steel work is to be thoroughly cleaned of rust, loose scales, dust etc. as per latest edition of IS: 1477-part-I and given one coat of red oxide paint conforming to IS: 2074 applied as per IS: 1477-part-II. Over the surface inaccessible after placing in position, two coats of red oxide paint should be applied.

CHAPTER – 4

POWER GENERATION EQUIPMENT AND SYSTEM

4.1 GENERAL

The power generation equipment and system is proposed to comprise mainly:

i. Solar Photo Voltaic Module.
ii. Power Conditioning Unit.
iii. Distribution Panel.
iv. Monitoring & Data Acquisition system.
v. Lightning & Over Voltage Protection.
vi. DC Batteries.
vii. Cables.
viii. Fire Fighting Equipment.
ix. Miscellaneous Equipment.

4.2 SOLAR PHTO VOLTAIC MODULES

Mono / Poly Crystalline Silicon Modules conforming to IEC 61215 or IEE 1662 or equivalent International Standards having an efficiency of not less than 13 % and out put ranging from 75 watt to 120 watts are proposed to be used.
The Solar Photo Voltaic modules may have following ratings:

i.	Power Out put	: Min. 75 Watts (under STC)
ii.	Open Circuit Voltage	: Not less than 21 V (under STC)
iii.	High Voltage Withstand Insulation Level	: 3 kV D.C. for 1 minute.
iv.	Array Capacity	: 87 kWp or so.

4.3 NUMBER OF MODULES AND ARRAY CAPACITY

Number of modules may range from about 1160 (for 75 W Module) to 730 (for 120 W Module) to give an output of 87 kWp.or so, as required.

4.4 POWER CONDITIONING UNIT

Power conditioning unit shall comprise 240 V DC input, and 415 V AC, 3- Phase, 50 Hz , pure Sine Wave out put inverter (rating: 75 kVA) with suitable 100 kW charge controller.

4.5 DC BATTERY BANK

Rechargeable Battery Bank is proposed to be provided as described below:

i. The DC Batteries shall consist of required number 12 V deep-discharge flooded lead acid positive tubular plate and pasted negative plate type storage cells, suitably interconnected to obtain DC system voltage of 240 V. ***More than three Parallel connections of storage cells shall not be used***.

ii. The cells shall be capable of withstanding deep discharges and frequent cycling with long maintenance intervals. The cell should have high Ah efficiency. ***Automotive or car batteries shall not be used***.

iii. The nominal voltage of the Battery Bank shall be 240 V and the capacity of 1200 AH at 10 hour discharge rate (C/10).

iv. The self-discharge rate of the battery bank or individual cell shall not exceed 4 (Four) percent (%) per month under ideal conditions.
The cycle life of the battery shall not be less than 1500 charge-discharge cycles between the fully charged state and the permitted maximum DOD; at a rate of C/10.

v. The Cells shall have ceramic vent plugs and include required number of corrosion-resistant inter-cell connectors, nuts, bolts, petroleum jelly, hydrometer and all other necessary accessories.

vi. The electrolyte volume shall be sufficient to allow topping at least twice a year, for continuous operation in the PV system.

vii. The cells shall be supplied in dry charged condition and complete with all required chemicals/electrolyte packed in separate containers (with 10% extra quantity shall be provided).

viii. Suitable number of corrosion-resistant and acid-proof storage racks shall be supplied to accommodate the cells. The rack design shall ensure that minimum space is occupied, without obstructing the maintenance requirements.

ix. Battery rack could be of matured treated Sal wood duly painted.
Placement of battery shall be done in a manner that maintenance of the battery could be carried out easily.

x. Non-reactive acid proof mat should be provided to cover the entire floor space of the battery room.

xi. Literature, Manual, Drawings, etc shall be provided for guidance and help proper O&M, particularly giving following information also:

a. Rated voltage and ampere- hour capacity of each storage cell at C/10 discharge rate;
b. Permitted maximum DOD;
c. Self-discharge rate;
d. Cycle life of the storage cell and the anticipated life (number of years) of the battery bank;
e. Total number of storage cells in use;
f. Instructions on first time charging, including specifications of the required battery charger;
g. Details on cell interconnections, if any, and
h. Safety procedures.

The battery components and rating are given in Table - 4.1 (Annexure – 4 /1).

4.5.2 Tools Kit

Necessary tools kit shall be provided along with each battery bank for any immediate maintenance requirements. These include, but not limited to :

i. A Thermometer

ii. Cell Tester, Hydrometer, Acid and Distilled water pouring container of required size, Battery connecting leads, Gloves, Gum boots, petroleum jelly are required to be supplied with each Battery Bank.

4.6 JUNCTION BOXES

i. The junction boxes shall be dust and water proof and made of FRP or MS (CRCA) as per Indian Standards. The terminals will be connected to copper lugs or bus bar of proper sizes.
ii. These will have suitable cable entry points fitted with cables glands.
iii. Suitable markings shall be provided on the lugs or bus bar for easy identification and cable ferrules will be fitted at the cable termination points for identification.
iv. Each main junction box shall be fitted with appropriate rating blocking diodes.
iv. The junction boxes shall have arrangement for:

a. Combine groups of modules into independent charging sub-arrays that will be wired into the controller.
b. Provide arrangement suitable rating of fuses for each string.
c. Provide a test point for each sub-group for quick fault location.
d. The rating of junction boxes shall be suitable with adequate safety factor to inter connect the Solar PV array.

4.7 LIGHTNING ARRESTER (LA) AND OVER VOLTAGE (O/V) PROTECTION

i. The SPV power plant shall be provided with LA and O/V protection.
ii. The LA is shall be made of 20 mm inch diameter and 3.75 m long GI pipe on the basis of the necessary meteorological data of the locations for the project.
iii. Necessary foundation for holding the LA is shall be arranged keeping in view the wind speed of the site and flexibility.
iv. Each LA shall be earthed through suitable size earth bus bar with earth pits. The earthing-pit shall be made as per IS 3043.

4.8 EARTHING

i. Each array structure of the PV array shall be properly grounded.
ii. Masts should be provided inside the array field.
iii. Provision shall be made for shorting and grounding of the PV array at the time of maintenance work.
iv. All metal casing/shielding of the plant shall be thoroughly grounded in accordance with Indian Electricity Act/IE Rules as amended up to date. Earth resistance shall be tested and maintained to 0.5 Ohms.
v. The earthing-pit shall be made as per IS 3043.

4.9 DANGER BOARDS

Danger Boards shall be provided in Hindi, English and local language as and where necessary as per IE Act/IE Rules.

4.10 POWER CONDITIONING UNIT (PCU)

4.10.1 Inverter

i. Inverter(s) shall:
   a. be of extremely high quality having high efficiency & microprocessor controlled Solar Mains Diesel (SMD) type and be capable of running in individual and parallel mode.
   b. be capable of monitoring its own parameters.
   c. shall have the feasibility by which inverter capability for supplying load, can be set at any pre determined load point by means of software. Beyond this load, the inverter should trip. The set points can also be remotely altered (set). The inverter(s) shall be so designed to be compatible with the Charge Controllers and distribution panel.
   d. be reliable and efficient solid-state devices (such as IGBT's) for DC-to-DC energy conversion.
   e. be designed for continuous, reliable and stable power supply for the specified loads.
   g. have high DC to AC conversion efficiency from 25 percent load to the full rated load. A load verses efficiency curve shall be provided.
   h. have a high overload capability. A minimum of 150 percent of full rated output for 30 seconds and be able to maintain the rated voltage and frequency during over load conditions.
   i. inverter output power factor in a range so as to supply or sink re-active power, as required.
   j. automatic re-start facility after overload triggered shut down, once . the load retains its set value.
   k. have both the AC and the DC lines suitable fuses and contactors on to allow safe start Up and Shut down of the system. Fuses used in the battery (DC) circuit shall be DC rated.
   l. be capable of operating in parallel with similar inverters.

ii. The inverter shall be:
   a. Three-phase solid-state type and the output wave shape of the inverter shall be sinusoidal.
   b. Required to running on the principle of the load-sharing basis.
   c. The having efficiency of more than 92% at full load.

The specifications are given in Table – 4.2 (Annexure – 4 / 2).

4.10.2 Spare Parts

Required spare parts and control cards are proposed be provided for 5 years O&M period as per the recommendations of the manufacturer. Each solid-state device shall be protected to ensure long life of the inverter as well as its smooth functioning.

4.11 PLANT CONTROL, DATA LOGGER & PLANT MONITORING UNIT

This unit shall be suitable for the following :

i. Controlling of the entire power system through a centralized station.
ii. Measurement and / or recording of energy parameters.
iii. Data logger or energy meter to record the energy data at a pre-determined interval basis.

iv. Measurement & continuous acquisition of ambient air temperature, wind speed, solar radiation, PV module temperature, battery voltage and current during charging & discharging period, battery temperature, inverter output voltage, current and output frequency.
v. Operating state monitoring and failure indication.
vi. Representing and monitoring data in both the graphics and tabulation mode.
vii. Controlling & monitoring the entire power system through remote terminal, as well as from a local terminal should be possible.

Necessary PCs with color monitors, modems, hardwires & software are recommended to be provided along with Plant Control, data logger & plant monitoring unit. Both the software and hardware required for interfacing the plant including the CPUs with color monitors, modems are to be provided.

4.12 COMMON AC DISTRIBUTION PANEL BOARD

i. A Distribution Panel Board (DPB) shall control the AC power from inverter to four feeders through switches.
ii. AC DPB shall have the arrangement for measuring all electrical quantities such as Voltage, Current of different feeder line & energy supplied to the different feeder.
iii. AC DPB shall have enclosure to protect from dust, vermin proof & adequate cooling arrangement. The bus-bars are to be made of copper of desired size. Design & Drawing is to be submitted to the purchaser before installation by obtaining necessary approvals.

4.13 DC DISTRIBUTION BOARD

DC distribution board shall consist of suitable metal casing with provision of incoming & out going cables. Each incoming & outgoing feeder must be provided with MCB of appropriate capacity. Arrangement for indications shall be made in the switchboard to identify status of the switchboard.

4.14 CABLES

All cables should be as per IS Standard and should be as per requirement.

4.14.1 Cabling in the Array Field and Control Room

Cabling in the array field shall be carried out as per IE Rules, this include the size & type of the cable, the cable layout, depth of the trench, covering the cables, etc. Cabling inside control room should be in cable trench duly covered with RCC slabs. Size of cables & wires required are to be provided before commencement of work. Un-armored and armored cable as and where necessary shall be used. Cables shall be laid in GI pipes of suitable size in open trench as required. Cables shall be laid in the ground at a depth of 1m from the ground level along the approved route with necessary brick and GI pipe protection. Whenever the cable crosses the roads, drains, water sewage pipes or entering / leaving the buildings the cable shall be laid in Class-B GI pipe of suitable size.

4.14.2 Wires

All wires should be as per IS and should be of appropriate grade as per requirement. Only copper wires of suitable size and of reputed make shall have to be used.

4.14.3 Cable Glands

All connections are to be made through suitable cable glands/lug/terminals; crimped properly & with use of Cable Glands.

4.14.4 Cable Marking

All cable/wires are to be marked with proper manner by good quality ferule or by other means so that the cable can be easily identified.

4.15 SOLAR WATER DISTILLATION PLANTS

Approved quality Solar Water Distillation Plant of capacity 3 to 4 liters per day is to be installed on suitable GI structure. If required the contractor can contact Solar Energy Centre for fabricating Solar Water Distillation Plant. At least two nos. plastic pots and one funnel are to be supplied along with each Distillation Plant.

4.16 ENGINEERING DRAWING & MANUALS

All relevant engineering drawings, electrical drawings, civil drawings and other drawings in respect of installation of power plant, all relevant documents along with installation and operation & maintenance manuals are to be supplied.

Annexure – 4 / 1

Table - 4.1: Battery Components and Rating

Sl. No.	Item	Components / Rating
1	**2**	**3**
1.	Container	Polypropylene Co-polymer / hard rubber with carrying handle.
2.	Cover	Protective cover of polypropylenes against dirt & possible short circuit.
3.	Terminals	Made of lead alloy suitable for bolted connection. The terminals should be greased with petroleum gel.
4.	Electrolyte	Battery grade Sulphuric Acid
5.	Self Discharge	Less than 4% per month at 30^0 C.
6.	Life Expectancy	1500 cycle duty at 27^0 C at 80% depth of discharge.
7.	Nominal Voltage	2 Volt.
8.	Type	As approved by Railways or CECRI or ERTL or ETDC and as per relevant standards for batteries for referred use.
9.	Service Life	Should perform satisfactorily for a minimum period of 6 year under operating conditions as mentioned.

Annexure – 4 / 2

Table – 4.2: Specifications

Sl. No.	Item	Specifications
1	2	3
1.	**PV CHARGE CONTROLLER**	
i.	Switching elements	**IGBT**
ii.	Type of Charger	PWM
iii.	Nominal Rating	240 V, 100 kW
iv.	Control	Microprocessor based
v.	PV Input	From PV Array 200V to 400V DC (20 in series)
vi.	Output Voltage	Suitable for charging 240V nominal Battery Bank
vii.	Charging Current	300 A from PV
viii.	Protections	Deep Discharge (included in Inverter) Input Surge Voltage Battery high charge current Battery over voltage Battery reverse Polarity Solar Array reverse Polarity
ix.	Indications	Mains ON Boost Mode Enabled High Battery Temperature Fault High Battery Voltage Fault Low Battery voltage High Battery Charge current fault Heat sink over temperature fault Battery breaker opened/tripped Input Over/Under Voltage (for AC operation)
x.	MIMIC Panel	Indicates power activity and operation of the Charge Controller/Battery Charger
xi.	Dielectric Strength	1.1 kV between Input/Output & ground with EMI protections
xii.	Cooling	Forced, with temperature sensitive fan operation

1	2	3
2.	**INVERTER**	**75 kVA**
i.	General Features a. High efficiency microprocessor controlled design, suitable for stand alone operation b. Parallel synchronized operation possible of the same configuration, Each inverter can monitor its own parameters c. Completely compatible with Charge Controller and Distribution Panel. d. Suitable for continuous, reliable operation, High overload capacity. e. Manual restart after any tripping due to fault. This is a safety requirement.	
ii.	Input DC Voltage	240 V nominal
iii.	Output Voltage	400V- 415V nominal, 50 Hz, 3 phase, 2 wire
iv.	Waveform	Sine wave, <3% THD
v.	Switching Elements	IGBT
vi.	Voltage Regulation	+/- 1% against input voltage and load regulation for input voltage variation from 214V to 330 V, 0 to 100% load
vii.	Frequency	50Hz +/- 0.5 Hz
viii.	Output Power	75 kVA
ix.	Efficiency	More than 92% at 100% load, at the rated input DC voltage
x.	Parallel Operation	2-Inverters can be operated in synchronization with load sharing capability if required at any time
xi.	No load power consumption	Less than 2.5% of total output rating
xii.	Overload capacity	150% for 30 sec, Output voltage may drop by about 5% maximum. Frequency is maintained.
xiii.	Step Load Recovery	Less than 5 Sec. from 0 to 100% load, with a transient variation not more than 15% of nominal voltage
xiv.	Dielectric Strength	1.1 kV between Input/Output & ground and 1.5 kV between input and output with EMI protections removed
xv.	Short Circuit Protection	Circuit Breaker and electronic control
xvi. xvii	Battery Low Voltage	Auto shut down at 214V and starting at 230V, manual reset, software settable
xviii.	Output Low/High Voltage	Auto shut down when +/- 10% of Nominal output voltage is exceeded, Software settable. Manual reset
xix	High Battery Voltage	Auto shutdown, Software settable, manual reset
xx.	AC Reverse Power	Auto shutdown manual reset
xxi.	AC Over Current	Auto shutdown, Software settable, manual reset
xxii.	Instrumentation	LCD display panel

1	2	3
xxiii.	Status Indications	Control Supply OK (Green) PCU On line (Green) System Fault (Red – flashing)
xxiv.	Fault Indications	Flashing Lamp External fault contact Fault details on LCD panel and computer
xxv.	Instantaneous Display	Power Output in kW Output Voltage Power Factor System frequency Battery voltage/current Inverter kWh summation Battery current summation All above displays on the LCD panel and the Computer
xxvi.	Time & Date stamped Logging Parameters	Power Output in kW Output Voltage Power Factor System frequency Battery voltage/current Inverter kWh summation Ambient/PV temperature Wind speed
xxvii.	Cooling	Forced, with temperature controlled fan operation

CHAPTER - 5

POWER EVACUATION AND DISTRIBUTION SYSTEM

5.1 CONSUMER VOLTAGE, FREQUENCY AND VARIATION

The consumer voltage shall be 415 V, 50 Hz and variation of voltage and frequency within ± 5% and ± 3% respectively.

5.2 PROVISION OF LOAD LIMITERS

MCBs or load limiter of proper size are to be installed at the load points on each location as per the requirement of the load.

5.3 LIGHTNING PROTECTION

Suitable Lightning Arrestors shall be provided. The earth electrode resistance is recommended to be less than 1Ω.

5.4 EARTHING

i. Earthing in the Power plant shall be as per the specifications provided in Chapter -4.
ii. It is not compulsory to draw an earth line in the distribution circuit.
iii. Earthing shall be done as per the Indian Electricity Rules.

5.5 DISTRIBUTION SYSTEM

i. Distribution of electricity shall be through 3-Phase, 415V by 18mm² or higher size insulated ACSR conductor as required.
ii. The required length of overhead distribution cable from the control room to the load points shall be used. The distribution lines will be laid in a manner that each consumer can be served without long service lines from the overhead cable.
iii. For overhead distribution, the required number of poles with associated insulators, fasteners, stay sets and like shall also be used. The distance between poles shall conform to the Electricity Rules.
iv. The poles for distribution lines may be hard wood, reinforced or pre-stressed concrete or MS galvanized tubular poles. Height of poles should be clear 6 m above the ground level after grouting.
v. MS distribution board shall be provided on poles to locate the load limiter switches.

5.6 CABLES

i. Aluminium, copper, ACSR and high strength aluminium alloy overhead cables are recommended for use.
ii. Minimum ground clearances for overhead lines are 5.8m across motorable roads, 5.5m by the side of motorable roads and 3.0m over open ground. The minimum horizontal top clearance is 1.5 m.

iii. In heavily vegetated or forested areas, insulated cables are recommended for use.
iv. Sags and tensions of cables, size of poles, types of insulators etc. are to be used as per the Indian Electricity Rules.
v. Selection of conductors shall be as per the Indian Electricity Rules.
vi. The spacing shall be 300mm between conductors for a vertical arrangement of overhead lines and the neutral conductor shall be at the lowest.
vii. The joints must be durable, strong, adequate for their purpose and visible. Bi-metallic clamps should be used for joints, which connect dissimilar metals.

5.7 TYPE OF POLES

5.7.1 Materials

This could be hard wood, reinforced or pre-stressed concrete or galvanized pipe. The wooden poles should be treated / painted and the steel poles painted for longer life. If care for safety can be ensured, the trees may be used for laying the cables.

5.7.2 Span of Poles

Following span is recommended for distribution system for houses. The span length for the distribution line running cross-country may be taken as 60 to 90 m as per the site requirement. The span length may be higher for the line running through hilly areas.

The span of the Poles shall be:

a. Up to 16 sq. mm insulated wire : Maximum 30 m.
b. Above 16 sq. mm and up to 35 sq.mm : Maximum 25 m.

5.7.3 Span and Sag

Span and sag shall be provided as the REC Standards.

5.8 INSULATORS

i. For bare cables, LT insulators are recommended for use.
ii. For insulated cables, nylon bobbins or telecom insulators may be used as partial insulators.
iii. The connections are to be carried out as per REC Standards.

5.9 STAYS

Stays must be used at the first and the last poles of the straight lines and also at any turns.

5.10 HOUSE WIRING

i. MCBs or load limiters will be used as incoming protection device (depending upon the recommended load).
ii. One circuit with 1.5 sq. mm cable can be used for installations up to 1kW. The wire shall be of 600 V grade insulation.
iii. Standard switches designed for 230 V AC shall be used.

iv. Conduits/Batons shall be used for internal wiring or can be clipped onto the wooden parts for running on the roof section.

5.11 MAINTENANCE MANUALS

Maintenance manuals shall be provided and kept in place for use during O & M of Power plant.

5.12 LABELS AND NOTICES

i. All electrical components; particularly switches, protection trips, circuit breakers, fuses etc.; shall carry labels describing their functions.
ii. H.V. warning labels shall be placed on all cabinet doors, terminal covers etc.
iii. A circuit diagram of load limiter shall be provided at control room of Power Plant.
iv. A block diagram showing overall electrical lay out shall be provided in the Control room of Power Plant and it shall be clearly visible and accessible.
v. An illustrated notice, in local language, shall be provided to warn the people of the danger of electrocution. It shall be durable, within easy view and contain practical information on preventing and coping with electrocution and electric shock.

5.13 SELECTION OF CABLE

Selection of cables shall be made keeping in view the basic requirements, cost effectiveness and the environmental etc.

CHAPTER - 6

TESTING AND COMMISSIONING

6.1 TESTING

Testing of equipment and works shall be carried out as may be required as per the relevant I.S./ I.E.C. Standards.

6.2 COMMISSIONING

After the erection and testing of the equipment/works as per above, commissioning of the plant and works shall be carried out and here the term “Commissioning” shall mean the activities of functional testing of the complete system after erection and testing, including tuning or adjustment of the equipment for optimum performance and demonstrating to the Purchaser that the equipment performance meets the requirements of the specifications.

6.3 ACCEPTANCE TESTS AT SITE

The contractor shall carry out tests to obtain the guaranteed out put and efficiency at the site as per the plan prepared by him and submitted to the Purchaser before hand.

CHAPTER – 7

PROJECT IMPLIMENTATION STRATAGY

7.1 GENERAL

A three-tier arrangement is proposed for project implementation.

7.2 ARRANGEMENT

7.2.1 Nodal Agency

Rajsthan Renewable Energy Corporation, Limited (RRECL), Jaipur will be the Nodal Agency. The Nodal Agency is proposed to have the following functions:

i. Obtaining project approval form MNES, Government of India.
ii. Receiving funds from MNES and disbursement thereof as required.
iii. Co-ordination with the Rajsthan Forest Department at various levels.
iv. Arrangement of land for installation of the plant & the system.
v. Preparation of Bid document as per the Model Specifications to be issued by the MNES, floating tender & processing it, placing order and overall supervision of the project implementation.
vi.. Overall coordination for project implementation and its Operation and Maintenance during 5 year's contractual period and there-after.
vii. Arrangement for funding of the project etc.

7.2.2 Rajsthan Forest Department

Following functions are proposed to be carried put by the Rajsthan Forest Department:

i. Motivation and formation of Village Energy Committee (VEC).
ii. Creating awareness and interest amongst the villagers.

7.2.3 Village Energy Committee

The VEC is proposed to carry out the following functions:

i. Motivation and creating interest amongst the villagers for success of the project.
ii. Collection of initial contribution from the villagers towards installation of the Plant and the System.
iii. Collection of monthly payment from the users.
iv. Arrangement and supervision of the record.
v. Arrangement / appointment of manager, operators etc. for running of the plant and system as required.
vi. Operation of Bank Account.

CHAPTER – 8

CONSTRUCTION PROGRAMME

8.1 PRE-CONSTRUCTION ACTIVITIES

Pre-construction activities, viz: preparation of bid-document, purchase of bid-document by prospective bidders, study and submission of bid will take some time. It will be followed by opening of bid, its finalization, and placement of order and signing of contract. A period of 3 months is considered sufficient for these activities and provided in the Bar Chart.

8.1 CONSTRUCTION ACTIVITIES / PERIOD

8.1.1 Construction Activities

Construction activities have been shown in the Bar Chart Fig. 8.1. The period for various construction activities have been taken as below:

		Days
i.	Contractors mobilization	15
ii.	Survey & Investigation	15
iii.	Preparation of Drawings & Documents & Submission	30
iv.	Checking of Drawings, Documents & Approval	30
v.	Construction of Civil Works	60
vi.	Manufacture & Supply of Equipment, Material F.O.R. Site	75
vii.	Installation of Module structure	15
viii.	Installation of SPV Modules & Batteries	30
ix.	Installation of Power Conditioning Unit , Control, Protection & Metering System	30
x.	Installation of Distribution System	30
xi.	Installation of House Wiring & Meters (Where necessary)	30
xii.	Testing & Commissioning	15
. xiii.	Others Works	15
xiv.	Trial Run	15

Considering the over lapping periods of the various activities, the total period of construction will be 12 months only.

8.2 CONSTRUCTION ACTIVITIES

Construction activities have been shown in the bar chart. A period of 1 month has been allowed for mobilization of the contractor. Trial run period of 15 days has also been considered to ensure safe and reliable operation of the plant as it has been noticed that at times the plant is erected & commissioned but then it goes out of operation for some reason or the other and then, the plant remains idle for a considerable period before being put back on operation.

The place being remote, located deep in the forest and connected through Kachha forest road which becomes problematic during monsoons and rainy days, some period is likely to be lost causing delays. Some time margin has been considered for the

same. However, the contractor may finish the whole work in lesser period if possible. The O & M shall start after successful commissioning and trial run of the plant and the system.

8.3 CONTRACTUAL PERIOD OF O & M

The O & M is proposed to be carried out by the contractor for initial 5 years and thereafter the plant will be run by the villagers.

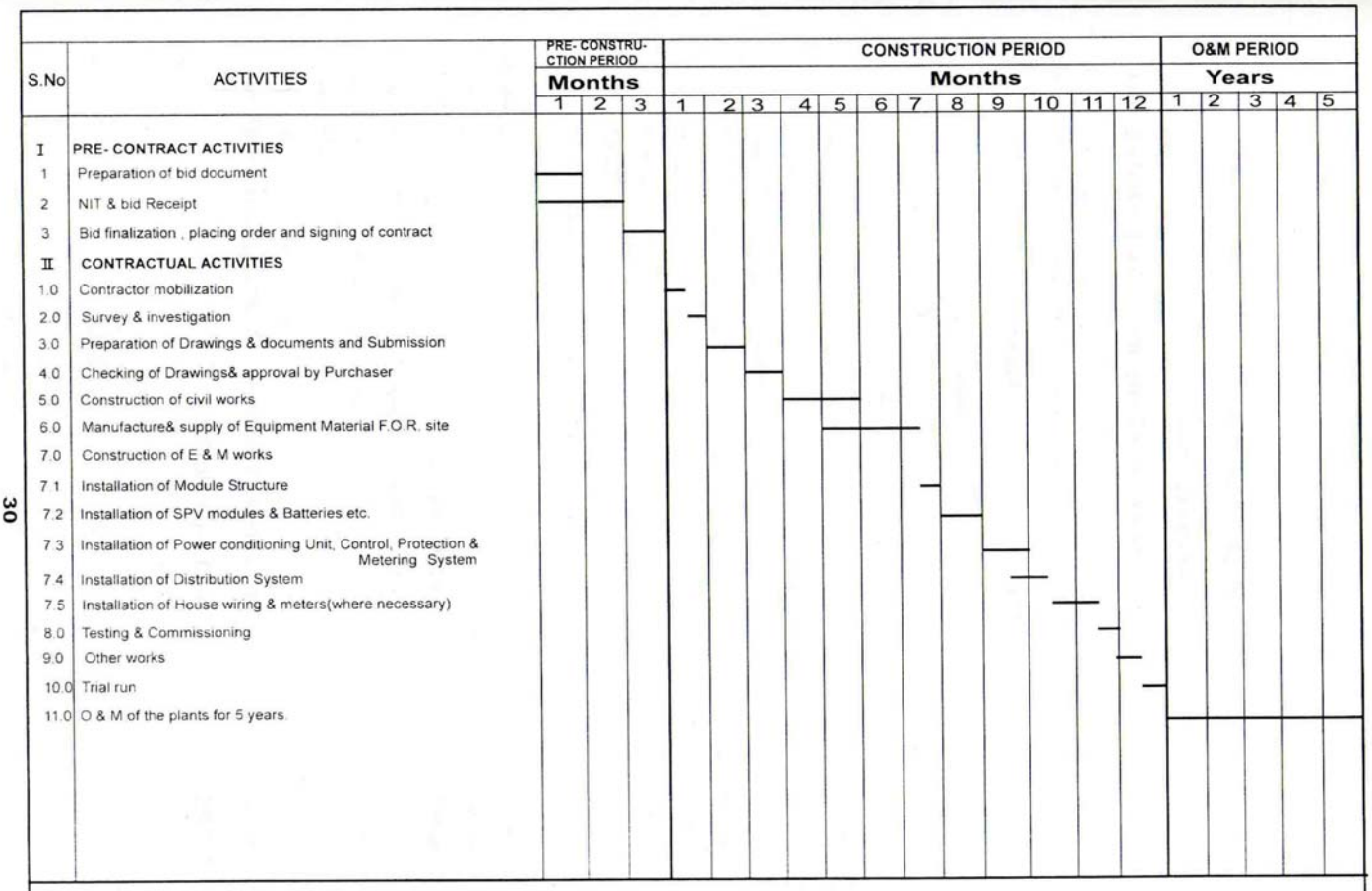


FIG. 8.1- BAR CHART :SOLAR P. V. BASED ELECTRIC POWER PROJECT MAGRA (DISTT. UDAIPUR,RAJSTHAN)

CHAPTER – 9

ESTIMATED COST

9.1 ESTIMATED COST OF THE PLANT AND SYSTEM

The cost of the civil works, plant and the system, is shown in Tables – 9.2 & 9.3 and the over all cost estimate in Table – 9.1.

TABLE 9.1 : COST ESTIMATE

Sl. No.	Items	Cost (Rs. in Lacs)
1	2	3
I	**Works**	
A	Preliminary	0.150
B	Land	0.250
C	Civil Works (as per Table 9.2)	16.00
J	Power Plant (as per Table 9.3)	179.00
K	Buildings	0.00
M	Plantation	0.00
O	Miscellaneous	0.00
P	Maintenance	0.00
Q	Special T & P	0.00
R	Communication	0.00
Y	Losses on stock	0.00
	Total I – Works	**195.40**
II	Establishment (2% of I- works excluding Buildings)	3.908
III	Ordinary T & P (1% of I – works)	Nil
IV	Suspense	Nil
V	Receipts and recoveries	(-) Nil
VI	Indirect Charges (1% of I – works for Audits Accounts)	1.954
	Total Project Cost	**201.262**

TABLE 9.2 : CIVIL WORKS

Sl. No.	Item	Qty.	Rates (Rs. Lacs)		Cost (Rs. Lacs)		
			Mate-rials FOR Desti-nation	Istalli-ng & Com-miss-ioning	Mate-rials FOR Desti-nation	Istalli-ng & Com-miss-ioning	Amount
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1.	a. Construction of SPV plant Building. b. B. Module Yard etc.	100 sq.m LS	0.05	Incl-uded	Incl-uded	Incl-uded	5.0 2.00
2.	Drinking Water supply System in the village.	LS	--	--	--	--	5.00
3.	Construction of Fencing, Gate, 4m wide Approach Road & 1m wide Path ways in the Array Yard etc.	LS	--	--	--	--	2.00
4.	Miscellaneous	L.S.	--	--	--	--	2.00
				Sub-	**Total**		**16.00**

TABLE - 9.3 : ELECTROMECHANICAL WORKS

Sl. No.	Item	Qty.	Rates (Rs. Lacs)		Cost (Rs. Lacs)		
			F.O.R Destination	Erect & Commissioning	F.O.R Destination	Erect & Commissioning	Amount
1.	Supply & fixing of 43.50 kWp composite capacity SPV Modules with the mounting structure.	2 Sets	22.00	Included	44.0	Included	80.00
2.	Supply, installation, testing & commissioning of low maintenance Tubular type lead acid battery bank having 120 batteries (each having 15000Ah, 2 Volt (under STC) connected in series in each bank.	2	10.00	0.50	20.00	1.00	30.00
3.	Battery Protection & Control Panel	1	0.50	0.05	0.50	0.05	0.55
4.	Design, Manufacture, Supply & Installation of Full Sign Wave 37.50 kVA, 240 V DC input, and 415 V, 50 Hz,3-Phase AC output PCU complete with charge controller, battery charger & inverter modules with Control & Protection.	2 Nos.	12.00	Included	24.00	Included	24.00
5.	AC Feeder Panel	2 Nos.	2.00	0.10	4.00	0.20	4.20
6.	Supply, laying & installation of armoured, PVC sheathed, PVC insulated cables including supply & fixing of compression type cable glands of brass.	LS					3.00
7.	Lightning Conductor	LS					0.35
8.	Solar Water Distillation Plant	LS					0.15
9.	Earthing complete with GI pipe electrode for SPV Array, Solar water distillation plant, Distribution system, etc.	LS					0.15
10.	Supply & fixing of sub-junction boxes to terminate sub-array connections	LS					0.10
11.	Supply & fixing of main junction boxes to interconnect sub-junction boxes	LS					0.10
12.	Supply & fixing of MCBs, Distribution boards, etc	LS					0.20
13.	Supply & installation of Dry Chemical Fire Extinguishers, Sand buckets etc. for class B & C type fire	LS					0.15
14.	L T Distribution Line,	14.0 km	2.00	Included	28.00	Included	28.00
15	Service Connections	217Nos.	0.01	Included	2.17	Included	2.17
16.	Street Lights	40 Nos.	0.01	Included	0.40	Included	0.40
17.	Training Etc.	LS					0.30
18.	Miscellaneous	LS					5.18
						Total	**179.00**

9.2 FUNDING **Rs. Lacs**

i.	By Grant From MNES	:	152.470
ii.	Contribution by Villagers @ Rs. 1000/per HH	:	2.17
iii.	Contribution by Nodal Agency	:	46.22
	Total		**201.262**

TABLE 9.4 : COST OF GENERATION WITHOUT SUBSIDY

Sl. No.	Items	Rs. In Lacs
1	**2**	**3**
1	Project Cost	201.262
2	Annual Interest during Construction	6.642
3	Total Project Cost	207.904
4	Annual working expenses (as per table 10.6)	13.626
5	Interest @ 12 % on total project cost	24.948
6	Total annual expenses	38.574
7	Annual generation at power house (Million Units) i. At 80% of Load Factor ii. At 60% of Load Factor	 0.1022 0.0767
8	Cost of generation per kWh (in Rs.) i. At 80% of Load Factor ii. At 60% of Load Factor	 Rs. 37.744 Rs. 50.325

TABLE 9.5 : STATEMENT OF YEARLY WORKING EXPENSES

Sl. No.	Items	Cost (Rs. In Lacs)
1	**2**	**3**
1	Operation cost @ 1% of works cost	2.013
2	Maintenance cost of C-works @ 1%	0.160
3	Maintenance of E&M works @ 2%	3.580
4	Annual depreciation charges (as per Table – 9.7)	7.873
	Total	**13.626**

TABLE 9.6 : COST OF GENERATION WITH SUBSIDY

Sl. No.	Items	Rs. in Lacs
1	**2**	**3**
1	Project Cost	201.262
2	Capital Subsidy As per MNES	152.470
3	Balance Project Cost	48.792
4	Annual Interest during Construction	1.610
5	Total Project Cost	50.402
6	Interest @ 12 % on total project cost	6.048
7	Annual working expenses (as per table 9.6)	13.626
8	Total annual expenses	19.674
9	Annual generation at power house (Million Units) i. At 80% of Load Factor iii. At 60% of Load Factor	 0.1022 0.0767
10	Cost of generation per kWh (in Rs.) i. At 80% of Load Factor ii. At 60% of Load Factor	 Rs. 19.251 Rs. 25.667

TABLE 9.7: ANNUAL DEPRECIATION OF ASSETS

Sl. No.	Items	Life in years	Cost (Rs. Lacs)	Rate of Depreciation in %	Depreciation Rs. Lacs
1	**2**	**3**	**4**	**5**	**6**
1	Land	Infinity	0.00	NIL	NIL
2	Civil Works	35	16.00	3.40	0.544
3	Plant & System	35	151.00	3.40	5.134
4	LT Distribution	25	28.00	7.84	2.195
				Total	**7.873**

9.3 FINANCIAL ANALYSIS

The financial analysis has been carried out as per Tables – 9.4 & 9.6. The cost of generation and the results are given below:

9.3.1 Cost Of Generation

i. Without Subsidy : Rs.37.744 / kWh

ii. With Subsidy : Rs. 19.251/ kWh

CHAPTER -10

OPERATION AND MAINTENANCE OF PLANT & SYSTEM

10.1 GENERAL

After the plant and system is tested commissioned and the trial period is over, the operation and maintenance for 5 years period will be the responsibility of the contractor who has supplied, erected tested and commissioned the plant and the system. The contractor may net use 100% of his own staff and may require certain number of additional persons for managing O&M under the guidance of his limited staff.

The Nodal Agency (RREDA) is proposed to form a Village Energy Committee (VEC) from amongst the village people to take care of the plant and the system during the initial 5 years O&M period and there-after. The VEC may arrange for the said additional staff from amongst the people of the village, depending on the age, physical so mental health, willingness and the educational qualifications.

10.2 O&M FOR INITIAL 5 YEARS

i. Regular O&M of the SPV Power Plant for a period of 5 (Five) years after commissioning along with supply of consumable items as necessary.

ii. Breakdown maintenance of the entire system including supply of necessary spare parts, if any.

iii. The O&M shall begin at the end of successful completion of the trial run of the power plant.

iv. The deputed personnel shall be qualified and well trained so that they can handle any type of operation hazard quickly and timely. These personnel shall be on round the clock duty .

v. The power plant shall be run for designated hours, therefore, the deputed personnel should attend the plant as per schedule.

vi. The security of the power plant will rest with the suppliers till such time operation and maintenance of the power plant is not handed over to the purchaser.

vii. Daily log sheet for the power plant as per format to be supplied by purchaser after commissioning of the power plant shall be maintained by the deputed personnel.

viii. The deputed personnel shall check and test all the equipment regularly, so that preventive actions, if any, could be taken well in advance to save any equipment from damage. Any abnormal behavior of any equipment shall be brought to the notice of purchaser immediately for appropriate action.

ix. Normal and preventive maintenance of the power plant such as cleaning of module surface, topping up of batteries, tightening of all electrical connections, changing of tilt angle of module mounting structure, cleaning & greasing of battery terminals, etc. are also the duties of the deputed personnel.

x. Deputed personnel will operate the plant in accordance with the availability of solar energy stored in the battery bank. Under no circumstances the operator shall take such actions those are damaging to the Power Plant and the battery bank. In case of non-availability of solar power suitable notice board may be displayed in front of the control room to avoid local problems.

xi. During the above O&M period, if there is any loss or damage of any component of the power plant due to miss- management / mis- handling or any other reasons pertaining to the deputed personnel, what-so-ever, the contractor shall be responsible for immediate replacement / rectification at his own cost. The damaged component may be repaired or replaced by new component. It shall be ensured by the contractor that the performance of the components or the system so repaired or replaced shall not degrade.

xii. Plant operator shall be available in the Power Plant during operation period of the Power Plant.

xiii. Operating staff and personnel to be provided by the Nodel Agency / Village Energy Committee shall be guided & trained in a manner that they shall become capable of O & M of the SPV plant and system after the O & M period of 5 years is over. They will be allowed to operate the plant under the guidance of the deputed personnel for not less than 1 year before the expiry of the O & M period of 5 years.

10.3 FORMATION OF COMMITTEE FOR SUPERVISION OF O & M

i. Executive Committee

The VEC will make an Executive Committee of 5 persons which will supervise and monitor:

a. Day to day functioning of the plant & system
b. Monitor day to collection of revenue & Expenditure

ii. Staff

Following Staff is proposed to be appointed by VEC from amongst the villagers:

a.	Manager	:	1 No.
b.	Operational Staff	:	6 Nos.

iii. Record Keeping

Following record is suggested to be kept and maintained by the VEC.

a. Cash receipt register
b. Cash book
c. Ledger
d. Bank Pass Book & Cheque Book
e. General Stock & Issue Register
f. Register for Consumables

iv. Supervision & Maintenance of Record

a. The manager will keep maintain the record, write cash book & maintain the account
b. VEC executive will check the accounts monthly
c. General Meeting of VEC will be held every quarter in which manager will place before it the records, accounts and status of the plant.
d. An annual audit of accounts assets and liabilities will be got carried out by a competent chartered Account appointed for the purpose by the Nodal Agency Appropriate action will be taken by the Nodal Agency after careful examination.

CHAPTER – 11

ENVIRONMENTAL IMPACT AND BENEFITS

11.1 ENVIRONMENTAL IMPACTS

i. The land required for the plant machinery is low and there will hardly be any adverse impact.
ii. The civil construction being of low order, thus causing almost no adverse impact.
iii. The plant being based on solar energy, it will be eco-friendly.

11.2 BENEFITS

i. There will be saving of 2 to 3 litres of Kerosene per HH per month i.e. of 5 kilolitre of Kerosine per annum.
ii. The villager use wood also for lighting as the quantity of kerosene received by them is not enough for lighting of about half an hour one an hour or so per day. There will be saving of this wood also.
iii. There will be awareness amongst the villagers about use and misuse of forest which will ultimately result in saving of forest from unintentional destruction (at present the village cause fire to clear the way in the forest for getting wood and do no care to ensure that the fire is not left as such to cause unintentional damage of forest.
iv. The living conditions of the villagers will improve.
v. The plant will help increase employment generation directly and indirectly.
vi. The children will be able to study better due to availability of light for good number of hours in the late evenings.

LIST OF PERSONNEL INVOLVEMENT

I. AHEC, IIT, ROORKEE

1. Sri Arun Kumar, Head, AHEC
2. Sri M. K. Singhal, SSO, AHEC
3. Sri Vijay Saini, SRF, AHEC

II. CONSULTANTS

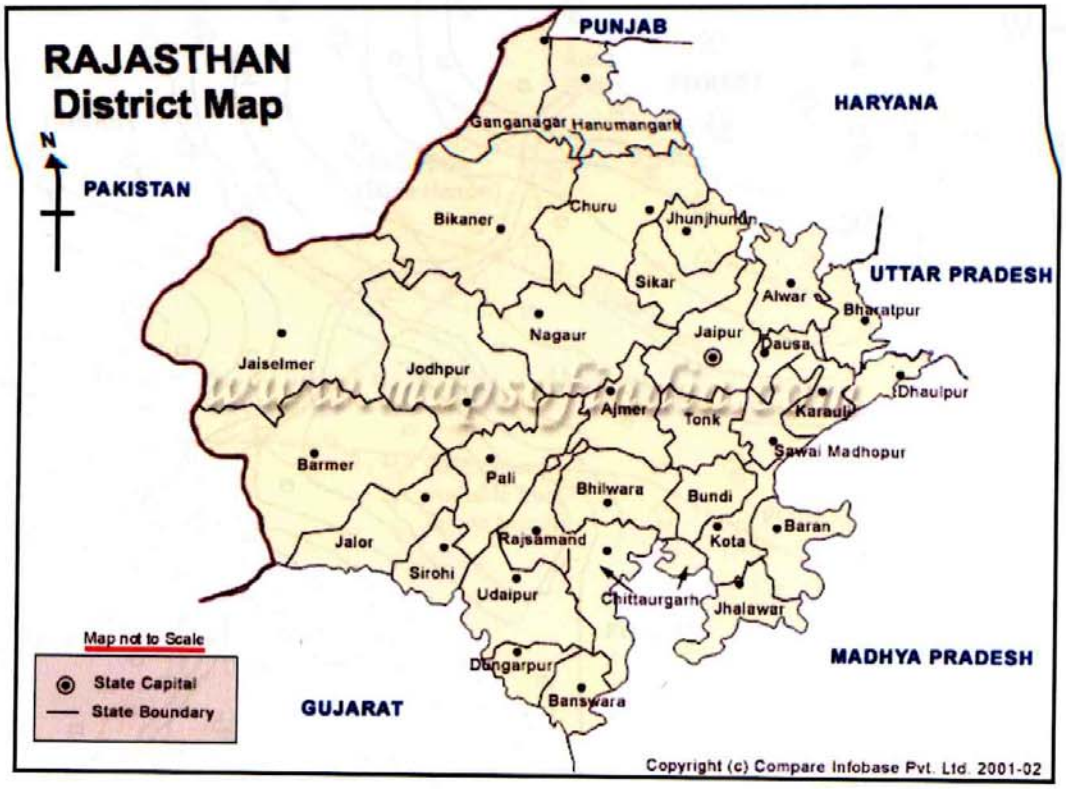
1. Sri Y. S. Jadaun, Former Chief Engineer (UPSEB)

III. ASSISTANTS

1. Sri R. K. Singhal, Technical Assistant
2. Sri Chandarpal Singh, Senior Attendant

IV. Maharastra Energy Development Agency

1. Sri V.V. Mahulkar, Manager (RE)
2. Sri Rahul Ramtek, Engineer



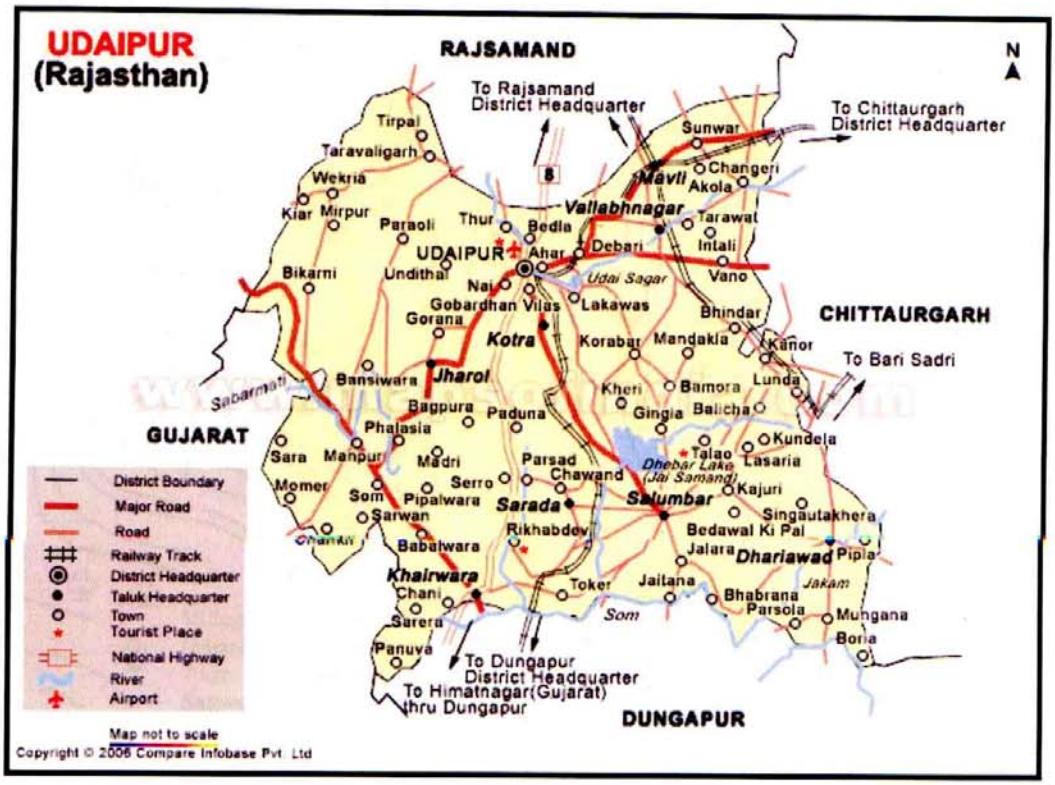
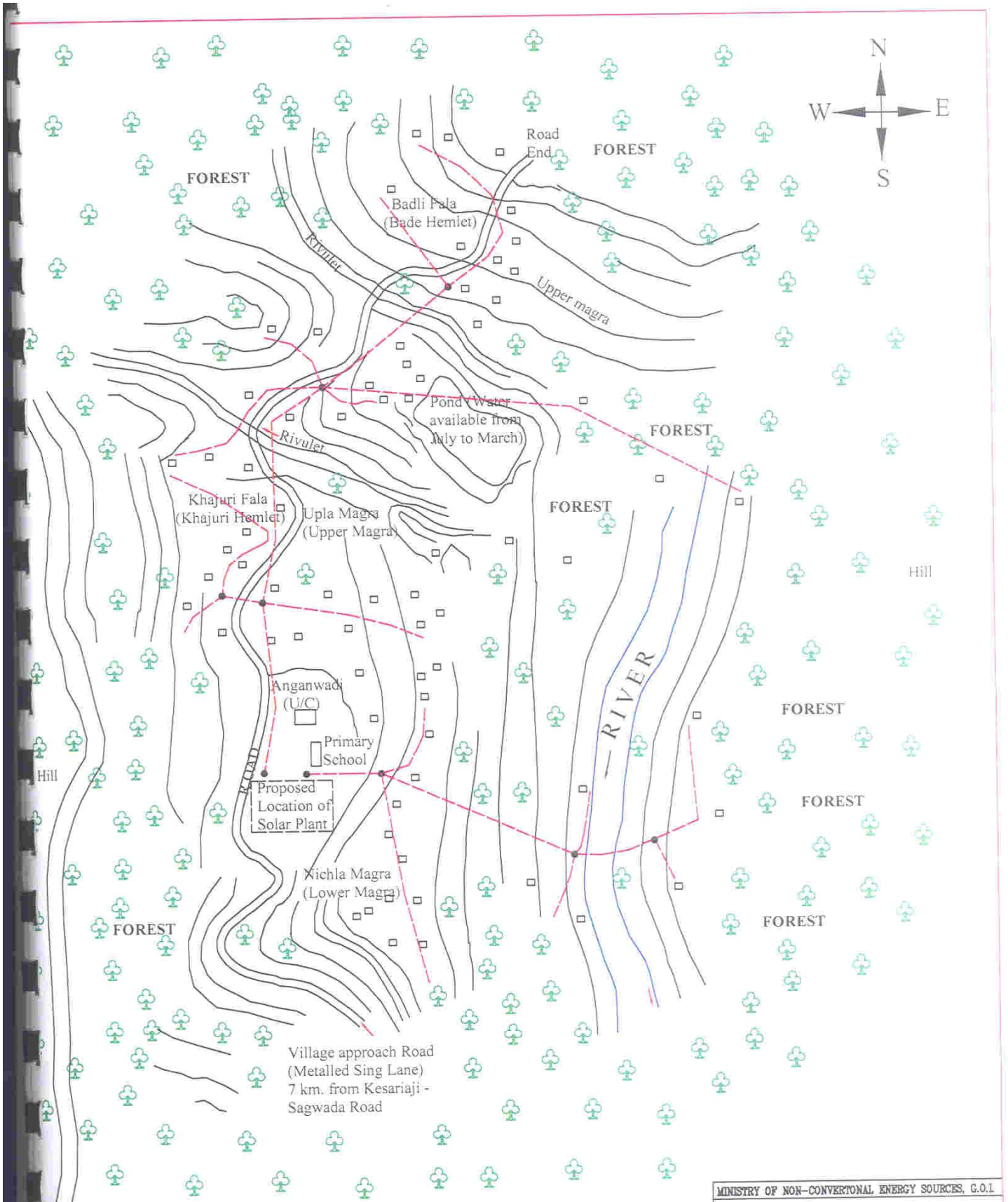


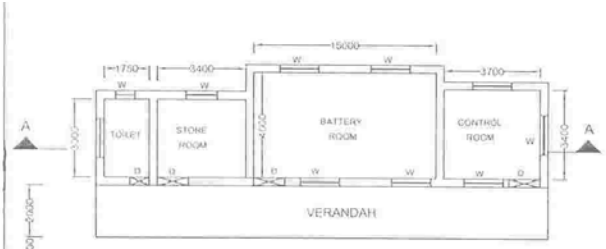
FIG 1.1 : DISTRICT MAP OF RAJASTHAN AND UDAIPUR

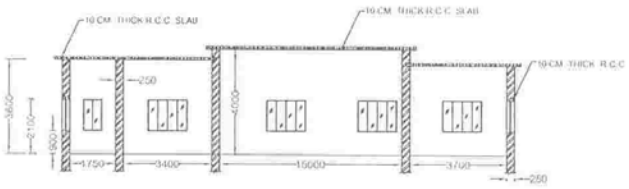


NOTE:-

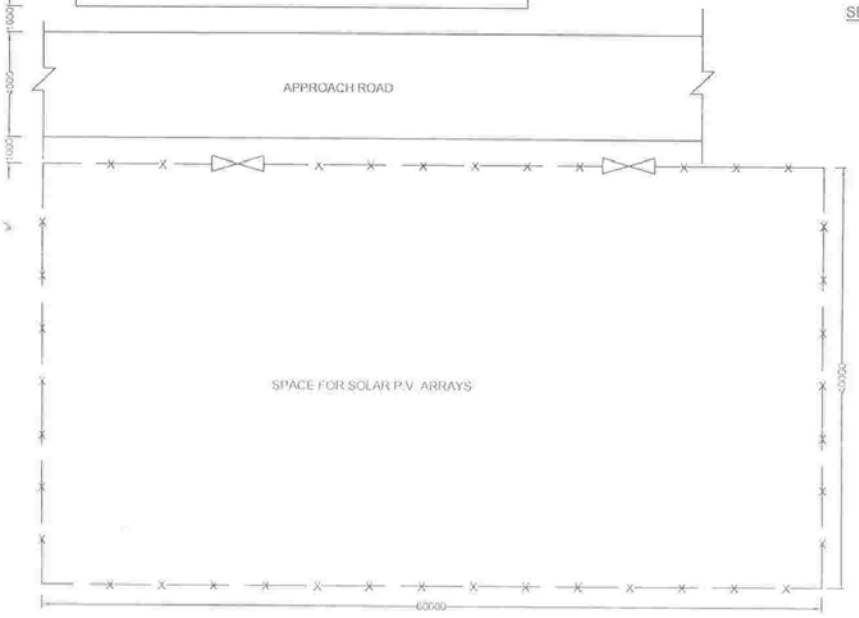
1. Tentative and not to scale.
2. L. T. Distribution line. ---------

MINISTRY OF NON-CONVERTONAL ENERGY SOURCES, G.O.I.	
Consultant : ALTERNATE HYDRO ENERGY CENTRE INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE	
SOLAR BASED POWER PLANT, MAGRA DISTT. UDAIPUR (RAJASTHAN)	
DRN.	SUS.
DSGN. (Y.S. Jodaun)	INSP.
CHKD.	APP.
DRG.NO. AHEC/C- 337-1	ROORKEE, AUG.2006 FILE NO.AHEC/C- 347

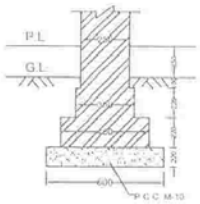




SECTION A-A



PLAN

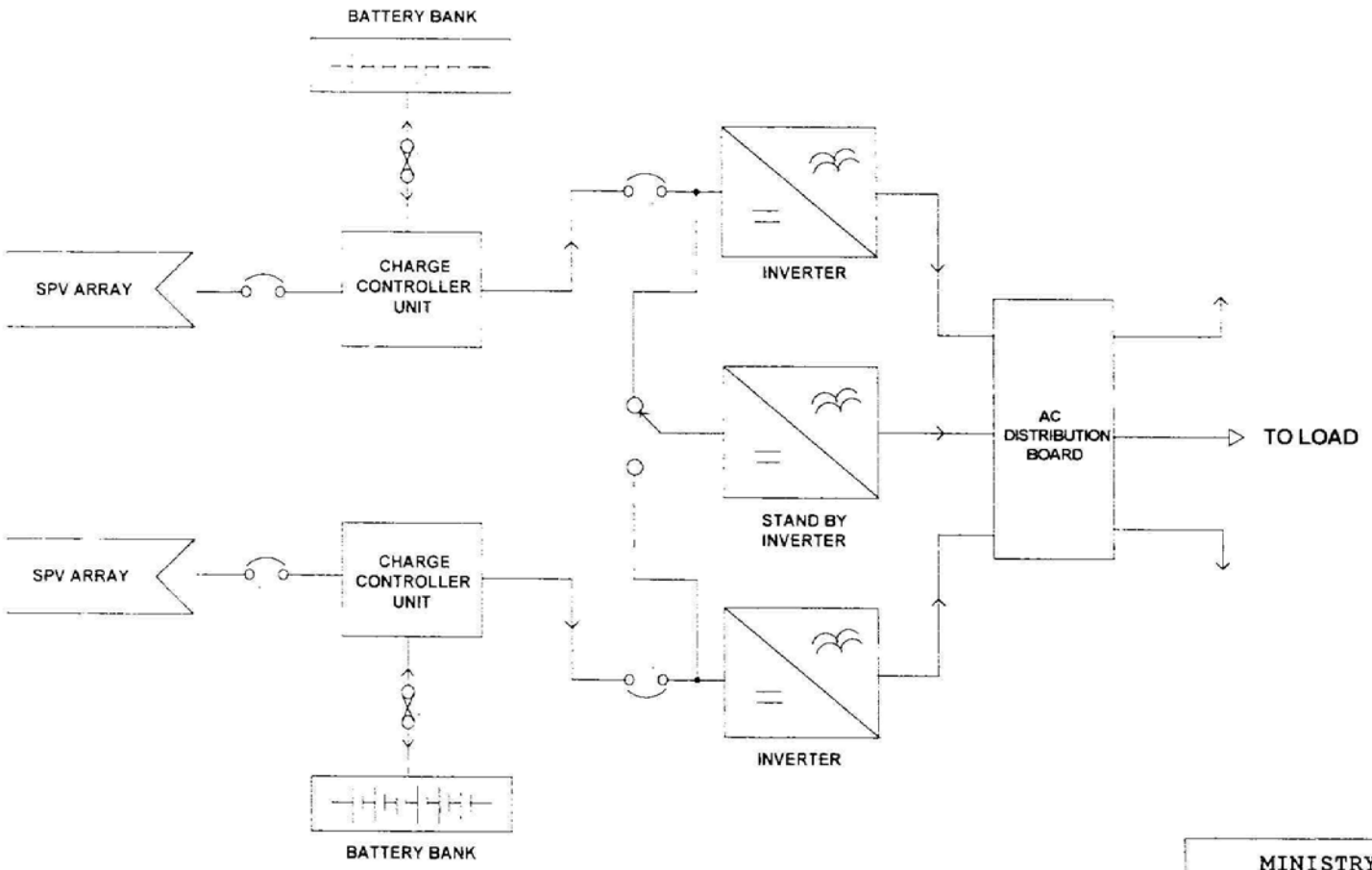


DETAILS OF FOUNDATION

NOTE :-

1. THE DRAWING IS TENTATIVE ONLY
2. NOT TO SCALE

MINISTRY OF NON-CONVENTIONAL ENERGY SOURCES, G.O.I.	
Consultant : ALTERNATE HYDRO ENERGY CENTRE, INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE	
SOLAR BASED POWER PLANT, MAGRA (RAJSTHAN)	
SOLAR PLANT BUILDING & OPEN YARD (50 kW)	
DRN.	S.B.
DSGN. (T.S. Bahori)	MSP.
CHKD.	APP.
DRG.NO. AHEC/D-327-2	ROORKEE, AUG. 2006 TLE NO.AHEC/T-347



MINISTRY OF NON-CONVENTIONAL ENERGY SOURCES G.O.I.

SPV POWER PLANT, MAGRA, (DISTT. UDAIPUR RAJASTHAN)

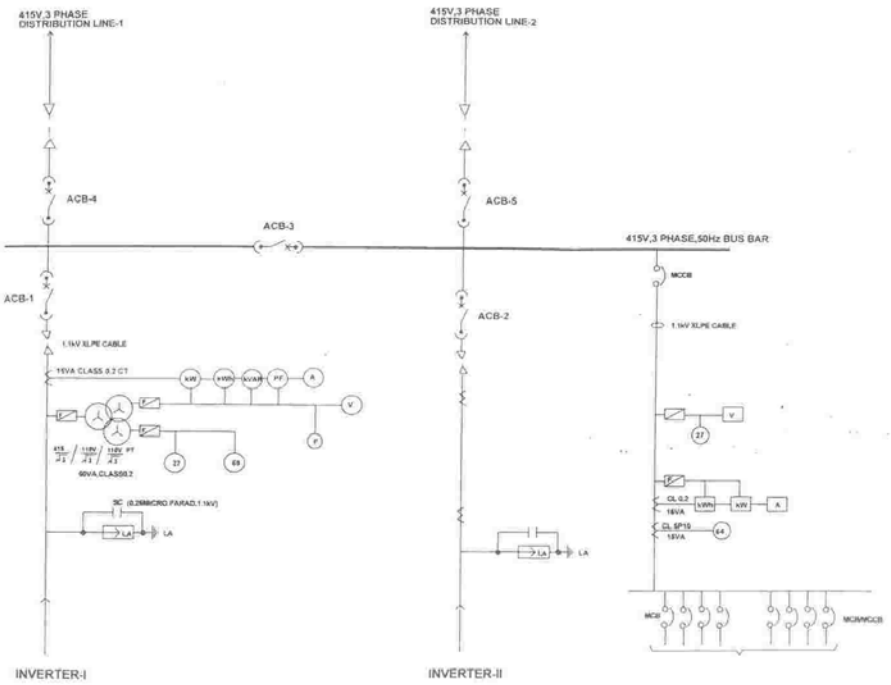
Consultant:

ALTERNATE HYDRO ENERGY CENTRE
Indian Institute Of Technology, Roorkee

SCHEMATIC DIAGRAM (2x25 kW)
SOLAR PHOTO VOLTIC POWER SYSTEM

DSGN.	Y.S.JADAUN	SUBT.	
CHKD.		INSP.	
DRAW	B.P.SINGH	APPD.	

E-337-1	Roorkee, Aug. 2006	File no. AHEC/C-347



PROTECTION

12	OVER SPEED ELECTRICAL /MECHANICAL
64	EARTH FAULT/EMT
59	OVER VOLTAGE
27	UNDER VOLTAGE

	LIGHTNING ARRESTOR
	LINE ISOLATOR/TPMO WITH EARTHING BLADE AND FUSE SET CURRENT TRANSFORMER
	POTENTIAL TRANSFORMER
	1.1kV AIR CIRCUIT BREAKER
	CABLE
	SURGE CAPACITOR
	FUSE

A	AMPERE METER
V	VOLT METER
kW	KILO WATT METER
kWh	KILO WATT HOUR METER
kVAR	KILO VOLT AMPERE REACTIVE
PF	POWER FACTOR METER
MCCB	MOULDED CASE CIRCUIT BREAKER
F	FREQUENCY METER

NOTE

1. THIS DRAWING IS TENTATIVE ONLY
2. THE ACB-3 SHALL REMAIN OPEN NORMALLY AND WILL BE CLOSED ONLY IF ACB-1 OR ACB-2 IS OPEN

MINISTRY OF NON-CONVENTIONAL ENERGY SOURCES G.O.I.

SOLAR PV BASED POWER PLANT, MAGRA, (RAJASTHAN)

Consultant: ALTERNATE HYDRO ENERGY CENTRE, Indian Institute Of Technology, Roorkee

Single Line Diagram

DSGN	Y. S. RAJAN	SHEET	
CHKD		DWG	
DRAWN	R. P. SINGH	APPD	

E-337-2 | Roorkee, Aug. 2008