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INSPECTION TRIP REPORT

S.T.E.G.
El Haouaria Wind Energy Test Facility
and
Hammam Biadha Photovoltaic
Demonstration Project

TUNISIA

US-AID Project No. 664-0328.16

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Submitted By:

Bergey Windpower Co., Inc.
Norman, Okla., USA

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Background

On August 18, 1986, Mike Bergey of Bergey Windpower Co., and Alan Cowan, consultant to BWC, traveled to Tunisia to inspect the wind energy test facility at El Haouaria and the photovoltaic demonstration system at Hammam Biadha Sid. Both projects were funded by US-AID and are operated by the Societe Tunisienna de L'Electricite et du Gaz (STEG).

The El Haouaria project consists of two grid-intertied wind turbines installed at an isolated and unattended site (Cape Bon) within 300 meters of the Mediterranean Sea. The wind turbines are a Bergey Windpower Excel-S 10 KWp unit and a Jacobs Wind Electric 23/12.5 12.5 KWp unit. Both units were installed in June of 1984 by a crew from the US Solar Energy Research Institute and STEG.

Both systems operated for several months but then experienced problems related to their electronics and other electrical equipment. Exact sequences and causes of these problems are not known, but it appears that the Bergey inverter (a power conditioning unit) failed, and that at a later time the Jacobs unit was severely damaged by a direct lightning strike to the Jacobs turbine. It is also believed that the Bergey

inverter was further damaged by this lightning strike. Attempts by STEG to repair the Bergey inverter were hampered by a lack of documentation and the fact that the STEG technician trained by SERI in O & M procedures had moved out of the country. Since few Tunisians speak English and SERI/BWC/Jacobs personnel do not speak French, language was another impediment to local repair of the wind turbines. STEG did not attempt to repair the Jacobs unit due to the severity of the system damage.

The objectives of the present activity are primarily to return the El Haouaria Wind Test Facility to full operation and to ensure its continued operation without need for further AID support. The purpose of the inspection trip then was to assess the problems at El Haouaria and develop plans for remedying these problems. In addition, MB and AC brought equipment and supplies which, it was hoped, would enable the Bergey unit to be repaired.

Although it has an excellent wind resource, Cape Bon is a harsh environment for a wind turbine. Its proximity to the sea causes significant corrosion and, due to the arid landscape, the air contains a high concentration of dust and sand. The soil consists of sand and rocks, so is difficult to establish good earth grounds. Finally, since the site is unattended, operational problems can go uncorrected for some time.

It is also worth noting that Tunisia operates a European standard 50 hertz utility network which differs in many ways from the 60 hertz U.S. System. The Bergey Excel-S at Cape Bon is the only 50 hz. unit that has been produced. It is believed that the Jacobs unit at Cape Bon is also unique in this way.

The Hammam Biadha project consists of three PV systems: a 30 KWp village electrification system, a 2 KWp farm electrification system, and a 1.5 KWp water pumping system. They were installed by Solar Power Corp. (a now defunct Exxon affilliate) in 1983 and have been operating satisfactorily since that time. MB and AC were asked to inspect the village system and suggest ways to improve performance monitoring.

Daily Activity Summary

Mon., August 18

- Arrived in Tunis at about 10:30 PM, met by Nasri Habib of STEG (Wind Program Manager).
- MB's luggage and tools/parts package did not arrive. Destination had been mismarked by Oklahoma City ticket agent as London rather than Tunis.
- Accommodations provided by STEG at the Majestic Hotel in Tunis.

Tues., August 19

- Met in early morning by Mr. Habib and Mohamed Ali Hassairi of US-AID.
- Traveled to US Embassy to arrange assistance in recovering MB's luggage and the tools/parts package.
- Traveled to STEG headquarters to collect other STEG personnel. Joined by Habib Bach (translator), Ben Abdallah Mohamed, Louhaichi Khaled, and Nafti Naceur.
- Traveled to the El Haouaria wind system facility (about 120km).
- Began inspection of equipment and training.
- Lunch taken in El Haouaria.
- Inspections and training continued.
- Traveled to Hotel Ennassim in Kalibia (about 40 km).
- Made two phone calls that evening to Bergey Windpower Co.'s Service Department.

Wed., August 20

- Traveled to wind system facility.
- Continued inspections (hampered by not having test equipment in MB's package).
- Lowered BWC Excel tower and climbed Jacobs tower.
- Began repairs, training continued.

- Lunch taken in El Haouaria.
- Received MB's luggage and test equipment mid-afternoon. Spare parts still being held by Tunisia Customs Service.
- Test equipment showed problems with Bergey inverter and sliprings and Jacobs generator and wiring.
- Continued tests, repairs, and training.
- Traveled to hotel in Kalibia, Hotel Ennassin.

Thurs., August 21

- Traveled to wind system facility.
- Continued repairs and training.
- Lunch taken in El Haouaria by STEG personnel; MB and AC skipped lunch to gain extra two hours at site.
- Concensus was that spares [parts for upgrading Excel turbine unit, re-insulating slipring assembly, and electrical spare parts] would not be obtained before MB and AC's departure. Therefore, Bergey unit was reassembled and tower was raised.
- Traveled to Tunis, stayed in Majestic Hotel.

Friday, August 22

- Spare parts package was obtained (thanks to great effort by M.A. Hassairi and STEG).
- Due to prearrangement, party traveled to Hammam Biadha to inspect the photovoltaic system located there.
- Conducted systems tests (see separate section on findings) and reviewed documentation.
- Traveled back to Tunis, Majestic Hotel.
- Note: This was Habib Bach's last day with the group.

Saturday, August 23

- Traveled to the El Haouaria wind system facility.
- Lowered Bergey tower and began retrofits/repairs on turbine.
- Began repair of Bergey inverter.

- Lunch taken in El Haouaria.
- Removed anemometers and data acquisition systems.
- Work continued until dark.
- Traveled to Kalibia, Hotel Ennassim.

Sunday, August 24

- Traveled back to wind test facility.
- Finished work on turbine, raised tower.
- Completed Bergey electronics repair.
- Attempted to operate Bergey unit, without success due to obscure problem with inverter.
- Attempted to diagnose and repair inverter problem, but after several hours determined that repairs would be needed at Bergey factory (no lunch taken).
- Packed equipment and tools away and restored site to original condition.
- Traveled back to Tunis, Majestic Hotel.

Monday, August 25

- Traveled to US-AID offices in Tunis for discussions with Mr. M.A. Hassairi of AID and Mssr.'s Habib, Boukhicha, Naceur, and Guellaz of STEG. Meeting covered a summary of the situation, progress made, and planning for completion of necessary tasks.
- Traveled to airport for flight departure at 1:45 PM.

Condition of El Haouaria Site:

1. Bergey Unit

A. Rotor spinning freely - unloaded due to electronics problem.
B. Wind turbine in generally good condition except for corrosion of electro-plated fasteners, inadequate insulation level for yaw axis slip-rings, and slight erosion of lead weights on blade pitch weights.
C. Tower in generally good condition, except for corrosion of electro-plated fasteners, and furling winch (severe), poor arrangement of wiring junction at base, and lack of grounding on guy wires. Guy cable tension was good. Winch system in excellent condition (due to use of two covers).
D. Underground wiring in good condition (checked with meggar on 8-23-86).
E. Disconnects and Bergey unit switchgear in good condition.
F. Synchronous inverter (Powersync) not operational. Signs of attempted repair by STEG and of a high energy electrical surge (i.e., lightning).

2. Jacobs Unit

A. Rotor not turning due to brake stuck in "on" position because of corrosion of disk brake mechanism.
B. Wind turbine in generally good condition except for significant corrosion of electroplated and painted components (e.g., blade pitch springs), inoperable blade feathering mechanism and brake winch due to corrosion, generator armature and field windings showed inadequate insulation levels, signs of surge in tower mounted arrestors.
C. Tower in generally excellent condition.
D. One power lead (of three) in underground wiring shows inadequate insulation level.

E. Disconnects and Jacobs unit switchgear have catastrophically failed due to severe lightning surge.
F. Synchronous inverter appears to be in excellent condition. One surge protection PCB has catastrophically failed, but others appear and check good.

3. Data Acquisition Systems

A. Both systems have catastrophically failed due to lightning surge; factory repair or total replacement required. Anemometers need complete overhaul. Temperature transducers need replacement.

4. Site and Facilities

A. All tools and materials left by SERI in 1984 were found in good shape.
B. Soil conditions are harsh rocks and sand. Would expect difficulty in establishing good earth grounding (poor soil conductivity).
C. Air contains much dust and salt spray. Corrosion is a significant problem. Leading edge of blades (Bergey) had accumulated dust, hard packed, of about .040". Later cleaning, operation, and inspection showed fast accumulation rate.
D. Winds during the day are strong and steady. Very good resource for wind turbine operation.
E. Many indications of lightning strike(s) were found.
F. Building in good shape.
G. Lumber from original shipping crates is still in the Storage Room.
H. Equipment wiring in Equipment Room is not well organized.

Repairs / Upgrades Performed

The following repairs/upgrades were performed (NOTE: An upgrade is a modification to the existing equipment recommended by the manufacturer to improve performance or reliability). STEG personnel participated in each task.

I) Bergey Excel-S Wind Turbine

1. Replaced Furling Winch. BWC originally supplied a painted furling winch because a zinc-plated version could not be obtained prior to shipment of the system to SERI in 1984. The plated unit was shipped later to SERI and forwarded by them to Tunisia. The painted unit was installed at El Hauaria and by Aug., 1986 had become severely corroded.
2. Upgraded Insulation of Turbine Slip-Ring Assembly. The resistance to ground for each of the three slip-rings (See Item #107 of the Excel-S Owners Manuals Parts Drawing) should be greater than 50 Megaohms (mΩ), but were tested at 8-16 mΩ. The possibility of this degradation was anticipated and the necessary materials for refurbishment had been brought. Following what is called a "Phenolic Paint Job," the slip-rings were tested at 28-34 mΩ. Since the insulating paint used for this task had not fully cured at the time of this test, it is believed that the slip-ring insulation level would soon rise above the specified minimum. This will be double-checked on the second visit.
3. Installed New Power Brushes. This retrofit eliminates a possible source of intermittent contact in the power leads.
4. Installed Bumper Shim Retrofit. This retrofit involves placing a 1/2" steel spacer underneath the left-side, viewed from tail towards blades, tail stop bumper (See Item #9 of the O.M. Parts Drawing). Its purpose is to restrict the tail fold angle during furling so that higher rotor speeds will be maintained. These higher rotor speeds, in turn, reduce the likelihood of severe blade bending

during periods of extremely turbulent high winds.

5. Installed Alternator Bolt Retrofit. This retrofit replaces the four 1/2" bolts attaching the alternator to the mainframe (See Item #40 of the O. M. Parts Drawing) with stronger 9/16" bolts.
6. Installed Furling Cable Swivel. This swivel should eliminate any furling cable kinking which might be caused by yawing twist build-up.
7. Recoated Blade Pitch Weights. Each rotor blade has a lead tipped pitch weight protruding from its leading edge three-quarters of the way out the blade (See Item #60 of the O.M. Parts Drawing). Since the turbine had been running unloaded (i.e., at higher than normal speed) for almost two years, the surface coating on the lead weights had eroded away - exposing the softer lead material. These pitch weights were recoated with silicon rubber. This material should last until a more resilient polyurethane coating can be applied on the next trip. The polyurethane leading edge tape on the blades was still in very good condition.
8. Cold-Galvanized Rusting Fasteners. Numerous zinc-plated fasteners have corroded in the high salt atmosphere of the site. A single can of cold-galvanizing spray paint was found remaining from the SERI work and was used to top-coat the corroded fasteners. Most of these fasteners will be replaced on the second trip.
9. Installed Fuses in the Turbine-Inverter AC Wiring. This retrofit provides protection against alternator burnout in the event that a phase-to-phase short circuit develops in the wiring or inverter.
10. Installed Improved Surge Suppression Components. These surge arrestors, installed both on the turbine and utility side of the inverter, provide better protection against lightning and outage induced line surges.
11. Replaced Printed Circuit Boards and SCR's (Silicon Controlled Rectifiers) in the Inverter. The inverter is a power conditioning system used on both the Bergey and Jacobs unit to make the turbine output compatible with utility generated power. [Problems with the Bergey Powersync inverter were, and are, the root cause of the non-operability of the system.] Following standard BWC diagnostic

procedures, a number of failed components were identified and replaced and several calibration adjustments were made. After all static tests had been passed, operation of the system was attempted. The system would not, however, "come on line" because an in-line 3Ø contactor (to the turbine) would not engage. Further tests showed that the contactor was functional but that its control signal was not being relayed. This problem has not been previously experienced and neither MB or AC could determine its cause in the few hours available on August 24th. This inverter will have to be returned to the BWC factory for repair.

II) Jacobs 12.5 Wind Turbine

1. Overhauled Disk Brake Caliper Assembly. The unit's rotor assembly would not turn because the unit's mechanical brake had siezed-up in the "on" position. The caliper unit was removed, overhauled, and reinstalled. The brake was then briefly operated before the brake winch failed. Both problems are attributable to corrosion.

III) Data Acquisition Systems

1. Removed Anenometers. The R.M. Young anemometers on both turbine towers were removed due to excessive play found in their rotor bearings. The looseness of these bearings suggests that the calibration has been lost.
2. Removed Data System Modules. The data acquisition modules located inside the equipment room contain separate microprocessors (Campbell Scientific Model 10X Micrologger), recorders, and interface circuits for each turbine. Both have been heavily damaged by lightning surges. The modules were disconnected and taken off the wall for future shipment to the U.S.

Hammam Biadha PV Site

Overall, the Hammam Biadha 30 KWp village electrification system is in excellent condition. The installation is very orderly and STEG has done a fine job in landscaping and upkeep. Tests indicate the photovoltaic panels are operating satisfactorily although it was not possible to determine whether they were meeting system specifications. Likewise, the Tri-Solar Maximum Power Controllers (MPC's) seem to be working satisfactorily. STEG, however, has had to replace a number of regulator circuit boards in these units (the six MPC's have a total of sixty regulator boards) and is virtually out of spares. STEG is concerned about its long range capability to maintain the MPC units.

The Village Battery Display and Control Unit (Tri-Solar) is, on the other hand, at least partially inoperative. Battery state-of-charge metering is not functional and the unit does not appear to be providing control signals to the AC Village Power Distribution Box. As a result, the Power Distribution Box is not providing automatic prioritized distribution of available power to the residential, commercial, and public loads. This function is now being accomplished manually. Installation of the spare control PCB's for the Battery Display and Control Unit did not correct the problem. With no wiring schematics and limited time available, it was not possible to do detailed troubleshooting.

Troubleshooting was also hampered by the fact that the on-site system documentation consisted solely of Solar Power Corp.'s original proposal to NASA/AID. The "as-built" systems manual was obtained the next day from STEG's office in Tunis. This manual is fairly complete and would be of great help at the PV site. STEG has loaned BWC a copy for possible compilation and translation. In any case, BWC intends to make several copies and bring them on the second Tunisia trip. Detailed circuit schematics were never released by the manufacturers.

The battery system is in good condition. The concrete floor underneath five of the forty-two batteries is discolored, but no signs of case leakage

could be found. The remaining system switchgear and the DECC static inverter seem to be in excellent condition. The farmhouse and water/pumping systems were not visited.

Mr. Nasri Habib indicated STEG's desire to obtain more detailed information on the energy flow within each system. It was decided that installing a total of eight DC kilowatt-hour meters (3 - Village system, 3 - Farmhouse system, 2 - Water/pump system) would provide the information STEG requires. STEG would also like to install a cumulative-hour operating time meter for the pump system because they suspect it may not be operating as often as it should.

Hammam Biadha is an impressive facility for which STEG and AID should be proud.

Training

Approximately 50% of the time on site in El Haouaria was spent in instruction and training of the STEG personnel. STEG personnel participated in all diagnostic work, retrofits, and repairs. In addition, considerable time was spent covering the operational aspects and design of both wind turbine systems.

STEG Support

Throughout the trip MB and AC received excellent support from the STEG personnel. Transportation, lodging, and meals had been well planned and fully arranged. Nasari Habib, in particular, showed his strong commitment to the success of the wind system project.

Recommendations for Future Actions

Restoring the El Haouaria Test Site to full function will require repair or replacement of a number of items; most of which were damaged by lightning strikes. Continued full operation of the facility will require upgrading its surge-withstand capability and imparting upon STEG the capability to fuly support O&M and repair of the Sites' equipment.

The approach of giving STEG the capability to support the Sites' equipment is believed to offer many advbantages over that of purchasing extended warranties from the manufacturers. First, the main problem has been lightning and all of the involved manufacturers exclude lightning damage form their warranty coverage (eg.-Act of God). Protection against the financial effects of lightning is generally provided by the owners' business or home insurance policy. A warranty covering lightning damage in a foreign country would involve potential libailities in excess of the equipments' cost and would have to be priced accordingly. Finally, any warrranty so purchased would provide only a few years of protection; after which STEG would be back in its original vulnerable position.

In the U.S., Bergey and Jacobs wind turbines are supported in the field by a number of dealers an independent service technicians. These technicians are trained to the point that they can cope with nearly all of the problems they might experiece in the field. The manufacturers are available to provide recommendations and parts and, for the most serious problems, in-factory repair. The manufacturer, however, does not dispatch a technician in response to customer service calls.

By providing STEG with the spare parts holding, specialized service equipment, documentation, and training necessary to give them this same service capability AID will be ensuring continued successful operation of the El Haouaria Wind Test Site. The value of the facility to STEG will also be enhanced by a more thorough understanding of the equipment. (It is worth noting that the STEG personnel participating in the inspection trip

activites have technical backgrounds superior to most U.S. technicians and they were all enthusiastic about learning more about the wind systems.) The spcific recommendations outlined reflect this overall approach to future operational support for the facility.

Resistance to lightning damage can be upgraded by improving the grounding systems for the turbines and building, and through the additon of surge arrestors in a number of locations. BWC has specified special conductive-salt leaching ground rods for installation in the rock/sand soil of Cape Bon. These rods will require extensive trenching to install but are considered criticial to increased surge protection. Improved grounding wire and connectors have also been specified.

For the data acquistion system BWC recommends consolidating the two heavily damaged modules into one built around a new Campbell Scientific 21X Micrologger. Since both of the existing Campbell Scientific 10X units are damaged beyond repair the consoldation approach will give STEG essentially the same capabilites as before but at a greatly reduced cost. This work would be done at BWC and SERI following shipment of equipment to the U.S. BWC has specified additonal Campbell Scientific equipment which will allow STEG to read data tapes directly into their existing IBM-PC compatible microcomputers, thus enhancing their data reduction capabilities.

BWC is also recommending the additon of cummulative KWH meters on the output of each wind turbine and a new Secondwind AL-2000S wind data logger. These items would provide STEG with another method of analyzing system performance which would be easier to use than the more complex Campbell Scientific system.

Finally for the El Haouaria Site BWC is recommending a number of facility upgrades that are not directly related to the operation of the equipment but which would enhance the facilities' utility and appearance. Chief among these is a rewiring of the Electronics Room and relocation of the turbine transformers. During the original installation in 1984 the building was being built at the same time that the electronics were

installed. As a result the component placement and wiring is poorly organized and the installation lacks a professional apearance. It is not at all like the well-organized and attractive installation at Hammam Biadha. BWC proposes that this situation be remedied.

For Hamman Biadha BWC has specified energy monitoring instrumentaiton and a few other minor components. Some circuit board repairs wil also be necessary. BWC plans to add spare parts purchase, documentation upgrading, and training from Tri-Solar/Chronar Corp. to its recommended future activities. These activities would be combined as much as possible with future activities undertaken in support of the El Haouaria Site.

A preliminary agenda and schedule for a possible U.S. training program is attached. BWC recommends that the Bergey inverter, R.M. Young anemometers, and data system modules be shipped to BWC as soon as possible. If acceptable to AID, BWC would attempt to compile the proposed equipment for shipment in December of this year.

The second BWC trip to Tunisia could occur in late January, 1987 or later (weather will be an important factor). The efficiency of this second trip would be enhanced if STEG could arrange lodging in the gas-pumping station dormitory located immediately adjacent to the El Haouaria Test Site.

Specific Recommendations

Bergey Turbine

1. Replace corroded fasteners
2. Apply polyurethane coating to blade pitch weights
3. Install switch box stand and fused disconnect with surge arrestors at tower base
4. Move underground wire run termination box at tower base

5. Add grounding system to guy-wire anchors
6. Improve grounding of tower base
7. Replace 70A utility-side breaker with 80A
8. Ship existing Powersync Inverter to BWC factory for repair and calibration

Jacobs Turbine

1. Replace corroded fasteners
2. Rebuild blade pitch control mechanism
3. Replace alternator and surge protection
4. Add fused disconnect with surge arrestors at tower base
5. Improve tower grounding
6. Replace brake winch
7. Replace faulty underground wire run
8. Replace turbine's utility-side disconnect switch inside equipment room
9. Replace PCB-10 inside Mastermind inverter

Data Acquisition System

1. Replace anemometers
2. Ship existing anemometer units to R.M. Young factory for possible rebuild
3. Replace temperature sensors
4. Send data system modules and power transducers to BWC for consolidation and calibration (See Item 5)
5. Assemble a new single data system using a Campbell Scientific 21X Micrologger and components from the existing systems
6. Add an IBM PC compatible data download capability for STEG use
7. Upgrade surge withstand capability of all data system components
8. Establish a systems log for recording all actions and observations
9. Install kilowatt-hour meters on the output of each inverter (meters supplied by STEG?)*
10. Install a new Secondwind AI-2000S wind data logger*

Site / Facilities

1. Establish more extensive spares holding for equipment, including spare inverters
2. Have STEG install best available surge arrestor components on service entrance
3. Install AC line surge arrestors after main service breaker
4. Establish inventory of potentially necessary supplies such as paints, sand paper, adhesives, wiring materials, cleaners, tape, and toiletries
5. Add a small tools kit (electronics) and extension cords (to reach towers)
6. Remove shipping crate wood from storage room*
7. Install shelves and wall hooks in storage room for tools, equipment, and spares (See Figure 1)*
8. Evaluate merits of moving turbine transformers into the storage room (See Figure 1)*
9. Evaluate merits of reinstalling system switchgear and inverters using equipment hangers and large wiring tray (See Figure 2)*
10. Fix lighting in main room and add light fixture to storage room*
11. Install water cooler and/or clean out water line coming from compression station.*
12. Add facilities sign out at the main road*

Documentation

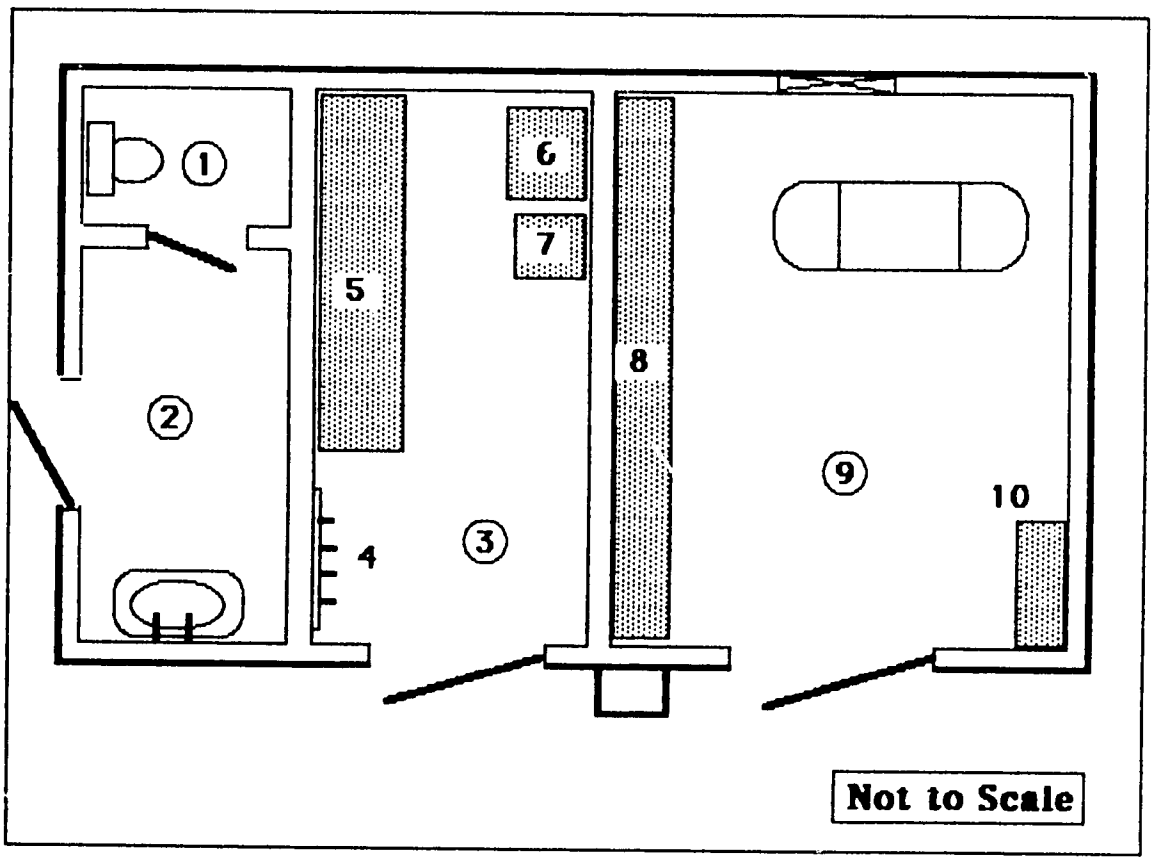
1. Compile/create an "as built" systems manual covering operation and maintenanace of the complete facility (System Owners Manual)
2. Compile/create diagnostic and repair manuals for discrete components of the system
3. If possible, obtain detailed wiring schematics for both inverters
4. Translate the above material into French and print at least six copies (1-AID/Tunis, 2-STEG/Tunis, 1-STEG/Site, 1-SERI/USA, and 1-BWC/USA)

Training

1. Encourage STEG to establish a stable technical team responsible for the operation of the El Haouaria wind energy test facility.
2. Bring this technical team to the U.S. for approximately 2 weeks of training at the BWC factory, a Jacobs facility to be determined, and the SERI Wind Energy Test Center.
3. Provide follow-up training during the second site trip.

* - These items are not absolutely necessary in bringing the wind energy test facility back into operation. It is believed, however, that they will enhance the utility and appearance of the facility.

PROPOSED ADDITIONS/MODIFICATIONS TO BUILDING CAPE BON TEST SITE



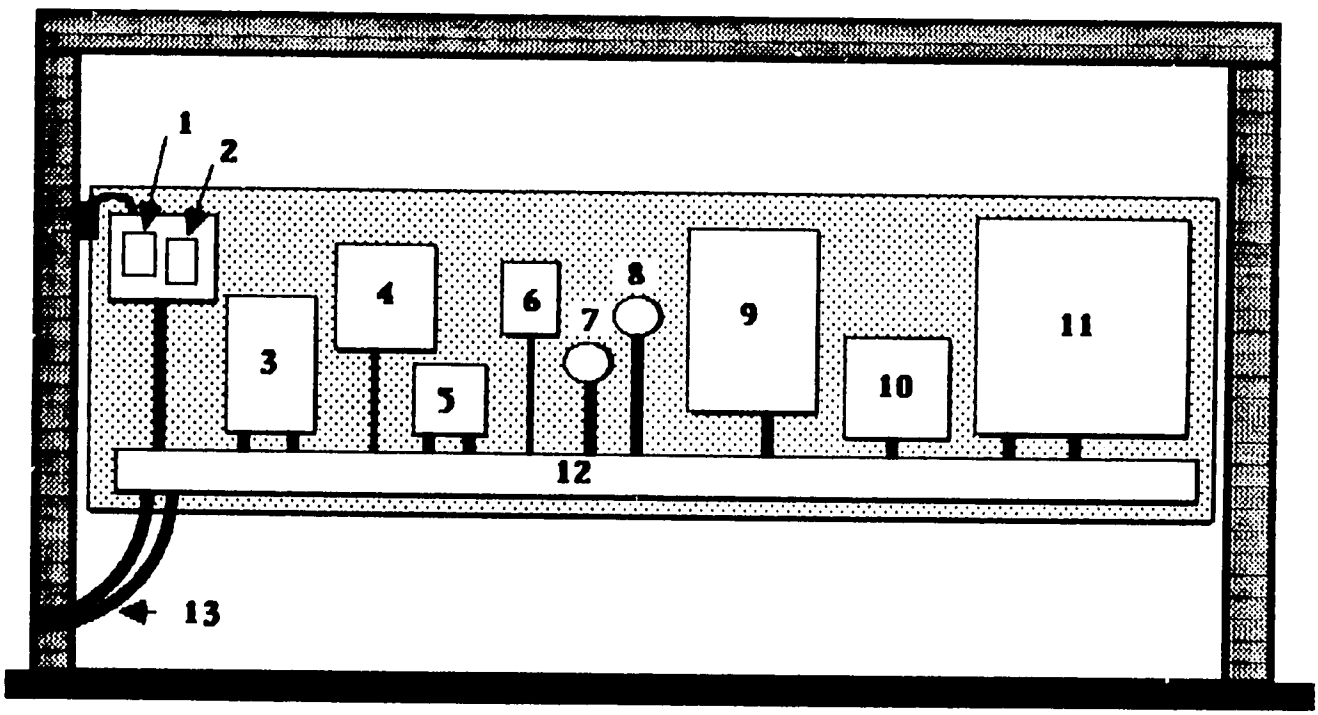
LEGEND:

1. Toilet
2. Wash Room
3. Storage Room
4. Equipment Hooks (add)
5. Shelves (add)
6. Jacobs Transformer (moved)
7. Bergey Transformer (moved)
8. Misc. Electronic Equipment
9. Electronics Room
10. Bookshelf (add)

FIGURE 1

BERGEY WINDPOWER CO., 1986

PROPOSED EQUIPMENT LAYOUT
ELECTRONICS ROOM
CAPE BON TEST SITE



EQUIPMENT:

1. Main Circuit Breaker
2. Kilowatt/hour Meter
3. Turbine Curcuit Breakers
4. Camp. Scien. Data Logger
5. Turbine Watt Transducers
6. Secondwind AL-2000S
7. Bergey KWH Meter
8. Jacobs KWH Meter
9. Bergey Inverter
10. Jacobs Choke Enclosure
11. Jacobs Inverter
12. Wiring Tray
13. Turbine Input Wires

Figure 2

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Preliminary Training Program Itinerary and Agenda

Oct. 9, 1986

Nov. 29 & 30: Travel to Norman, Oklahoma. Route TBD

Dec. 1-5: Instruction on Bergey system, Secondwind wind data loggers, and wind power technology in general. Location: Bergey factory

Dec. 6 & 7: Travel to SERI/Wind Energy Research Center, Boulder, Colorado.* Instruction on Jacobs systems and Campbell Scientific data logger

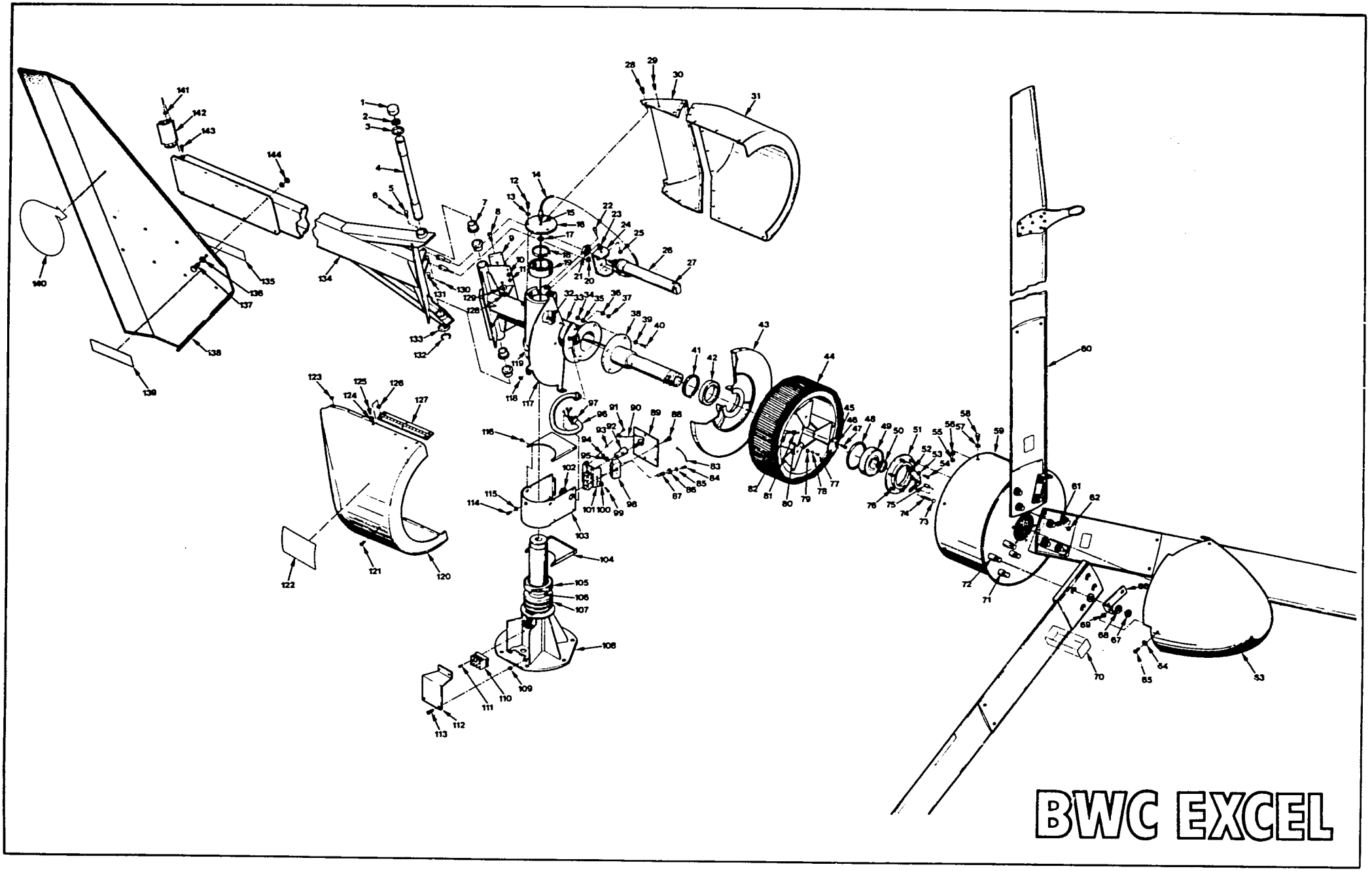
Dec. 10 & 11: Travel to Pryor Lake, Minnesota. Further instruction on Jacobs system.* Location: Pryor Lake Machine, Inc. (PLM has obtained service rights to Jacobs equipment)

Dec. 12: Travel to Boston, Massachusetts.* Tours of wind power and photovoltaics companies may be scheduled

Dec. 15 & 16: Instruction on Tri-Solar equipment.* Location: Tri-Solar/ Chronar, Inc., Bedford, MA

Dec. 17: Return to Tunis. Route TBD

* - accompanied by M. Bergey or other BWC representative


BWC EXCEL