

PHOTOVOLTAIC TECHNOLOGY PROJECT

ANNUAL REVIEW

BY

NASA Lewis Research Center

FOR

U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT
OFFICE OF ENERGY

December 18, 1981

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AGENDA

U.S. AID PHOTOVOLTAIC TECHNOLOGY PROJECT

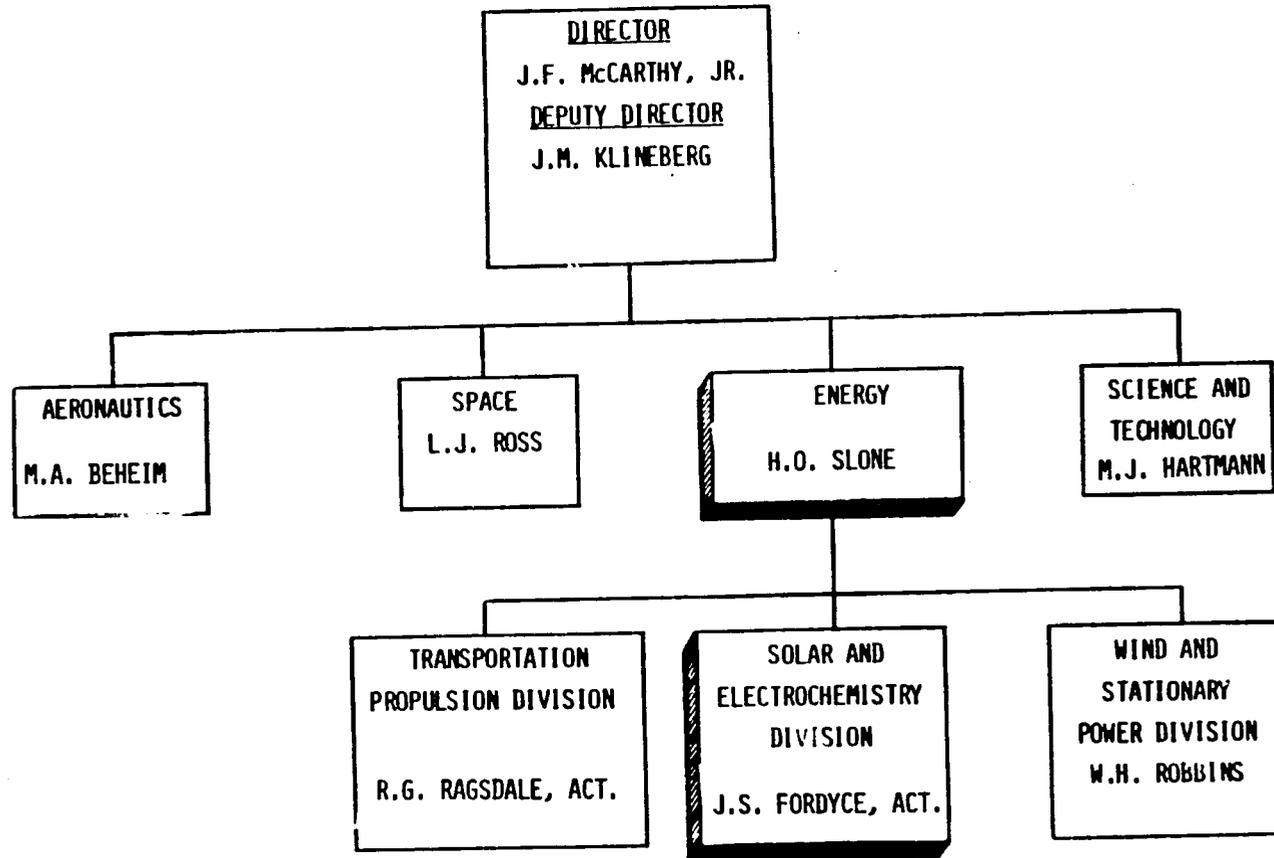
ANNUAL REVIEW

DECEMBER 18, 1981

NASA - LERC

EXECUTIVE SUMMARY	10:00 - 10:30 AM
WILLIAM J. BIFANO, MANAGER, SOLAR ENERGY PROJECTS OFFICE	
UPPER VOLTA SOLAR DEMONSTRATION - SLIDE SHOW	10:30 - 10:50
JAMES E. MARTZ, PROJECT ENGINEER	
REVIEW OF SUBPROJECTS	10:50 - 12:00

NASA LEWIS RESEARCH CENTER



NASA
LEWIS RESEARCH
CENTER

SOLAR & ELECTROCHEMISTRY DIVISION

J. S. FORDYCE, ACTING

PHOSPHORIC ACID FUEL CELL
LEAD CENTER OFFICE

M. WARSHAY, ACTING

SOLAR ENERGY PROJECTS
OFFICE

W. MASICA

SOLAR PROJECTS SECTION

W. BIFANO

SOLAR SYSTEMS SECTION

A. RATAJCZAK

SPACE PV BRANCH

H. BRANDHORST

PV RESEARCH SECTION

I. WEINBERG

PV TECHNOLOGY SECTION

A. FORESTIERI

ELECTROCHEMISTRY BRANCH

L. THALLER

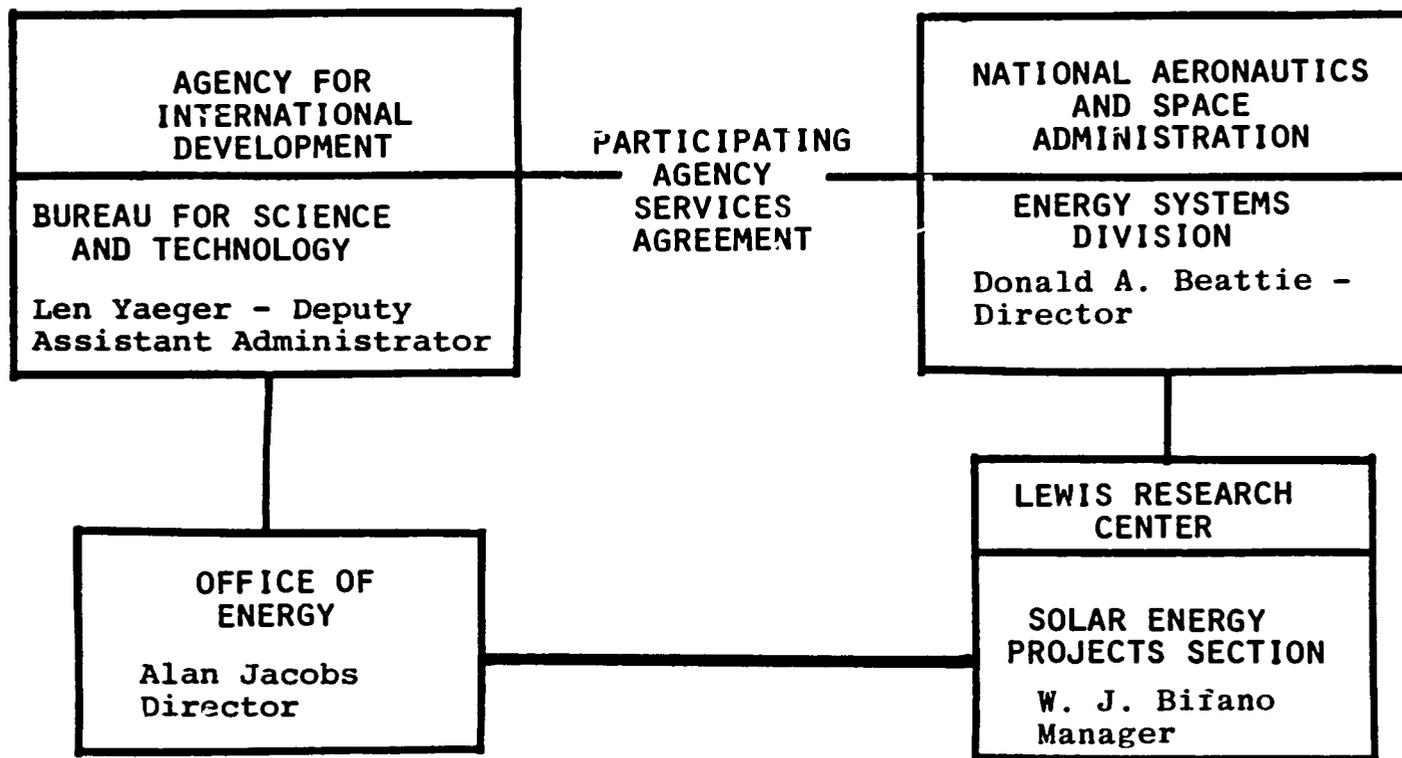
REDOX PROJECT OFFICE

ELECTROCHEMISTRY
TECHNOLOGY SECTION

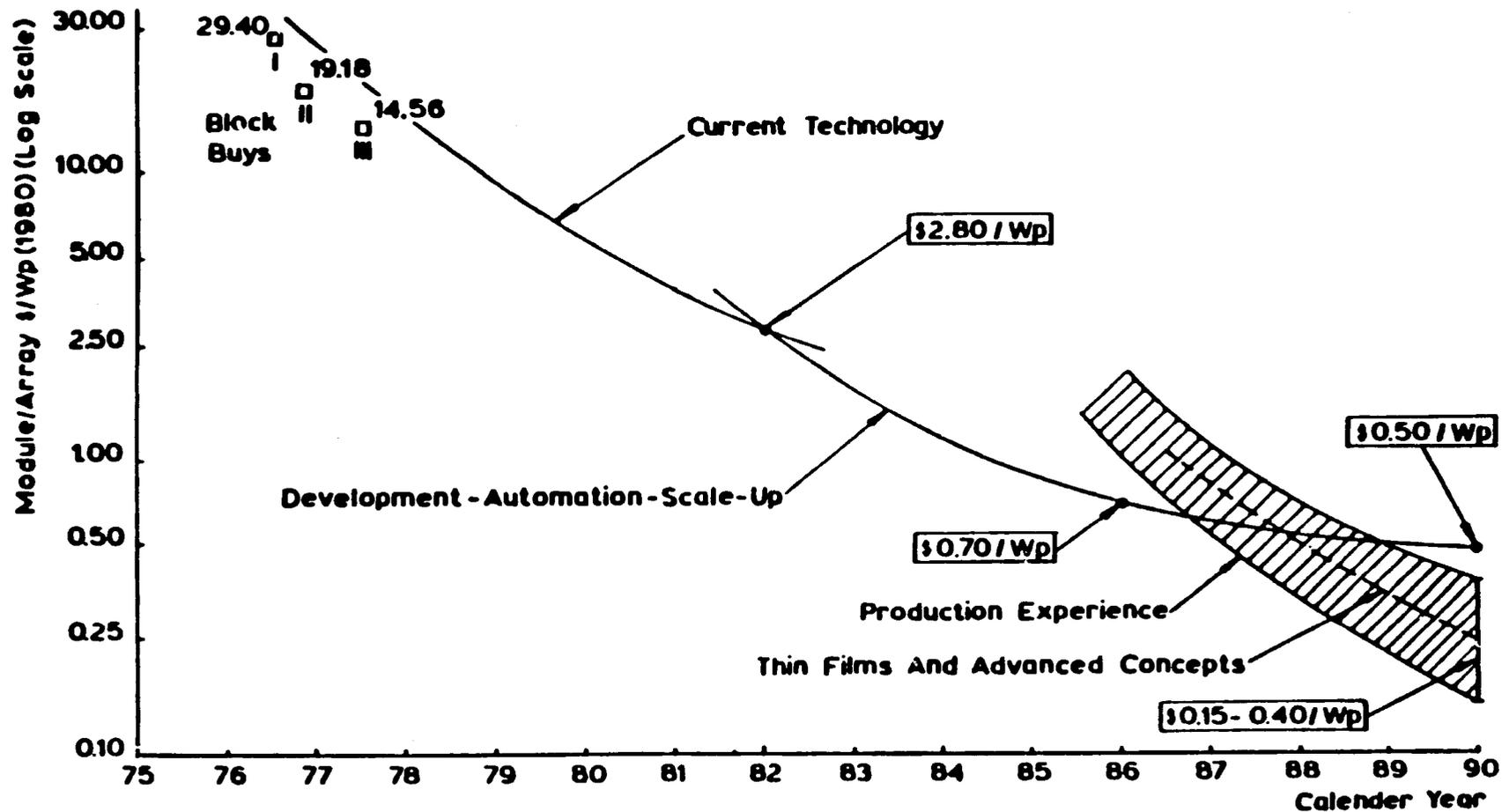
D. SOLTIS

PHOTOVOLTAIC TECHNOLOGY PROJECT

MANAGEMENT STRUCTURE



PHOTOVOLTAIC MODULE/ARRAY PRICE GOALS AND HISTORY (IN 1980 \$)

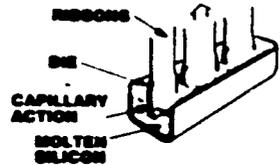


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SILICON SHEET-RIBBON

GROWN DIRECTLY IN DESIRED THICKNESS - BETTER SILICON UTILIZATION

RIBBONS PRODUCED WITH DIES EDGE-DEFINED FILM-FED GROWTH

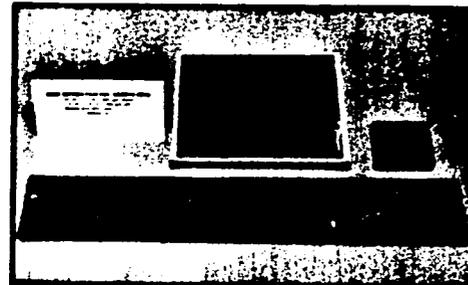


- PROVEN MULTIPLE RIBBON GROWTH
- EXTENSIVE CORPORATE INVESTMENT IN RIBBON PRODUCTION AND MODULE DEVELOPMENT
- MATERIAL QUALITY AND PRODUCTION REFINEMENT

MOBIL-TYCO SOLAR ENERGY CORP



4-cm RIBBONS
EMERGING FROM GROWERS



RIBBON, CELL, MODULE



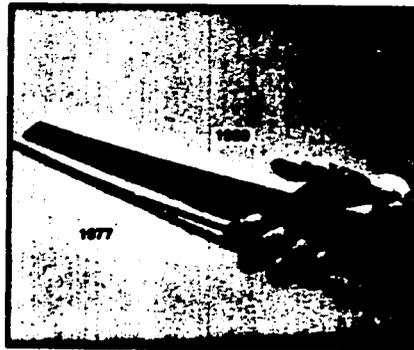
PILOT PRODUCTION—8cm RIBBONS

RIBBONS PRODUCED WITHOUT DIES WEB DENDRITIC GROWTH

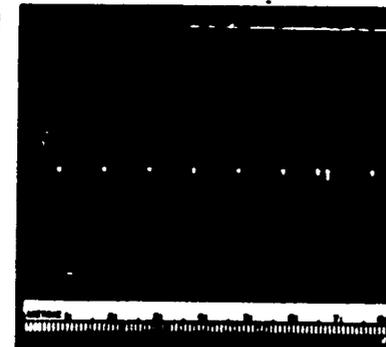


- HIGH QUALITY MATERIAL
- CORPORATE PROTOTYPE WEB, CELL, AND MODULE FACILITIES UNDER DEVELOPMENT
- AUTOMATED WEB GROWTH UNDER DEVELOPMENT

WESTINGHOUSE ELECTRIC CORP



WEB PROGRESS

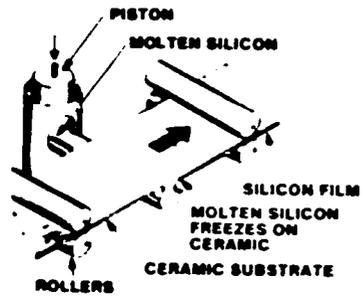


WEB AND CELL



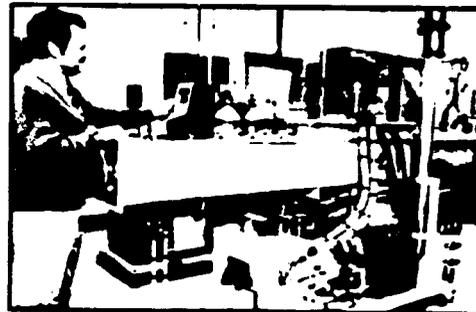
4cm WIDE WEB AND GROWER

FILM GROWN ON SUBSTRATE SILICON-ON-CERAMIC

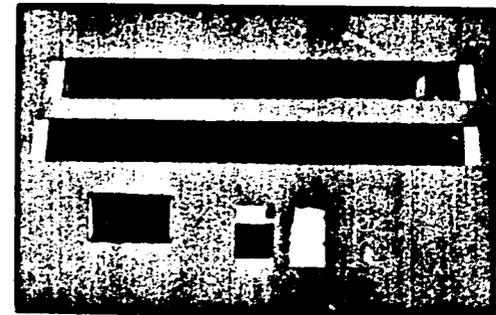


- LOW-COST CERAMIC SUBSTRATE DEMONSTRATED
- AREA GROWTH RATE EASILY INCREASED
- COMMERCIALIZATION UNDER CORPORATE REVIEW
- TECHNIQUE CONCEIVED AFTER LSA PROJECT STARTED

HONEYWELL CORP



SILICON ON CERAMIC EQUIPMENT



SILICON ON CERAMIC, CARBON COATED CERAMIC,
AND DIP COATED CELLS, FRONT AND BACK

U.S. DEPARTMENT OF ENERGY
COMMERCIAL PV SYSTEM PRICE GOALS (1980 \$)

SYSTEM APPLICATION		MODULE PRICE (\$/W _p)	SYSTEM PRICES (\$/W _p)	PRODUCTION SCALE (MW _F /YEAR)	USER ENERGY PRICE (\$/KWH)
REMOTE STAND-ALONE	1983	2.80	6-13	25	130
RESIDENTIAL	1986	0.70	1.60-2.20	100-1000	5-9
INTERMEDIATE LOAD CENTERS	1986	0.70	1.60-2.60	100-1000	6-9
CENTRAL STATIONS	1990	0.15-0.40	1.10-1.80	500-2000	4-8

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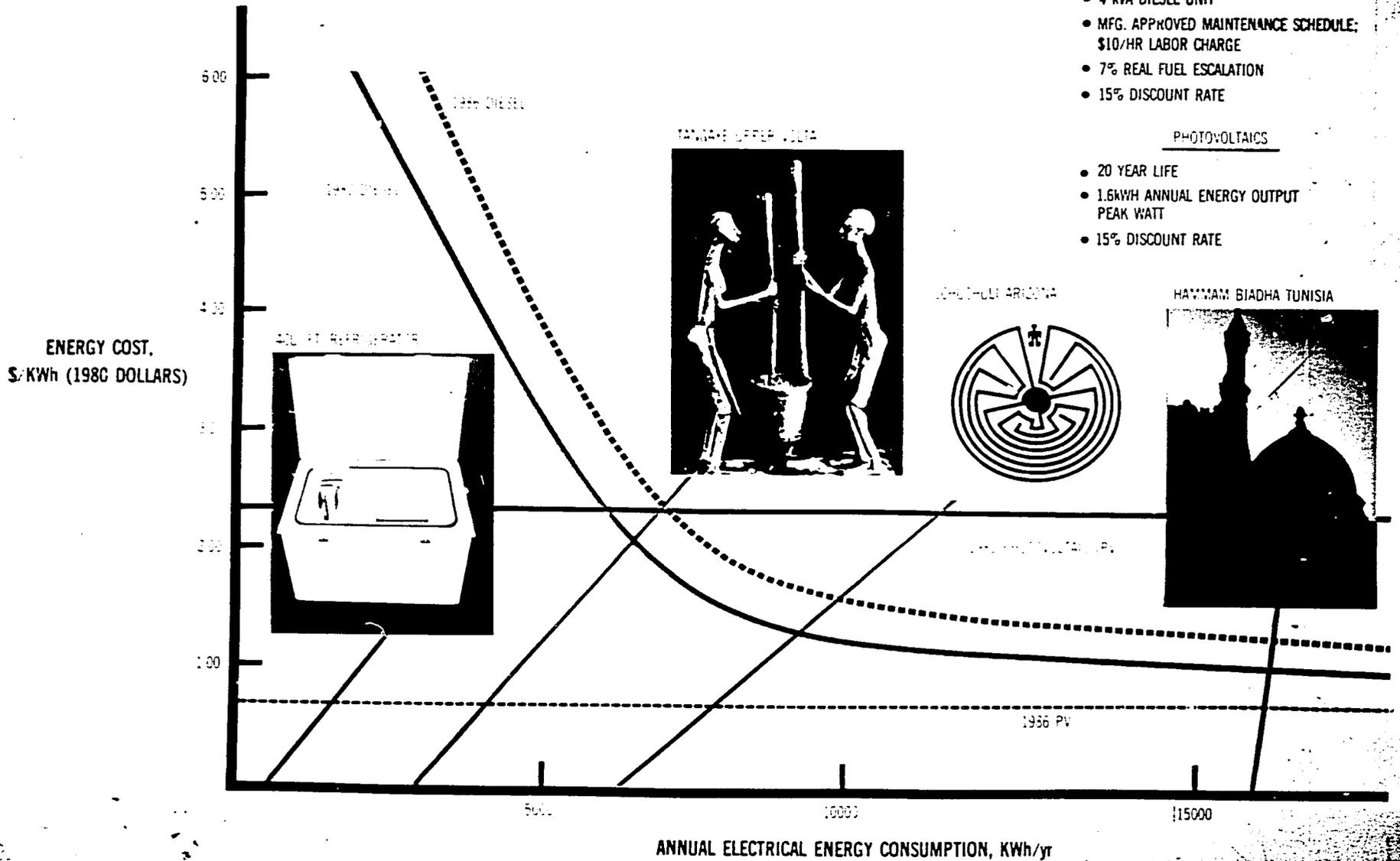
PHOTOVOLTAIC AND DIESEL ENERGY COST COMPARISONS

ASSUMPTIONS DIESEL

- 20 YEAR LIFE
- \$3/GALLON FIRST YEAR FUEL COST
- 4 KVA DIESEL UNIT
- MFG. APPROVED MAINTENANCE SCHEDULE;
\$10/HR LABOR CHARGE
- 7% REAL FUEL ESCALATION
- 15% DISCOUNT RATE

PHOTOVOLTAICS

- 20 YEAR LIFE
- 1.6KWH ANNUAL ENERGY OUTPUT
PEAK WATT
- 15% DISCOUNT RATE



TANJANAH OFFER 1966



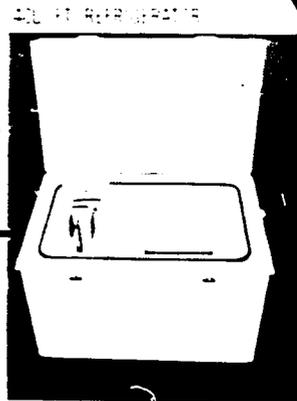
JACHBULI ARIZONA



HAMMAM BIADHA TUNISIA



ENERGY COST,
\$/KWh (1980 DOLLARS)



JEDDAH SAUDI ARABIA

5000

10000

15000

ANNUAL ELECTRICAL ENERGY CONSUMPTION, KWh/yr

PHOTOVOLTAIC TECHNOLOGY PROJECT

STATUS OF U.S. PHOTOVOLTAIC INDUSTRY

- o 19 U.S. PV COMPANIES HAD TOTAL SALES OF \$49M (PV WAS LEADING SOLAR TECHNOLOGY)
 - OVERSEAS SALES REPRESENTED OVER HALF OF TOTAL U.S. SALES; INCREASED 79% OVER 1979
- o U.S. GOVERNMENT SUPPORT DECREASING: \$160M IN '81; \$78M IN '82; \$27.5M IN '83
- o FOREIGN COMPETITION INCREASING
 - JAPAN, FRANCE, GERMANY PLUS 30 OTHER COUNTRIES FUNDING PV R&D
 - 70 TO 80 COMPANIES EXPECTED TO BE MAKING CELLS/MODULES WORLDWIDE BY END OF 1982
- o ROLE OF U.S. GOVERNMENT AS PERCEIVED BY SOLAR INDUSTRY (DEC. 1981): RISK REDUCTION THROUGH SUPPORT OF
 - ADVANCED R&D
 - FIELD EXPERIMENTS
- o ASSESSMENT OF INDUSTRY ACCORDING TO RECENT BATTELLE STUDY:
 - IMPROVED SELECTION OF HIGHER QUALITY MODULES
 - INCREASED PRODUCTION CAPABILITY
 - EXPANDED SELECTION OF SYSTEMS AND PRODUCTS
 - STRONGER PRODUCT DISTRIBUTION AND DEALER NETWORKS

OVERVIEW

TITLE: U.S. AID PHOTOVOLTAIC TECHNOLOGY PROJECT

NASA CENTER: LEWIS RESEARCH CENTER

OBJECTIVE: TO DEMONSTRATE THE SUITABILITY OF PHOTOVOLTAIC SYSTEMS FOR SELECTED APPLICATIONS IN RURAL AREAS OF DEVELOPING COUNTRIES

APPROACH:

- o DEFINE REQUIREMENTS FOR SPECIFIC APPLICATION(S) IN RESPONSE TO REQUESTS FROM U.S. AID MISSIONS
- o DESIGN, DEVELOP AND DEPLOY RELIABLE PV POWER SYSTEMS THROUGH CONTRACTS
- o PROVIDE TRAINING AND INFORMATION SERVICES IN SUPPORT OF PV DEMONSTRATIONS UNDER CONTRACT

FUNDING: IN-HOUSE 20% CONTRACT 80%

MAJOR

DELIVERABLES

- o UP TO 20-PV POWERED VACCINE REFRIGERATORS. INSTALLATION TO BEGIN IN SECOND QUARTER OF CY 1982
- o FIVE PV-POWERED MEDICAL SERVICES APPLICATIONS IN ECUADOR, GUYANA, KENYA (2) AND ZIMBABWE. INSTALL IN FOURTH QUARTER OF CY 1982
- o TECHNICAL PLAN (RENEWABLES PORTION) FOR AID/INDONESIA ENERGY PROJECT, NOVEMBER 1981
- o PV POWER SYSTEMS FOR REMOTE EARTH STATIONS IN SUPPORT OF AID RURAL SATELLITE PROJECT.

PHOTOVOLTAIC TECHNOLOGY PROJECT

MAJOR SUBPROJECTS

- PROJECT MANAGEMENT: CONTROL, DIRECTION AND INTEGRATION OF ALL ACTIVITIES NEEDED TO ASSURE ACCOMPLISHMENT OF STATED OBJECTIVES IN ACCORDANCE WITH ESTIMATED FISCAL, MANPOWER AND SCHEDULAR ESTIMATES PROVIDED IN OPERATING PLAN
- PLANNING AND STUDIES: ACTIVITIES WHICH PROVIDE THE INFORMATION BASE NECESSARY TO SELECT AND IMPLEMENT PV APPLICATIONS IN DEVELOPING COUNTRIES
- APPLICATION SUPPORT: WORK WHICH DIRECTLY SUPPORTS IMPLEMENTATION OF MEDICAL APPLICATIONS
- APPLICATIONS: DESIGN, FABRICATION, TESTING, SHIPPING AND INSTALLATION OF PV POWER SYSTEMS AT VARIOUS RURAL SITES IN DEVELOPING COUNTRIES (UNDER CONTRACT TO INDUSTRY)
- TRAINING & INFORMATION: TRAINING OF HOST COUNTRY PERSONNEL IN OPERATION, MAINTENANCE AND REPAIR AND MONITORING OF PV SYSTEMS AND DISSEMINATION OF INFORMATION

OTHER AID ACTIVITIES MANAGED BY NASA-LE RC

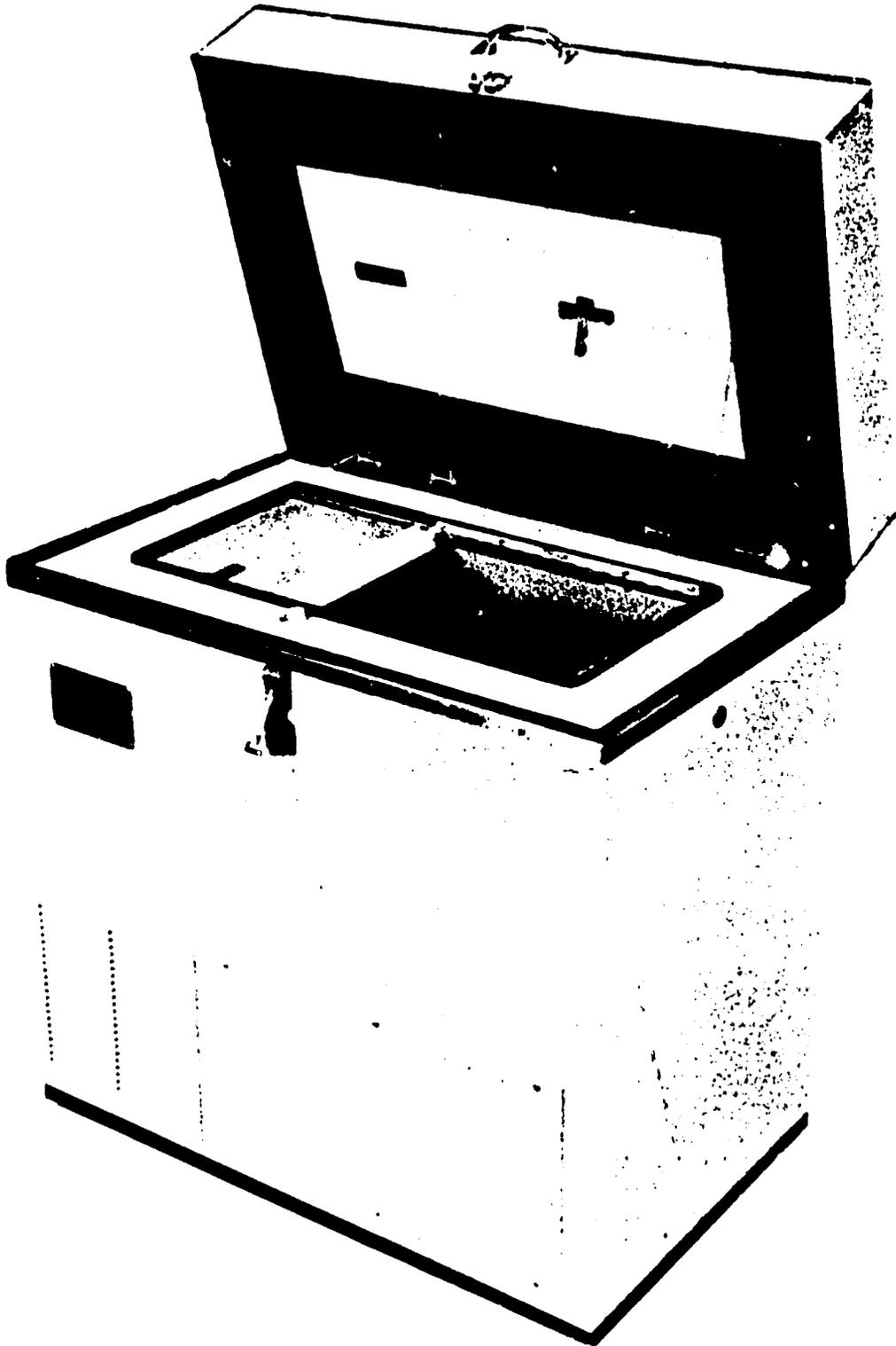
- o EGYPT RENEWABLE ENERGY PROJECT - TECHNICAL ASSISTANCE
- o TUNISIA RENEWABLE ENERGY PROJECT
- o UPPER VOLTA SOLAR DEMONSTRATION PROJECT

PHOTOVOLTAIC TECHNOLOGY PROJECT

MAJOR APPLICATION SECTORS

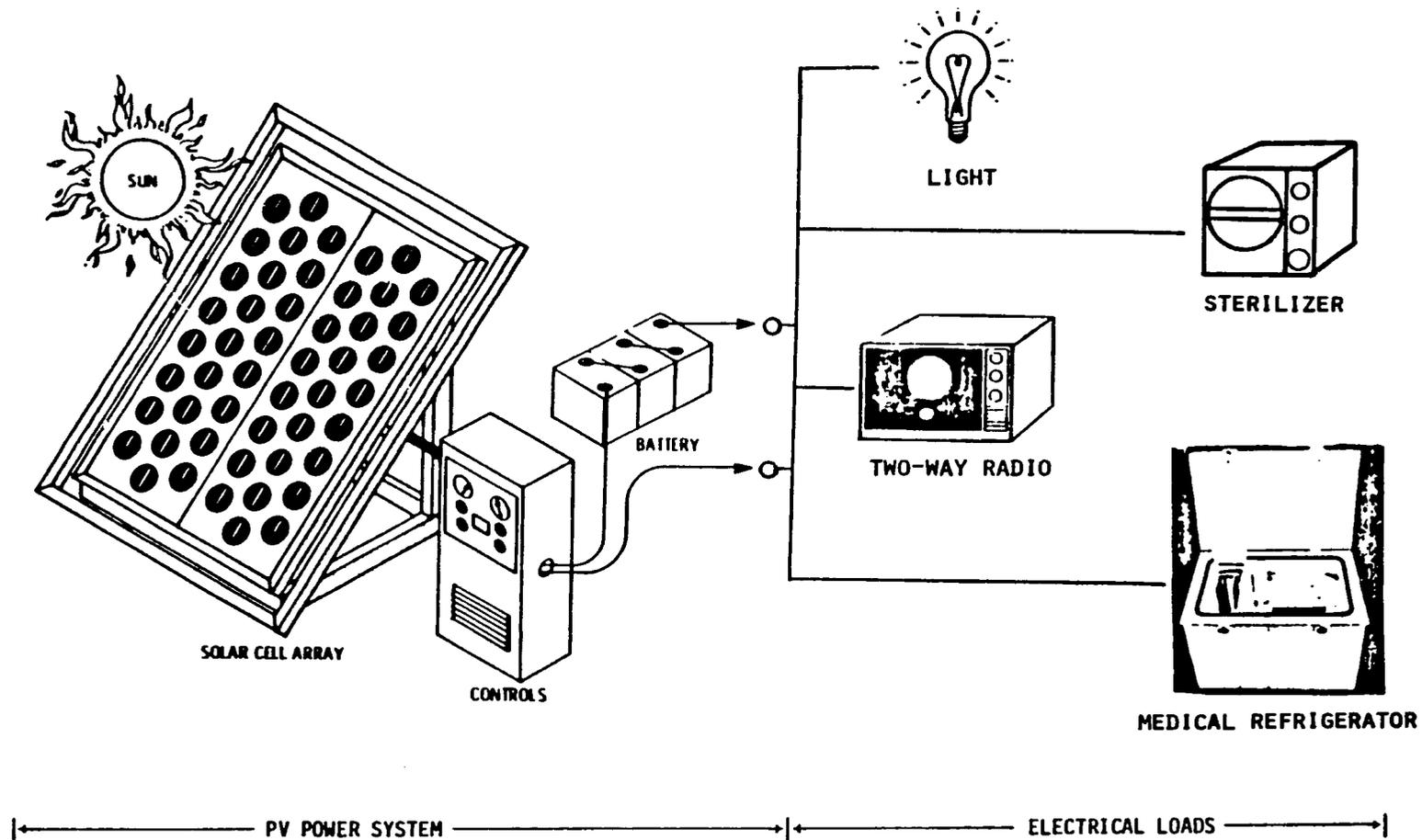
- o HEALTH: RURAL MEDICAL POSTS/CLINICS
- o HEALTH: REFRIGERATORS FOR IMMUNIZATION PROGRAMS
- o COMMUNICATIONS AND EDUCATION : REMOTE EARTH STATIONS
- o VILLAGE: DOMESTIC, COMMUNAL, AND COMMERCIAL AGRICULTURE
(UPPER VOLTA, TUNISIA AND EGYPT)

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DCM-12SF SOLAR PHOTOVOLTAIC
POWERED FOOD/MEDICAL REFRIG-
ERATOR/FREEZER UNIT.

SCHEMATIC DRAWING OF A MEDICAL PHOTOVOLTAIC SYSTEM



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SCHEDULE/RESOURCES

TITLE: U.S. AID DEVELOPMENT AND SUPPORT PROJECT

ACTIVITY	FY 81	FY 82	FY 83	FY 84	FY 85
COMMITMENTS					
		VACCINE REFRIGERATORS 	PV MEDICAL SERV. APPL. 		
PROJECT MANAGEMENT 1. ANNUAL REVIEW, AID/W		▽	▽	▽	▽
SYSTEM DEFINITION STUDY 1. EDUCATION/COMMUNICATION APPLICATION COMPLETE		▽			
APPLICATIONS 1. VACCINE REFRIGERATORS - FIRST UNITS OPERATIONAL 2. PV MED. SERV. APPLS. OPERATIONAL 3. PV POWERED EARTH STATION OPERATIONAL		▽	▽ 2 ▽ 3		
TRAINING & INFORMATION 1. GRANT AWARDED FOR MEDICAL SERVICES APPLICATION 2. U.N. CONFERENCE - NAIROBI		▽ 1 ▽ 2			
UPPER VOLTA PV PROJECT 1. REFURBISH & EXPAND 2. COMPLETE		▽ 1	▽ 2		
RESOURCES					
REIMBURSABLE (\$ MILLIONS)	2.5	0.43	0.45	TBD	TBD
IN-HOUSE MANYEARS	6.0	7.0	7.0	7.0	TBD

▽ MILESTONE
 DELIVERABLE

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U.S. AID PHOTOVOLTAIC TECHNOLOGY PROJECT

STATUS

- o A COST-SHARED REIMBURSABLE CONTRACT FOR \$771K HAS BEEN AWARDED TO THE SOLAREX CORP. FOR THE DESIGN, FABRICATION AND DEPLOYMENT OF THE FIVE PV MEDICAL SYSTEMS (APPROX. 10% COST SHARING)
- o A \$115K GRANT HAS BEEN AWARDED TO THE UNIVERSITY OF MICHIGAN FOR TRAINING AND INFORMATION SUPPORT
- o FINAL SITE VISITS HAVE BEEN MADE TO ALL FOUR COUNTRIES BY THE PROJECT TEAM LED BY STAN MARIK OF LERC
- o FIFTEEN CANDIDATE COUNTRIES HAVE BEEN IDENTIFIED FOR DEPLOYMENT OF PV-POWERED MEDICAL REFRIGERATORS; ELEVEN SPECIFIC SITES HAVE BEEN SELECTED
- o AWARD OF THE CONTRACT FOR FABRICATION AND DEPLOYMENT OF THE FIRST TEN PV-POWERED REFRIGERATORS IS SCHEDULED FOR LATE DECEMBER (APPROX. \$14K PER SITE)
- o THE PV MEDICAL EQUIPMENT CATALOG HAS BEEN COMPLETED AND IS SCHEDULED FOR DISTRIBUTION IN FEBRUARY 1982
- o DEFINITION STUDY COVERING EDUCATION/COMMUNICATION APPLICATIONS HAS BEEN CONDUCTED BY DHR, INC.
- o CONCEPTUAL DESIGN STUDY FOR PV-POWERED REMOTE EARTH STATIONS INITIATED
- o REPORT ISSUED ON OPERATIONAL PERFORMANCE OF TANGAYE PV SYSTEM, OCT. 1981; DESIGN REPORT IN REVIEW

U.S. AID PHOTOVOLTAIC TECHNOLOGY PROJECT

FY 1982 PLANS

- o DEPLOY 20 PV MEDICAL REFRIGERATORS BEGINNING IN 3RD QUARTER OF FY 82
- o COMPLETE FINAL DESIGN REVIEW FOR PV MEDICAL SYSTEMS BY MARCH 1982
- o COMPLETE CONCEPTUAL DESIGN STUDIES IN SUPPORT OF AID RURAL SATELLITE PROJECT
- o INITIATE PLANNING AND STUDY ACTIVITIES IN SUPPORT OF GUINEA BISSAU FORESTRY APPLICATION
- o PROVIDE TECHNICAL ASSISTANCE TO U.S. AID/INDONESIA RELATIVE TO PV AND SOLAR THERMAL COMPONENTS OF ENERGY PROJECT

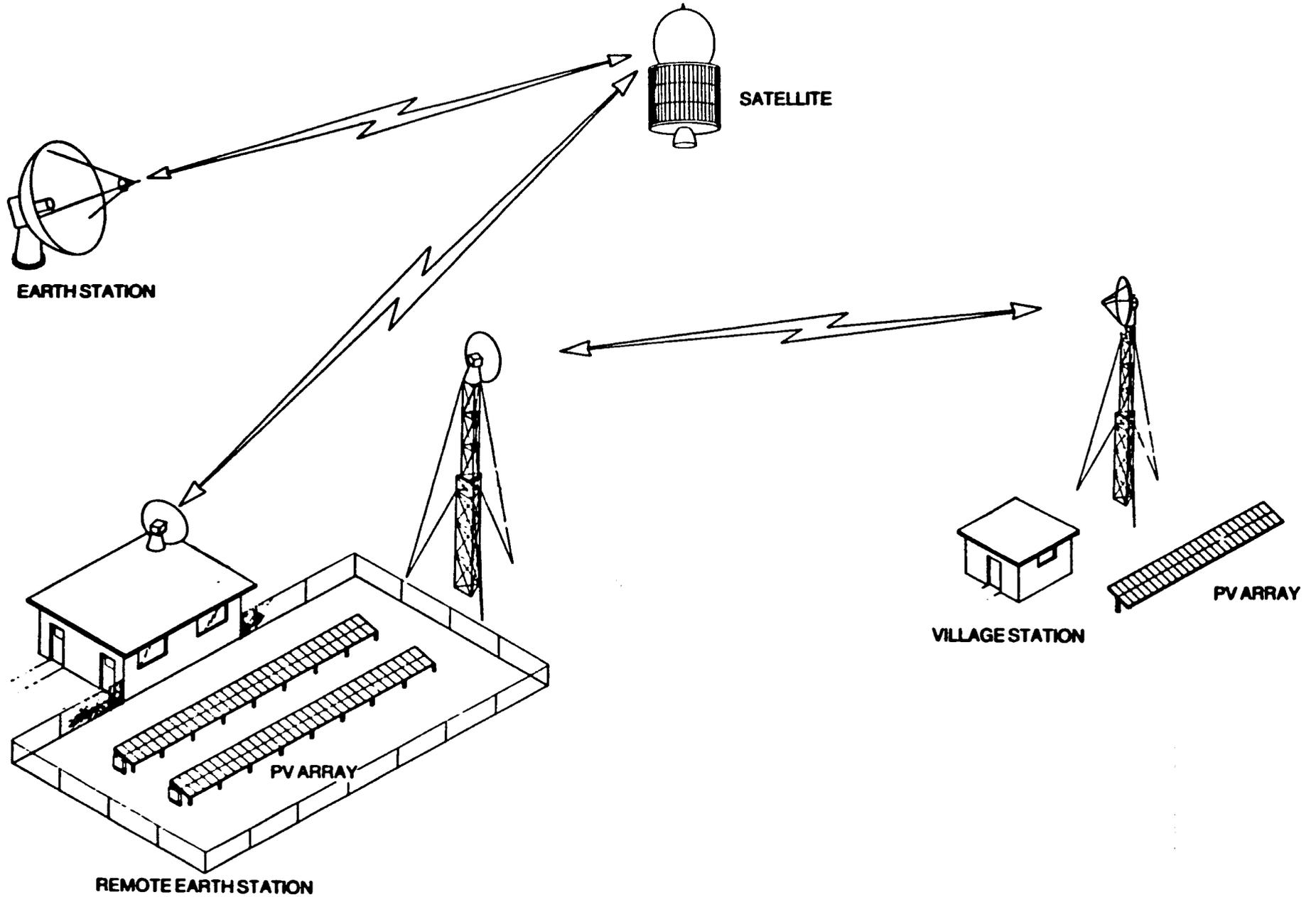
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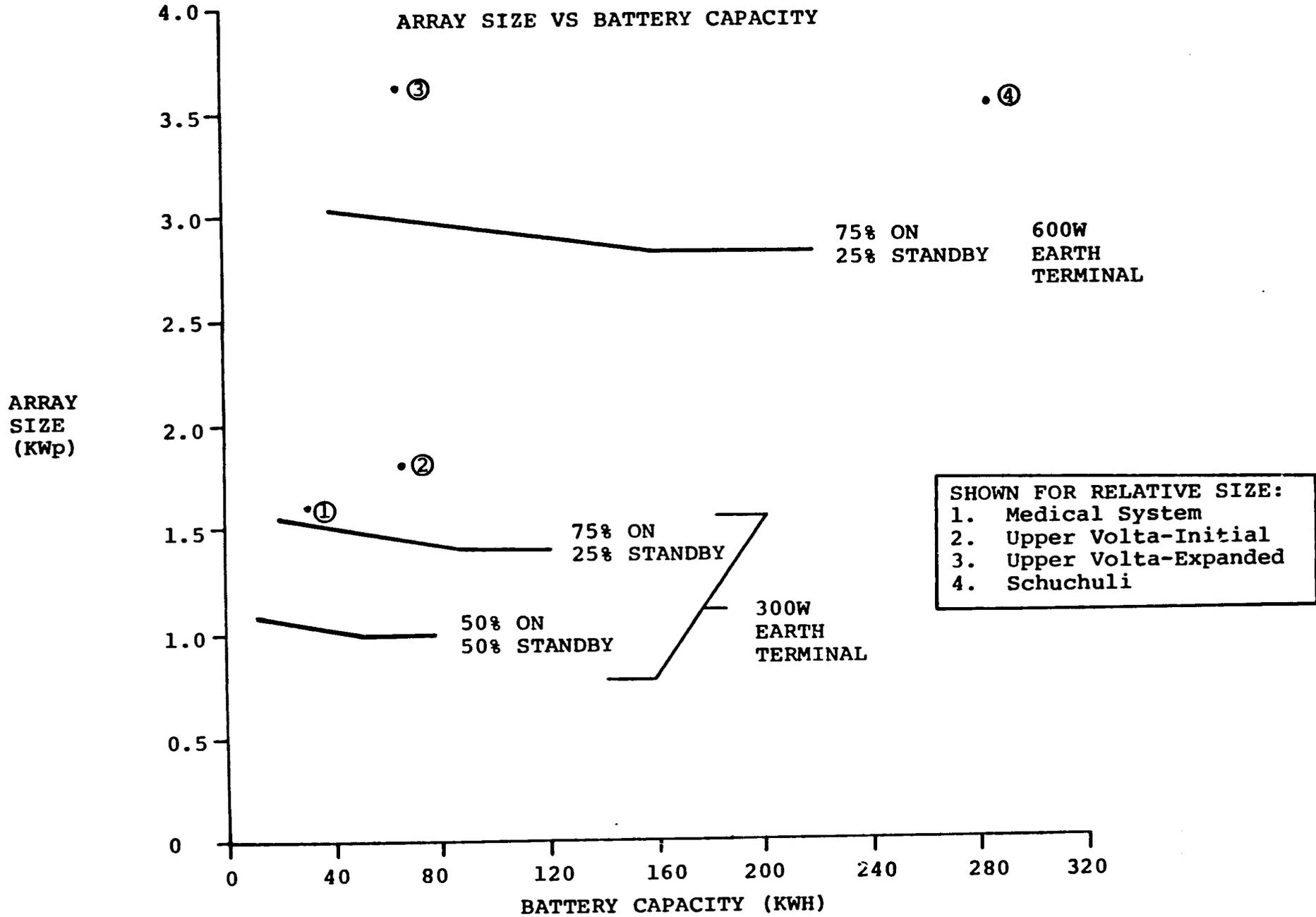
FIELD-TEST SITES FOR PV-POWERED MEDICAL REFRIGERATORS

<u>REGIONAL BUREAU</u>	<u>COUNTRY</u>	<u>SITE</u>
AFRICA	ZAIRE	KIONZO
	ZIMBABWE	CHIOTA
	LIBERIA	SUEHN
	UPPER VOLTA	TBD
ASIA	PHILIPPINES	TBD (2)
	INDONESIA	1) TAMBUN KECAMATAN 2) CIANJUR KECAMATAN
NEAR EAST	TUNISIA	ES-SMIRAT
	MOROCCO	MARRAKECH PROVINCE
	EGYPT	TBD (2)
LATIN AM. CARIBBEAN	GUYANA	SCHEPMOED
	ECUADOR	TBD
	DOMINICAN REPUBLIC	LAS TABLAS
	HONDURAS	TBD
	HAITI	ANSE-A-VEAU
	GUATEMALA	TIERRA BLANCA

APPLICATION OF PHOTOVOLTAIC POWER TO AID RURAL SATELLITE PROGRAM



PHOTOVOLTAIC POWER SYSTEM FOR SATELLITE EARTH STATION NEAR JAKARTA, INDONESIA



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RECENT UN PRONOUNCEMENT ON PHOTOVOLTAICS

"PHOTOVOLTAIC TECHNOLOGY IS PROVEN AND COSTS FOR APPLICATIONS IN ISOLATED AREAS ARE COMPETITIVE WITH TRADITIONAL SOURCES. CONTINUING TECHNOLOGICAL ADVANCES AND FAVOURABLE SOCIO-CULTURAL AND ENVIRONMENTAL IMPACTS MAKE PHOTOVOLTAIC GENERATORS INCREASINGLY ATTRACTIVE"

REPORT OF THE TECHNICAL PANEL OF EXPERTS,
UN CONFERENCE ON NEW AND RENEWABLE
SOURCE OF ENERGY

U.S. AID PHOTOVOLTAIC TECHNOLOGY PROGRAM

CONCLUSIONS

- o CURRENT COMMITMENTS WILL BE MET
- o NEW INITIATIVES WILL BE DEVELOPED

OVERVIEW

TITLE: U.S. AID TUNISIA RENEWABLE ENERGY PROJECT/DISTRICT ENERGY APPLICATIONS SUBPROJECT

NASA CENTER: LEWIS RESEARCH CENTER

OBJECTIVE: TO DEMONSTRATE THE ABILITY OF SOLAR AND WIND TECHNOLOGY TO PERFORM WORK AND SUPPLY THE MINIMUM SERVICES NECESSARY IN A VILLAGE AND IN RURAL AGRICULTURAL SETTINGS

APPROACH:

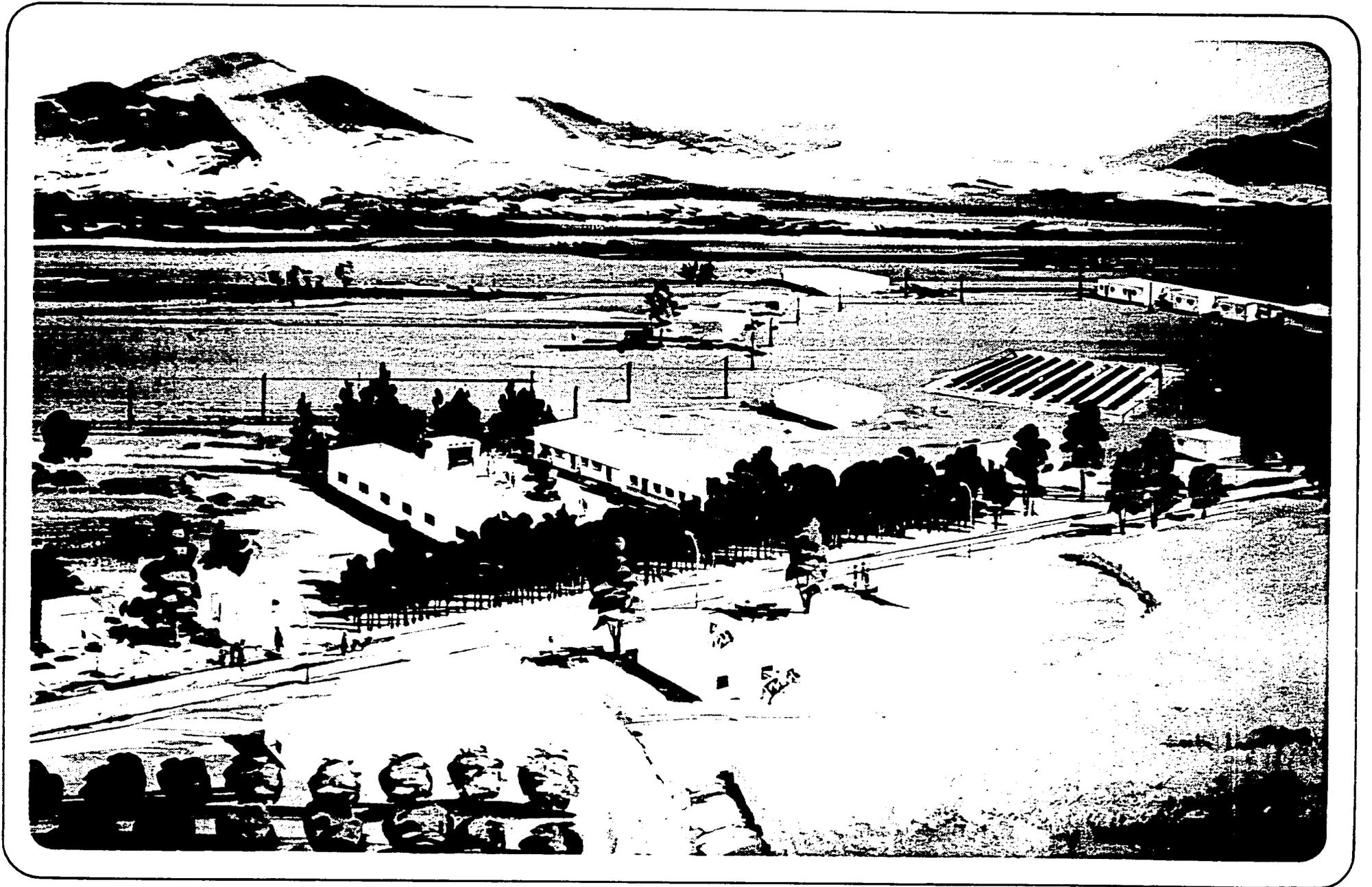
- o DEFINE SYSTEM REQUIREMENTS FOR SELECTED VILLAGE (HAMMAM BIADHA) AGRICULTURAL APPLICATIONS USING WIND, PHOTOVOLTAIC, AND SOLAR HEATING TECHNOLOGIES.
- o PREPARE CONCEPTUAL DESIGN OF SYSTEM FOR AID AND GOT APPROVAL.
- o PROCURE APPROVED SYSTEMS FROM U.S. AND TUNISIAN CONTRACTORS (DESIGN, FABRICATION, TESTING, SHIPPING AND INSTALLATION).

FUNDING: IN-HOUSE 8% CONTRACT 92%

MAJOR

DELIVERABLES:

- o OPERATION OF RENEWABLE ENERGY SYSTEMS (VIZ, PV, WIND, SOLAR HEATING) FOR VILLAGE AND AGRICULTURAL APPLICATIONS IN HAMMAM BIADHA BY NOVEMBER 1982
- o ISSUE EVALUATION REPORT BY JUNE 1983



SCHEDULE/RESOURCES

TITLE: U.S. AID TUNISIA RENEWABLE ENERGY PROJECT

ACTIVITY	FY 81	FY 82	FY 83	FY 84	FY 85
<p>COMMITMENTS</p> <p>PROJECT MANAGEMENT</p> <p>1. COORDINATION MEETING 2. PROJECT EVALUATION</p> <p>TESTS AND DEMONSTRATIONS</p> <p>1. CONTRACT AWARD 2. WIND AND SOLAR THERMAL SYSTEMS OPERATIONAL 3. PV SYSTEMS OPERATIONAL</p>					
<p><u>RESOURCES</u></p> <p>REIMBURSABLE (\$ MILLIONS)</p> <p>IN-HOUSE MANYEARS</p>	<p>0.59</p> <p>0.7</p>	<p>0</p> <p>0.6</p>	<p>0</p> <p>0.5</p>	<p>0</p> <p>0</p>	<p>0</p> <p>0</p>

▽ MILESTONE
◡ DELIVERABLE

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U.S. AID TUNISIA RENEWABLE ENERGY PROJECT

STATUS

- o \$776K CONTRACT AWARDED TO SOLAR POWER CORPORATION IN NOVEMBER 1981 (APPROX. 20% COST SHARING)
- o PROJECT INTEGRATION MEETING CONDUCTED IN TUNIS IN SEPT. 1981
- o FINAL DESIGN REVIEW SCHEDULED FOR MARCH 1982 IN TUNISIA
- o OPERATIONAL DATE SCHEDULED FOR NOVEMBER 1982

U.S. AID TUNISIA RENEWABLE ENERGY PROJECT

PLANNED ACCOMPLISHMENTS FY 82

- o CONDUCT FINAL DESIGN REVIEW MEETING IN MARCH 1982 IN TUNISIA
- o BEGIN SITE PREPARATION AND LOCAL CONSTRUCTION FOR SOLAR SYSTEMS (STEG) IN JANUARY 1982
- o BEGIN SITE PREPARATION AND LOCAL CONSTRUCTION FOR PV SYSTEMS IN MARCH 1982

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U.S. AID TUNISIA RENEWABLE ENERGY PROJECT

CONCLUSIONS

- o CURRENT COMMITMENTS WILL BE MET

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OVERVIEW

EGYPT RENEWABLE ENERGY FIELD TESTING PROJECT

U.S. AID/CAIRO

NASA CENTER: LEWIS RESEARCH CENTER (LERC)

OBJECTIVE: U.S. AID - TO FIELD TEST THE TECHNICAL, ECONOMIC, AND SOCIAL FEASIBILITY OF RENEWABLE ENERGY SYSTEMS IN EGYPT AND TO PROVIDE ANALYSIS, EDUCATION, AND TRAINING TO SUPPORT REPLICATION AND DIFFUSION OF PROMISING APPLICATIONS

LERC - TO PROVIDE TECHNICAL AND MANAGEMENT SUPPORT TO AID/CAIRO TO DEVELOP THE RENEWABLE ENERGY PROJECT

APPROACH: ACTING AS LEAD CENTER, LERC WILL ASSIST AID/CAIRO IN PREPARING THE PROJECT IDENTIFICATION DOCUMENT AND PROJECT PAPER

FUNDING: IN-HOUSE 30% CONTRACT 70%

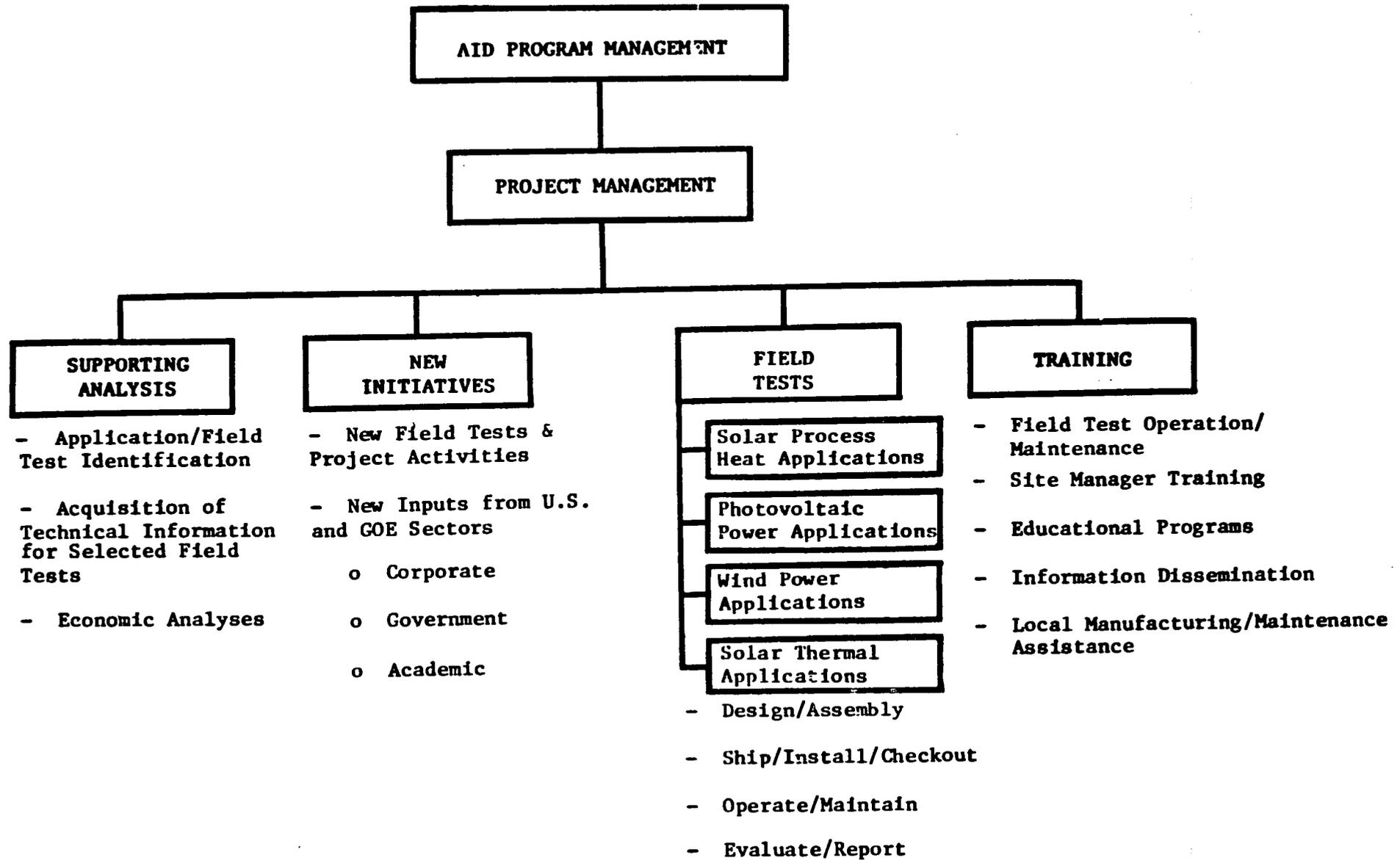
RESOURCES: TOTAL FUNDING - \$148K
LERC MANPOWER - 1 MY

OVERVIEW (CONTINUED)

EGYPT RENEWABLE ENERGY FIELD TESTING PROJECT

STATUS:

- o PROJECT IDENTIFICATION PAPER COMPLETED AND APPROVED BY AID IN MAY 1981
- o INPUTS FOR PROJECT PAPER SUBMITTED TO AID/CAIRO IN SEPT 1981
- o PROJECT PAPER INPUTS BEING REVIEWED
- o AID/CAIRO REQUESTED CONTINUED ASSISTANCE IN DEFINING SCOPE AND STRUCTURE OF PROJECT; ALSO REQUESTED ASSISTANCE IN OBTAINING AND PREPARING DESIGN SPECIFICATIONS FOR FIELD TESTS
- o NASA ROLE IN PROJECT MANAGEMENT TBD



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UPPER VOLTA SOLAR DEMONSTRATION PROJECT

OBJECTIVE:

- o TWOFOLD:
 - TO STUDY THE SOCIO-ECONOMIC EFFECTS OF REDUCING THE TIME REQUIRED BY WOMEN IN RURAL AREAS FOR DRAWING WATER AND GRINDING GRAIN
 - TO DEMONSTRATE THE SUITABILITY OF PHOTOVOLTAIC TECHNOLOGY FOR USE IN RURAL AREAS BY PEOPLE OF LIMITED TECHNICAL TRAINING

BACKGROUND:

- o ORIGINAL 1.8 KW SYSTEM OPERATIONAL MARCH 1979
 - WATER PUMPING
 - GRAIN GRINDING
- o HIGH FAILURE RATE OF SOLAREX 9200J MODULES DUE TO INTERCONNECT FAILURES
 - 26% OF MODULES FAILED DURING FIRST 18 MONTHS
- o SYSTEM WAS ON-LINE (I.E., BUSBAR WAS ENERGIZED) OVER 96% OF TIME

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PHOTOVOLTAIC TECHNOLOGY PROJECT

PLANNING AND STUDIES SUBPROJECT

STATUS

- o REPORT ON SURVEY OF INTERNATIONAL HEALTH ASSISTANCE COMMUNITY ISSUED (DR. NED WALLACE, U. OF WISC.)
- o A \$37K, 6-MONTH DEFINITION STUDY COVERING EDUCATION/COMMUNICATION APPLICATIONS COMPLETED BY DHR, INC. (BOTH "FINANCIAL" AND "ECONOMIC" LIFE-CYCLE COST ANALYSES CONDUCTED)
- o CONCEPTUAL DESIGN REPORT ON PV MEDICAL SYSTEMS PREPARED BY LERC
- o LIMITED SCOPE GRANT PROJECT AGREEMENTS PREPARED FOR VACCINE REFRIGERATORS; MEDICAL SYSTEM APPLICATIONS

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PHOTOVOLTAIC TECHNOLOGY PROJECT

APPLICATION SUPPORT SUBPROJECT

STATUS

- o LIMITED SCOPE GRANT PROJECT AGREEMENTS HAVE BEEN SIGNED BY HOST GOVERNMENTS (ECUADOR, GUYANA, KENYA & ZIMBABWE) FOR PV MEDICAL SYSTEM APPLICATIONS

- o THE GOVERNMENT/CONTRACTOR SITE INSPECTION TEAM COMPLETED ITS VISITS TO THE ABOVE COUNTRIES IN MID-DECEMBER 1981

- o A PV MEDICAL EQUIPMENT CATALOG WAS PREPARED BY A SMALL BUSINESS 8A FIRM; DISTRIBUTION SCHEDULED FOR FEBRUARY 1982

PHOTOVOLTAIC TECHNOLOGY PROJECT

MEDICAL REFRIGERATOR APPLICATIONS

- BACKGROUND:
- o KEROSENE ABSORPTION-TYPE REFRIGERATORS USED FOR COLD-CHAIN PRESERVATION OF VACCINES DO NOT MEET CDC/WHO REQUIREMENTS (VIZ., MAINTAIN TEMPERATURE AT 4-6° C AND PRODUCE 1 TO 2 KG OF ICE PER DAY AT 43° C AMBIENT)
 - o FUEL COST AVAILABILITY AND QUALITY A MAJOR PROBLEM IN MANY DEVELOPING COUNTRIES

OBJECTIVE: DEPLOY UP TO 20 PV-POWERED MEDICAL REFRIGERATORS AT SELECTED SITES FOR FIELD TEST AND EVALUATION

- APPROACH:
- o PROCURE 20 PV REFRIGERATORS, DEVELOPED UNDER CDC/DOE FUNDED CONTRACT
 - o SELECT SITES/PREPARE LIMITED SCOPE GRANT PROJECT AGREEMENT
 - o AWARD CONTRACT FOR DEPLOYMENT AND SERVICE
 - o COLLECT OPERATIONAL DATA, ANALYZE AND REPORT

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PHOTOVOLTAIC TECHNOLOGY PROJECT

MEDICAL REFRIGERATOR APPLICATIONS

STATUS

- o SOLAR POWER CORP. MEDICAL REFRIGERATOR HAS PASSED QUALIFICATION AND ACCEPTANCE TESTS (MEETS WHO AND CDC SPECS) SPECIFIED UNDER NASA-LERC (DOE/CDC-FUNDED) CONTRACT; MOTOROLA REFRIGERATOR STILL UNDER TEST
- o TWENTY CANDIDATE COUNTRIES AND ELEVEN SPECIFIC SITES HAVE BEEN IDENTIFIED FOR PV-POWERED REFRIGERATOR FIELD-TESTS
- o A SOLE-SOURCE, FIXED-PRICE CONTRACT FOR FABRICATION AND DEPLOYMENT OF THE FIRST TEN REFRIGERATORS FOR AID IS IN THE NEGOTIATION PHASE; AWARD EXPECTED IN LATE DECEMBER 1981
- o PROCUREMENT OF THE SECOND SET OF 10 AID-REFRIGERATORS WILL BE INITIATED FOLLOWING COMPLETION OF THE PROTOTYPE DEVELOPMENT CONTRACT BY MOTOROLA

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PHOTOVOLTAIC TECHNOLOGY PROJECT

MEDICAL SYSTEM APPLICATIONS

- BACKGROUND: PRELIMINARY SURVEY OF HEALTH ASSISTANCE COMMUNITY INDICATES NEED FOR RELIABLE POWER SYSTEM TO MEET BASIC ELECTRICAL NEEDS OF RURAL HEALTH CLINICS IN DEVELOPING COUNTRIES
- OBJECTIVE: DEPLOY STANDARD PV PACKAGES AT SEVERAL TYPICAL RURAL HEALTH FACILITIES
- APPROACH:
- o USE MASTER BUY PROCUREMENT FOR FABRICATION AND DEPLOYMENT OF STANDARD DESIGN (I.E., NON-COUNTRY SPECIFIC) PV SYSTEMS
 - o SYSTEMS TO MEET BASIC ELECTRICAL REQUIREMENTS OF TYPICAL RURAL HEALTH FACILITIES IN ECUADOR, GUYANA, KENYA (2), AND ZIMBABWE
 - o MONITOR AND EVALUATE PERFORMANCE OF SYSTEMS FOR 2 YEAR PERIOD
 - o PROVIDE TRAINING AND INFORMATION DISSEMINATION

PHOTOVOLTAIC TECHNOLOGY PROJECT

MEDICAL SYSTEMS APPLICATIONS

STATUS

- o SOLAREX CORP. SELECTED FOR THE DESIGN, DEVELOPMENT & DEPLOYMENT OF FIVE PV MEDICAL SYSTEMS FOR ECUADOR, GUYANA, ZIMBABWE & KENYA (2)
- o A COST-INCURRENCE LETTER WAS ISSUED TO SOLAREX ON OCT. 27, 1981.
- o CONTRACT AWARD ANTICIPATED BY END OF DECEMBER;
ESTIMATED COST \$771K (APPROX. 10% COST SHARING BY CONTRACTOR ANTICIPATED)

2/8

ROLES AND RESPONSIBILITIES OF NASA-LERC IN MEDICAL SYSTEMS APPLICATION
(AS ASSIGNED IN LIMITED SCOPE GRANT PROJECT AGREEMENTS)

- o ASSUME OVERALL TECHNICAL, FINANCIAL, AND ADMINISTRATIVE MANAGEMENT RESPONSIBILITY
- o ASSIGN A PROJECT MANAGER AND PROJECT ENGINEER FROM THE NASA-LERC STAFF
- o MAKE ARRANGEMENTS FOR THE COLLECTION OF INSOLATION DATA AND OTHER METEOROLOGICAL INFORMATION
- o UNDERTAKE CONCEPTUAL SYSTEMS DESIGN
- o PREPARE A DETAILED FINAL IMPLEMENTATION PLAN AND SCHEDULE AND SECURE APPROVAL BY HOST GOVERNMENT AND U.S. AID/MISSION
- o PROCURE NECESSARY GOODS AND SERVICES FROM A U.S. CONTRACTOR FOR SYSTEM DESIGN, FABRICATION, TESTING, DEPLOYMENT, AND OPERATION
- o MONITOR AND TECHNICALLY DIRECT THE WORK OF THE CONTRACTOR
- o PROVIDE TRAINING AND ORGANIZE INFORMATION DISSEMINATION ACTIVITIES
- o PARTICIPATE WITH HOST GOVERNMENT AND U.S. AID/MISSION IN PROJECT EVALUATIONS AND REPORTING
- o PROVIDE TECHNICAL ASSISTANCE, AS REQUIRED, FOR APPROXIMATELY TWO YEARS FOLLOWING THE DEDICATION OF THE INSTALLATIONS (ESTIMATED NASA LEVEL OF EFFORT IS 0.5 PERSON-YEARS PER YEAR)

PHOTOVOLTAIC TECHNOLOGY PROJECT

MEDICAL SYSTEMS APPLICATIONS

RESOURCE SUMMARY

<u>NONRECURRING SYSTEM COST:</u>	<u>ESTIMATED COST, \$K</u>
DESIGN, R&QA, DRAWINGS, MANUALS	
FABRICATION AND TESTING	215
<u>RECURRING SYSTEM COST:</u>	
BASELINE SYSTEM	
MATERIALS	
PV MODULES	17
BALANCE OF SYSTEM	26
LOADS	4
INSTALLATION AND CHECKOUT	10
PACKAGING AND SHIPPING	10
G&A, CONTINGENCY	<u>13</u>
	80
<u>MONITORING AND REPORTING:</u>	
5 SYSTEMS	120

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PROPOSED SUPPORT OF AID RURAL SATELLITE PROGRAM

OBJECTIVE: PROVIDE PV POWER SYSTEMS TO MEET ELECTRICAL NEEDS
SUCH AS EARTH STATIONS, TERMINALS, REPEATERS, ETC.

- STATUS:
- o PRELIMINARY ELECTRICAL REQUIREMENTS ESTABLISHED THROUGH MEETINGS AND DISCUSSIONS WITH S&T/ED AND THEIR CONTRACTORS
 - o SITE INSPECTION CHECKLIST DEVELOPED AND SENT TO S&T/ED CONTRACTOR
 - o CONCEPTUAL DESIGN/PRICE ANALYSIS ACTIVITY INITIATED
 - o MEMO FROM EY&ED REQUESTING USE OF UNOBLIGATED FUNDS APPROVED ON NOVEMBER 2, 1981

PRELIMINARY ESTIMATES OF REMOTE EARTH STATION
ELECTRICAL REQUIREMENTS

<u>LOAD</u>	<u>POWER REQUIREMENT PER CHANNEL</u>	
	<u>IDLE</u>	<u>ON-LINE</u>
SCPC DOWN CONVERTER	8.71 WATTS	8.71 WATTS
DEMOD	5.0	5.0
VOICE PROCESSOR	---	2.5
FM MODULATOR	---	0.5
SUPERVISORY & REMOTE	0.13	0.13
TRANSMITTER (VOX)	---	55.0
UP CONVERTER	9	9
LIGHTS (GENERAL)	TBD	TBD
TEST EQUIPMENT	TBD	TBD
	22.84 WATTS	80.84 WATTS

TOTAL EXPECTED LOAD = 300 WATTS FOR 18 HOURS (EFFECTIVE) FOR TWO CHANNELS
ASSUME VOX DUTY CYCLE OF 30%

PHOTOVOLTAIC TECHNOLOGY PROJECT

TRAINING AND INFORMATION

BACKGROUND: PLANNERS AND DECISION MAKERS FROM DEVELOPING COUNTRIES HAVE EXPRESSED INTEREST IN DEVELOPING INDIGENOUS CAPABILITY REGARDING USE OF PV SYSTEMS

OBJECTIVE: PROVIDE FOR TRAINING AND INFORMATION DISSEMINATION ON PHOTOVOLTAIC SYSTEMS AS PART OF NON-COUNTRY SPECIFIC APPLICATION PROJECTS

APPROACH:

- o INCLUDE PROVISIONS FOR USER TRAINING AS PART OF MEDICAL SYSTEMS CONTRACT
- o SECURE SERVICES OF CONTRACTOR(S) FOR GENERAL TRAINING AND INFORMATION ACTIVITIES (E.G., SEMINARS, CONFERENCES)
- o FACILITATE PARTICIPATION OF HOST COUNTRY PERSONNEL IN PROJECT PLANNING AND IMPLEMENTATION (E.G., PROPOSAL EVALUATION, TECHNICAL REVIEWS, TRAINING)

PHOTOVOLTAIC TECHNOLOGY PROJECT

TRAINING AND INFORMATION SUBPROJECT

STATUS

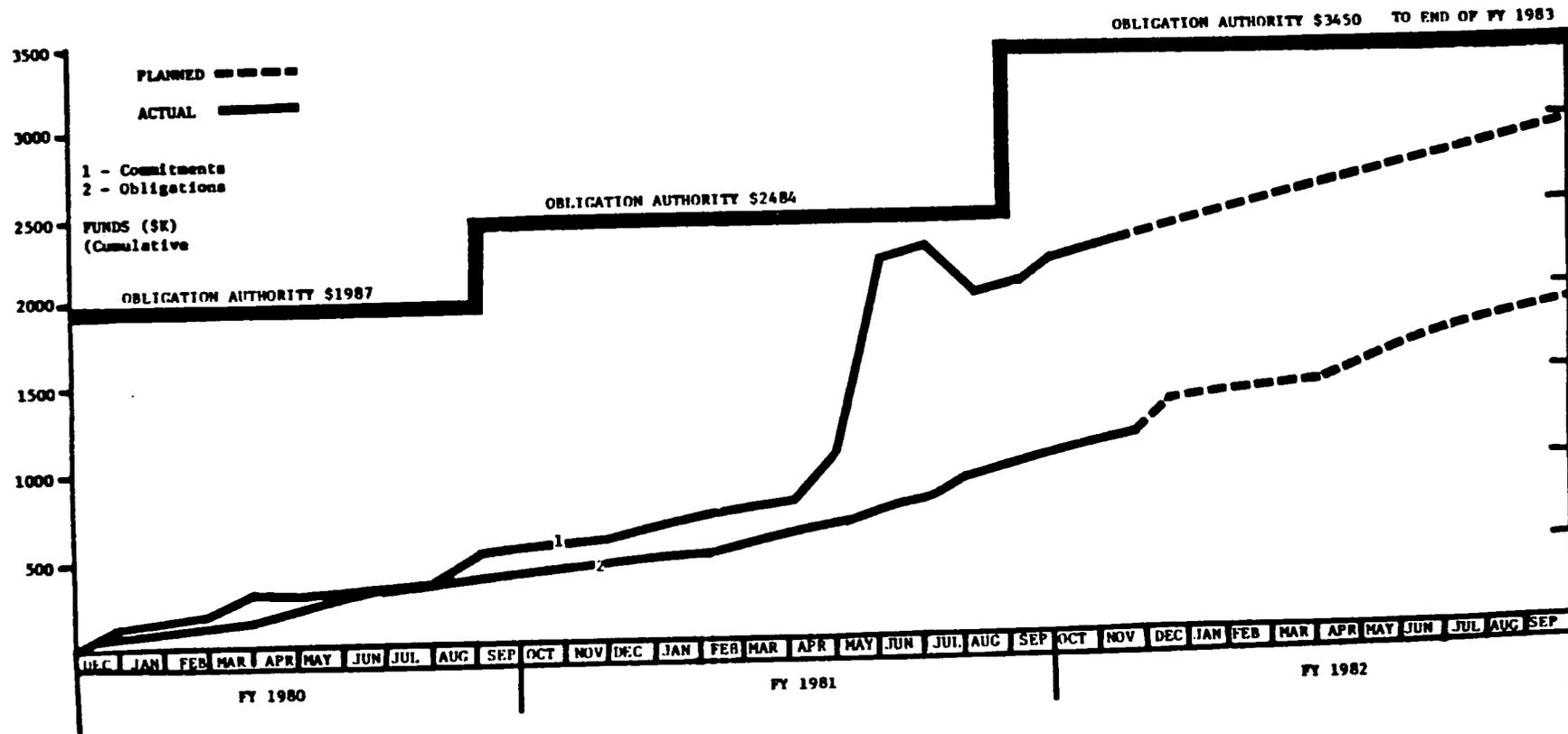
- o AWARDED GRANT FOR \$115K TO THE UNIVERSITY OF MICHIGAN FOR TRAINING AND INFORMATION SUPPORT

- o SUPPORTED RENEWABLE ENERGY CONFERENCE, NAIROBI, KENYA, WITH TECHNICAL PRESENTATIONS AND EXHIBITS (AUGUST 1981)

- o PROVIDED TECHNICAL PRESENTATIONS/TRAINING AT NASA-LERC FOR PERSONNEL FROM SEVERAL HOST COUNTRIES

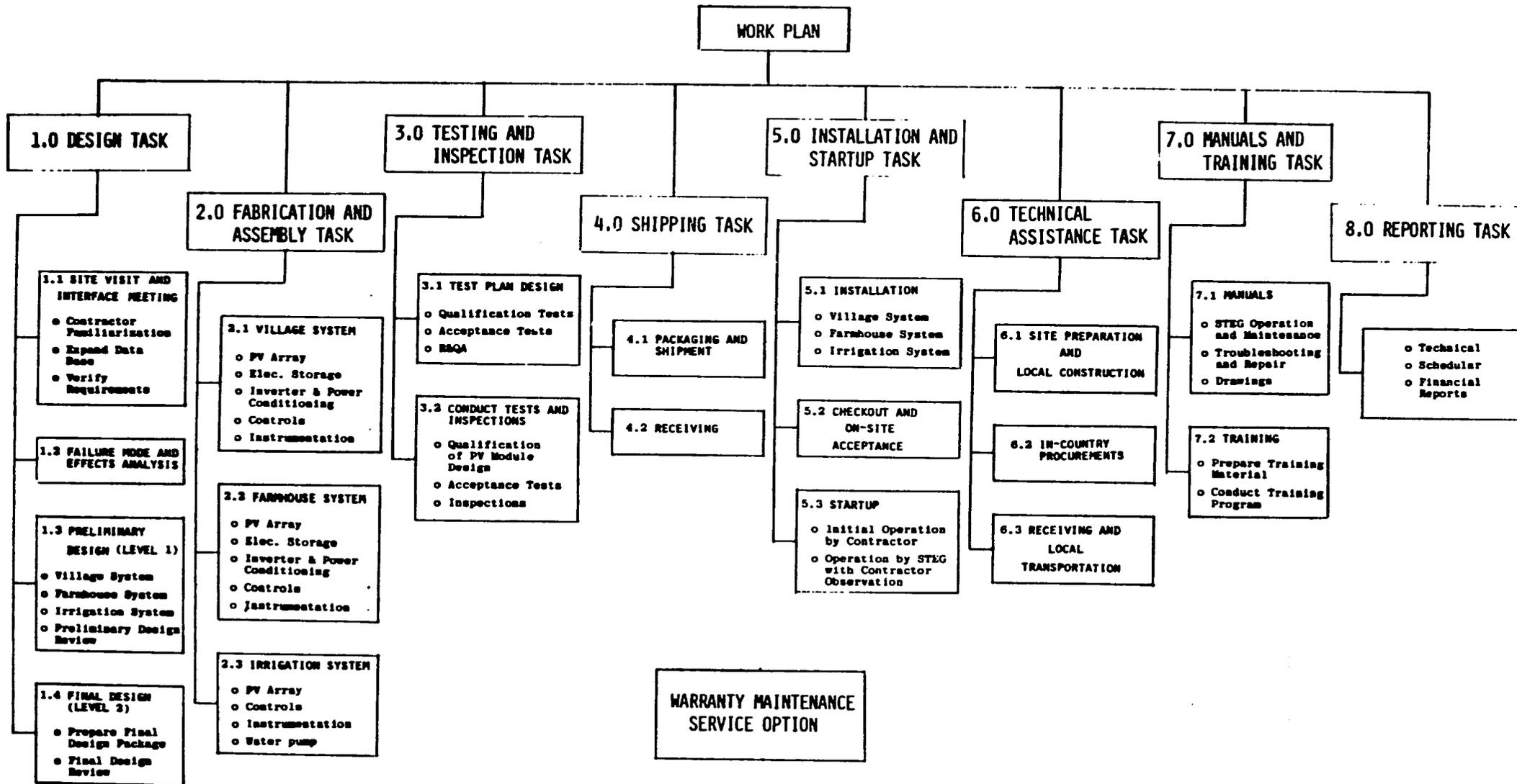
- o SUPPORTED U. OF F. TOUR OF PAPAGO INDIAN VILLAGE BY TAET PARTICIPANTS

AID PHOTOVOLTAIC TECHNOLOGY PROJECT - OVERALL RESOURCE SUMMARY



PHOTOVOLTAIC POWER SYSTEMS FOR TUNISIA RENEWABLE ENERGY PROJECT

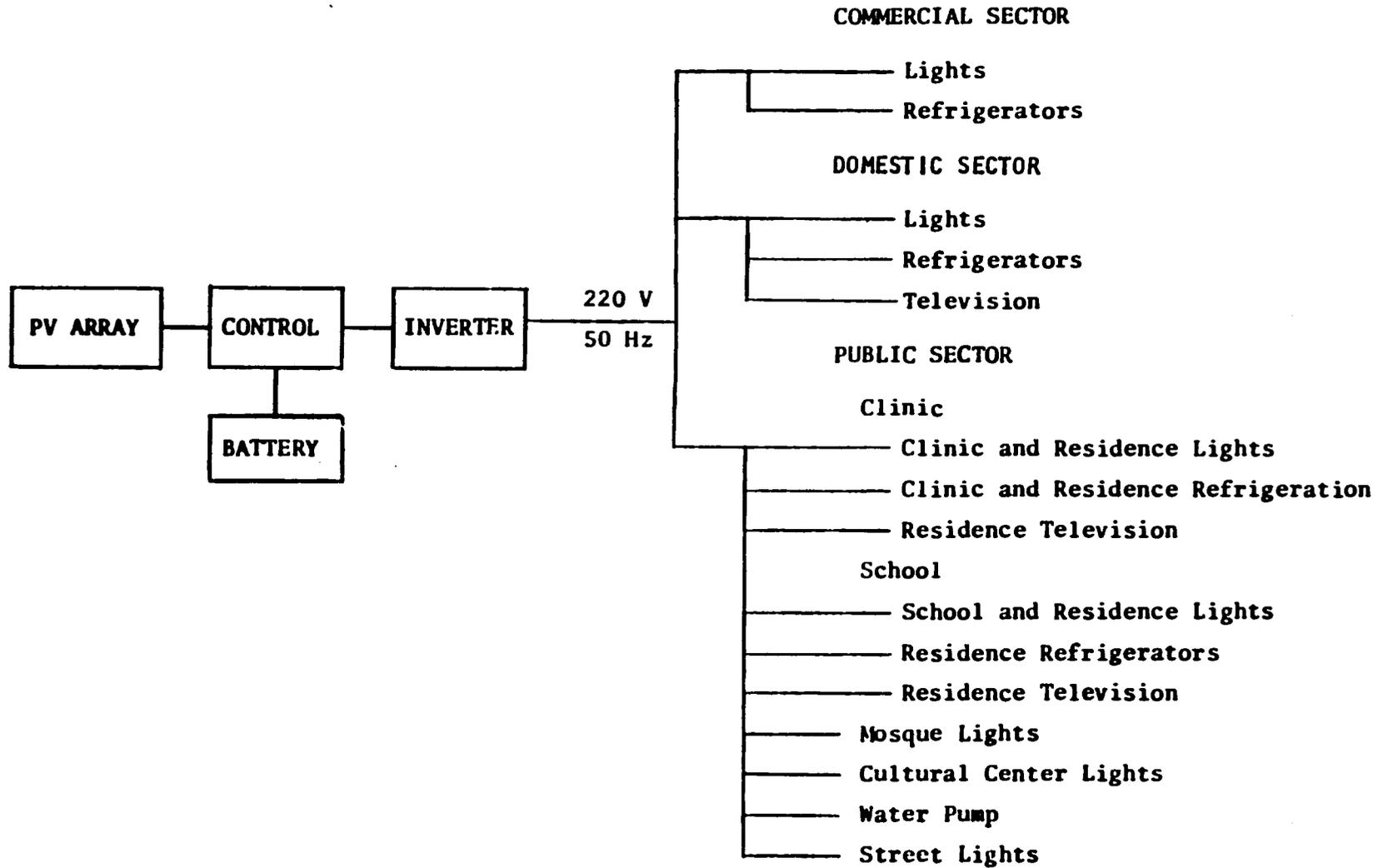
Work Breakdown Structure



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HAMMAM BIADHA

Central PV System Schematic Diagram



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TUNISIA RENEWABLE ENERGY PROJECT
SOLAR TECHNOLOGY DEMONSTRATIONS FOR HAMMAM BIADHA

	Solar and Wind Technologies Demonstrated	Application	
		Description	Number
Agricultural Applications	Wind-Powered Water Pumping plus Solar Greenhouse with Thermal Storage	Greenhouse farming Crop: Early or late season vegetables	Two
	PV-Powered Water Pumping	Open field farming Crop: In season vegetables or young fruit trees (1-3 hectare fields)	One
	PV Electrification (Dispersed) plus PV-Powered Water Pumping plus Solar Greenhouse with Thermal Storage	Remote, stand-alone PV electrical system for domestic farm needs and greenhouse farming with drip irrigation Crop: Early or late season vegetables	One
Village Applications	PV Electrification (Central)	Village power system to meet basic electrical needs of rural community.	One
	Water Heating	Solar hot water system for clinic (non-sterilization applications).	One
	Space Heating	Solar heating system for nurse's quarters and examining room of clinic.	One

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TUNISIA RENEWABLE ENERGY PROJECT

MILESTONES

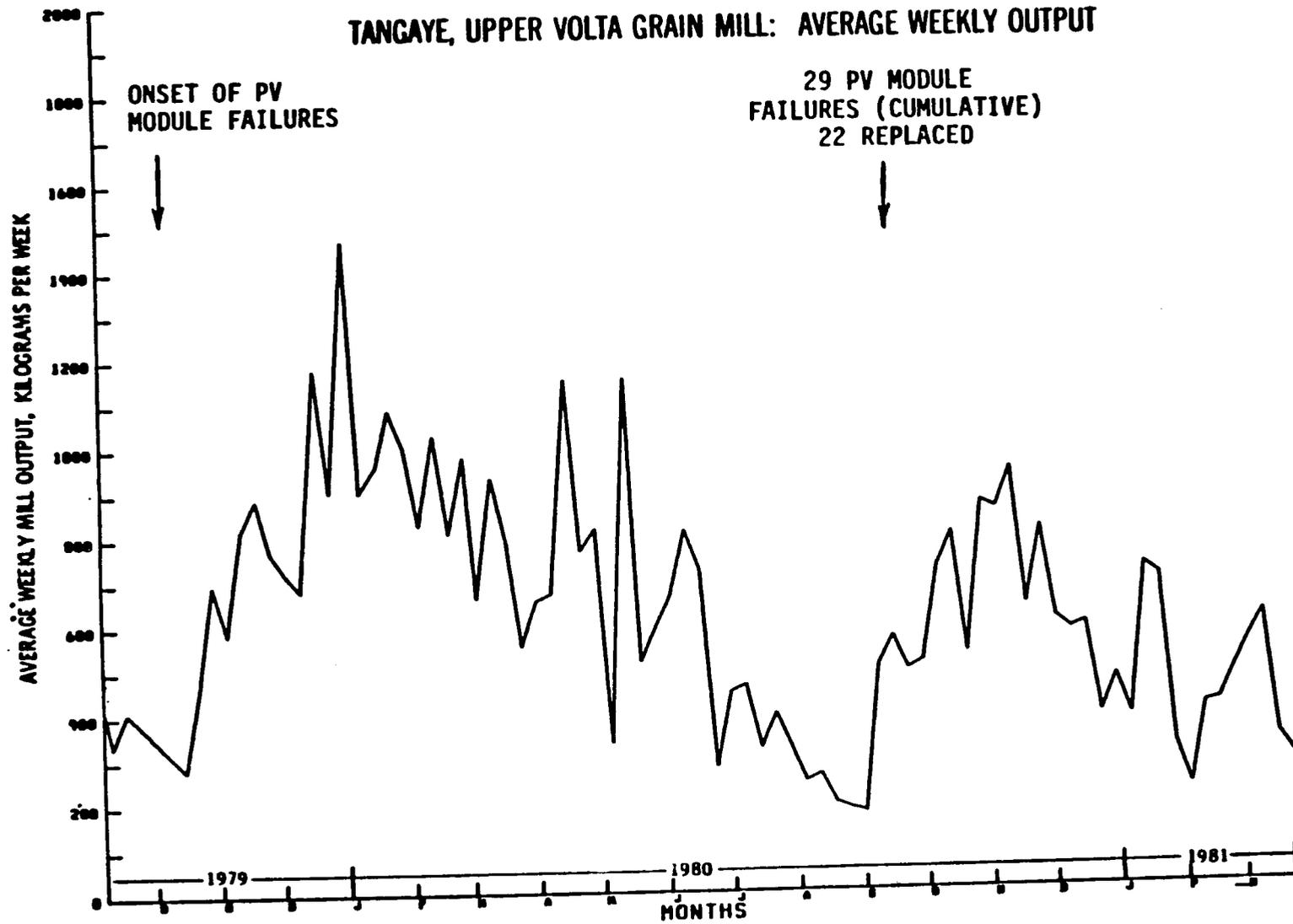
- o CONTRACT SIGNED 11/4/81
- o WORK PLAN RECEIVED - IN REVIEW 11/23/81
- o FINAL DESIGN REVIEW 3/4/82
- o START SITE PREPARATION 3/17/82
- o SHIP EQUIPMENT (EXCEPT BATTERIES) 6/15/82
- o SITE PREPARATION COMPLETE 6/16/82
- o SHIP BATTERIES 7/14/82
- o START INSTALLATION 8/15/82
- o BATTERY DELIVERY TO SITE 9/30/82
- o FINISH INSTALLATION 10/6/82
- o FINISH CHECKOUT/FORMAL STARTUP 10/29/82

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UPPER VOLTA SOLAR DEMONSTRATION PROJECT

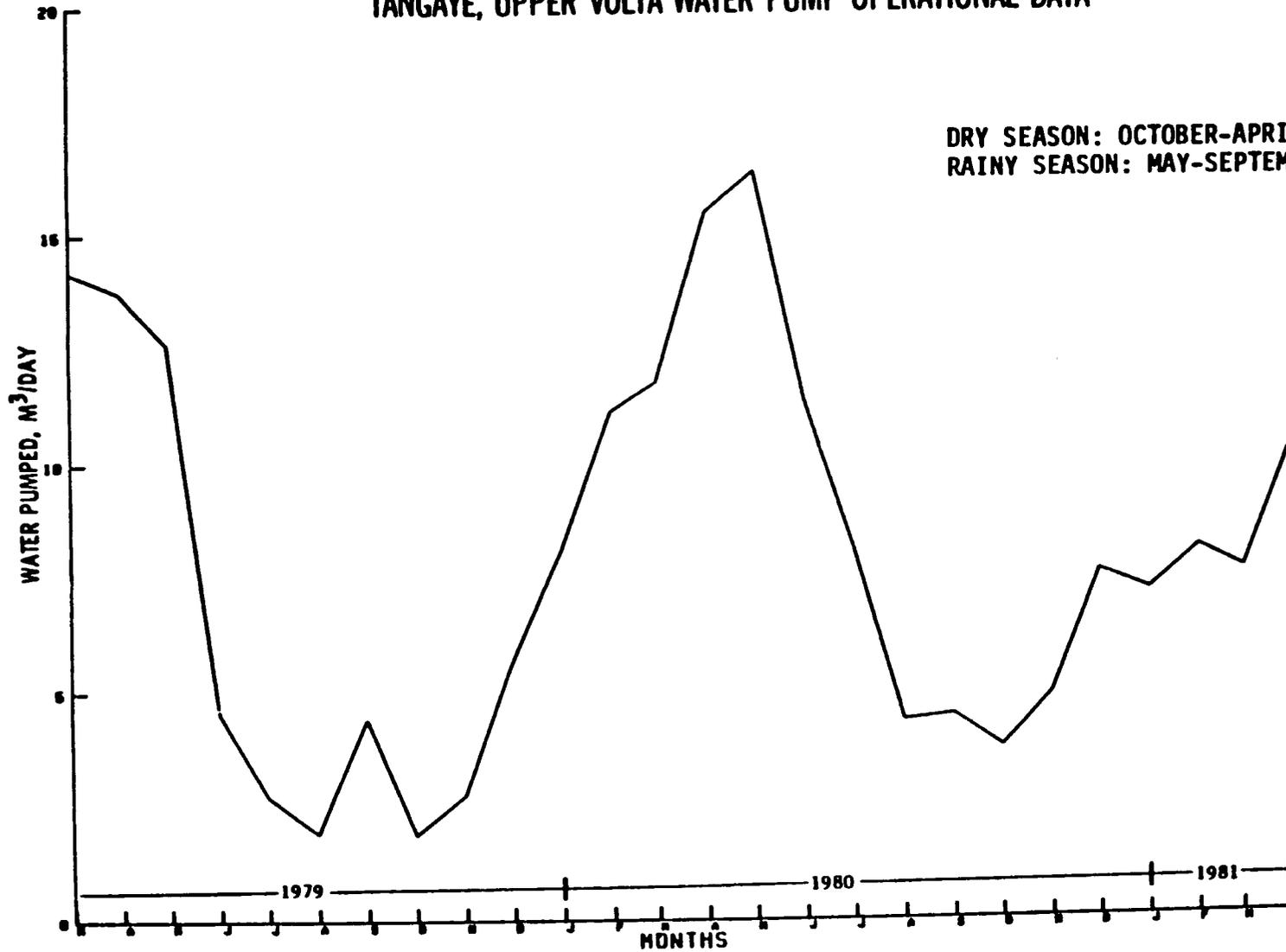
STATUS

- o SYSTEM ENLARGED TO 3.6 KW WITH MODULES SUPPLIED BY DOE, AN IMPROVED HAMMERMILL WAS INSTALLED AND ALL EXISTING SOLAREX 9200J MODULES REPLACED - MAY 1981
 - FIRST DEMONSTRATION OF MODULARITY OF PV SYSTEMS IN THE FIELD
 - GRAIN GRINDING CAPACITY INCREASED BY FACTOR OF FOUR
- o PERSONNEL OF L'HYDRAULIQUE ET DE L'EQUIPMENT RURAL HAVE BEEN TRAINED BY LEWIS ENGINEERS AND HAVE ASSUMED RESPONSIBILITY FOR MAINTENANCE AND REPAIR
- o SODIUM-VAPOR LAMP INSTALLED ON TANGAYE GUEST HOUSE BY AID PERSONNEL IN SEPTEMBER 1981; ILLUMINATES PATIO FOR NIGHT-ADULT EDUCATION CLASSES
- o SYSTEM TO BE TURNED OVER TO GOUV - MARCH 1983 - PER LSGPA



TANGAYE, UPPER VOLTA WATER PUMP OPERATIONAL DATA

DRY SEASON: OCTOBER-APRIL
RAINY SEASON: MAY-SEPTEMBER



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UPPER VOLTA SOLAR DEMONSTRATION PROJECT

OPERATIONAL EXPERIENCE

PV ARRAY

- o GROUND BURIAL OF SUPPORT STRUCTURE IS ACCEPTABLE
- o INDIGENOUS PERSONNEL CAN ASSEMBLE, INSTALL, CHANGE FAILED MODULES

CONTROLS

- o ELECTRONIC CONTROLS PREFERRED OVER ELECTROMECHANICAL TYPE
- o LOAD MANAGEMENT CAN BE PERFORMED BY LOCAL PERSONNEL MANUALLY

BATTERY

- o BATTERY ROOMS NEED CONCRETE FLOORS

MILL

- o BURR MILLS ARE UNACCEPTABLE FOR COMMERCIAL FLOUR PRODUCTION
- o HAMMERMILLS PREFERRED

PUMP

- o WELL YIELD DATA CAN BE UNRELIABLE
- o PUMPED VS DRAWN WATER DOES NOT ENCOURAGE WASTE

MAINTENANCE AND REPAIR

- o LOCAL PERSONNEL, WITH ADEQUATE TRAINING, ARE ABLE TO OPERATE AND MAINTAIN THE SYSTEM SATISFACTORILY

UPPER VOLTA PV SYSTEM EXPANSION - FACT SHEET

<u>Item</u>	<u>Before Expansion</u>	<u>After Expansion (6/3/81)</u>
Array fenced-in area	50'x50'	50'x100'
Array size	1.8 kW peak	3.6 kW peak
Module type/No. cells per module	Solarex 9200J/42	Sensor Technology P/N 20-10-1452 Rev H/44
Number of modules	96	192
Number of module series strings	12	24
Panel configuration	8 series modules per string	8x2 series - parallel per string
Array current at peak power	15 amps	29 amps
Nominal system voltage	120 VDC	same
Control	6 solid state duty cycle regulators	same
Battery type	C&D KCP SD-7	same
Number of battery cells	55 cell, single string	same
Battery ampere hours	540 amp-hours	same
Array/battery circuit breakers	30 amp	40 amp
Mill	Bell #10 bottom discharge hammermill	Jacobson 120b hammermill
Mill motor	Applied Motors 120 VDC, 21 amp, 3 hp	same
Milling rate	30 kg/hr (maize)	57 kg/hr (white sorghum), 91 kg/hr (maize), 250-270 kr/hr (red sorghum)
Pump	Jenson 11W5A	same
Pump motor	Applied motors 120 VDC, 2.5 amp, ¼ hp	same
Pumping rate	1.18 cu meters/hr 5-15 cu meters/day	same same
Lights	1 ea 2x20 watt fluorescent in mill	1 ea 1x20 watt fluorescent in mill 3 ea 2x20 watt fluorescent in guest house