Sun and wind power

New energy sources

by 1st Lt. R. Clark Dunn

In an era of declining fossil fuel reserves, some new energy sources such as wind power, fuel cells, and solar energy are being developed by the US Army at Fort Huachuca, Arizona, to power its more remote communications sites.

Because no better system has been available, the Army has for years depended upon the standard gasoline and diesel generators as electrical power sources even though commanders have been frustrated by the significant maintenance requirements of this equipment. However, the oil embargo of the mid 70's and recent studies which indicate a need for 80 percent reduction in the use of fossil fuels by the year 2000 has spurred an awareness of the need to develop alternate energy sources.

In addition, Army communications has long had problems with the installation of hardware at remote locations. The installation of commercial power lines to these sites often meant many miles of costly transmission lines. Where commercial power could not be installed on a priority mission, generator powered manned sites were utilized.

The Defense Communications Engineering Center (DCEC) at Reston, Va., is now providing the means through which alternative energy sources can be developed and produced, providing initial funding and a system concept. The US Army systems engineering necessary to deploy new energy technologies into the field is being carried out by the US Army Communications-Electronics Engineering Installation Agency (USACEEIA) at Fort Huachuca.

USACEEIA is working on developing alternative energy sources that will increase a site's survivability and dependability while reducing the costs of personnel and electrical power. This is accomplished by constantly monitoring state-of-the-art energy sources, testing off-the-shelf hardware, and providing the means by which a promising energy source can be integrated into the standard military system.

The Communications Engineering Directorate (CED) of USACEEIA has completed the design of the basic system and is working to complete a variety of system upgrades. The project, entitled "Unattended Defense Communications System (DCS) Power System," has been implemented using off-the-shelf hardware with a design objective to make the system unmanned except for a few visits during the year by maintenance personnel.

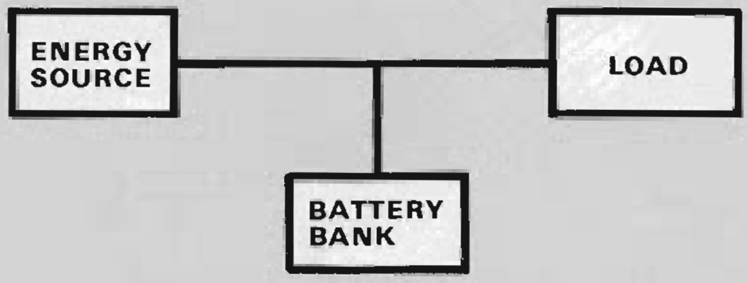
System design

The system is designed to work in the following manner:

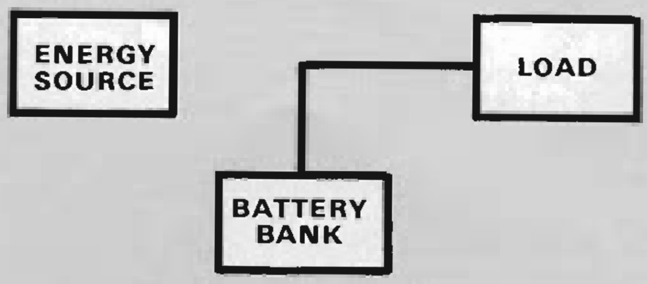
Since solar cells and wind-powered electric generators provide power at the sun's and wind's discretion, the energy must be captured and stored when it is available. The system, therefore, has three basic elements as depicted in figure 1.

The configuration will vary from one location to another. The energy source and battery bank are the primary interchangeable items, with the control and energy management system for the device remaining relatively the same. The device operates in two modes: the "charging period," and "discharging period." The charging period, as shown in figure 2, occurs when the system captures an alternative energy such as solar. Energy is supplied to the battery bank and load during this phase. The energy supplied to the battery is thus stored for use at a later time. When the energy source fades, the system begins its "discharge phase" as shown in figure 3. The system processes a variety of devices not depicted in the scheme, but the concept is simple and very effective.

BASIC COMPONENTS
FIGURE 1



SYSTEM CHARGING PHASE
FIGURE 2



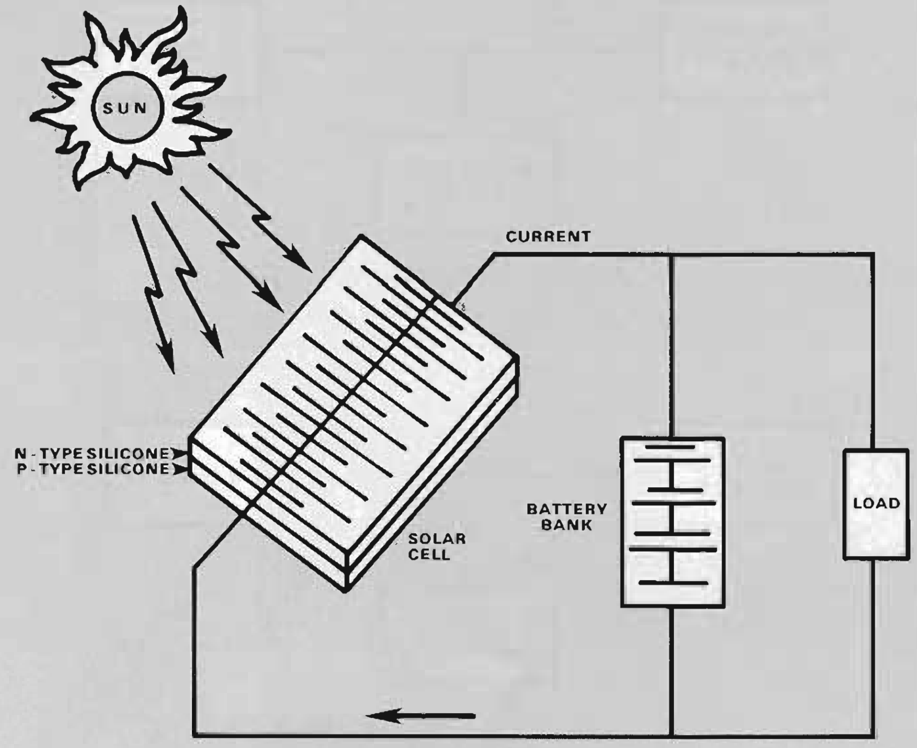
DISCHARGE PHASE
FIGURE 3

The initial system is designed to use a variety of potential electrical energy sources such as wind, solar, fuel cell, thermoelectric generator and closed cycle Rankine at this time. Currently being tested at Fort Hauchuea are solar cells and a wind-electric generator. Other sources are on-line to be tested in the future.

The solar cell

The USACEEIA test system's solar array consists of 72 solar panels to provide 2600 watts of solar energy input. The solar cell is a semiconductor device that converts light energy directly into electrical energy. The amount of electrical power delivered by the solar cell depends on the array size, light intensity, and solar cell efficiency.

Conventional solar cells are made by doping pure, cylindrical silicon crystals with other chemical elements. When phosphorus is added during the growth of the crystal, the silicon develops negative (n) charge carriers (electrons). When boron is added, positive (p) charge carriers (holes) appear. The crystal cylinders are then sliced into wafers. High-temperature diffusion of phosphorus into a boron-doped silicon creates an n-type-to-p-type junction and a built-in field. When the diffused silicon layer is illuminated, incoming units of light energy (photons) are absorbed by the electrons within the silicon wafer. This creates negative charges which are attracted to the p-type silicon. Thus, in basic terms, the striking of sunlight on the upper layer of the solar cell and subsequent passing of solar energy through the cell causes an electrical current flow. The solar cell is depicted in figure 4. The movement of electrons provides a current that can be used to charge batteries and power a



SOLAR CELL OPERATION
FIGURE 4

load. The cells are then carefully combined to form the correct voltage and current combination.

Wind power

The wind-electric generator is another source that is being tested. The device consists primarily of a multiple-induction alternator, a rectifier/charger and a shunt regulator, as shown in figure 5. The system is much like the common automotive alternator. The shunt regulator uses a field coil for regulation and thus allows the Unattended DCS Power System's control unit to disconnect the machine automatically.

Other systems

USACEEIA has recently begun testing a thermoelectric unit as an emergency backup device. The unit operates under the general principle of a common thermal couple. It is a device developed by the US Army Electronic Research and Development Command. The Corps of Engineers have also been tasked to install a closed cycle Rankine system as another energy source. This closed cycle Rankine system works on the steam generator principle and is reliable in harsh environments. A 2000 watt unit is tentatively scheduled for test late this year by USACC at Fort Huachuca.

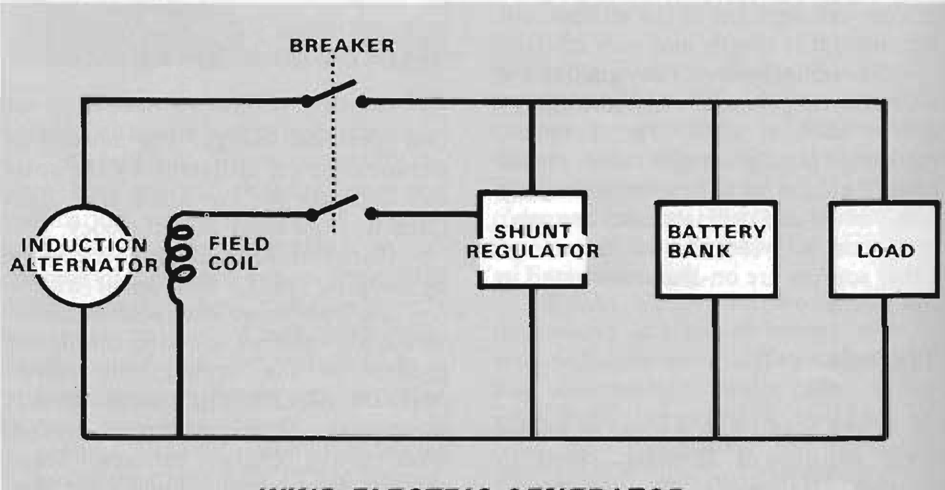
Another technology being monitored is fuel cells. These devices are currently used by NASA in the space program and were developed by United Technologies for field use by the Army. The devices are highly efficient and quiet. They are fueled with methanol. Although many other technologies have been considered and found impractical for application, USACEEIA continues to monitor industry for devices that are suitable for deployment into field test environments.

One versatile basic unit

USACEEIA's intent in the design phase of this program was not to provide a vast assortment of unique new systems, but instead to fabricate one basic unit capable of adapting to a variety of sources and loads. USACEEIA intends to provide a system that the agency could use in a variety of ways, not a unique device that will require a research and development effort every time a new site is planned.

The system, therefore, is versatile. It can be installed in a variety of existing shelters, and each source is designed to be compatible and combinable with all other sources. Planners have already begun to look at providing a variety of system voltages.

The existing prototypes at Fort Huachuca are presently installed for 48 volts operation which is the standard US Army installation for several communications facilities. The solar array, wind generator, battery bank, and control units could easily be reconfigured over an operational range of 5 to 70 volts with relatively minor changes of a few component values and some rewiring.



WIND-ELECTRIC GENERATOR
FIGURE 5

The system has been designed for ease of operation using standard hardware readily obtainable. Much of this hardware is available in the military logistics system at the present time.

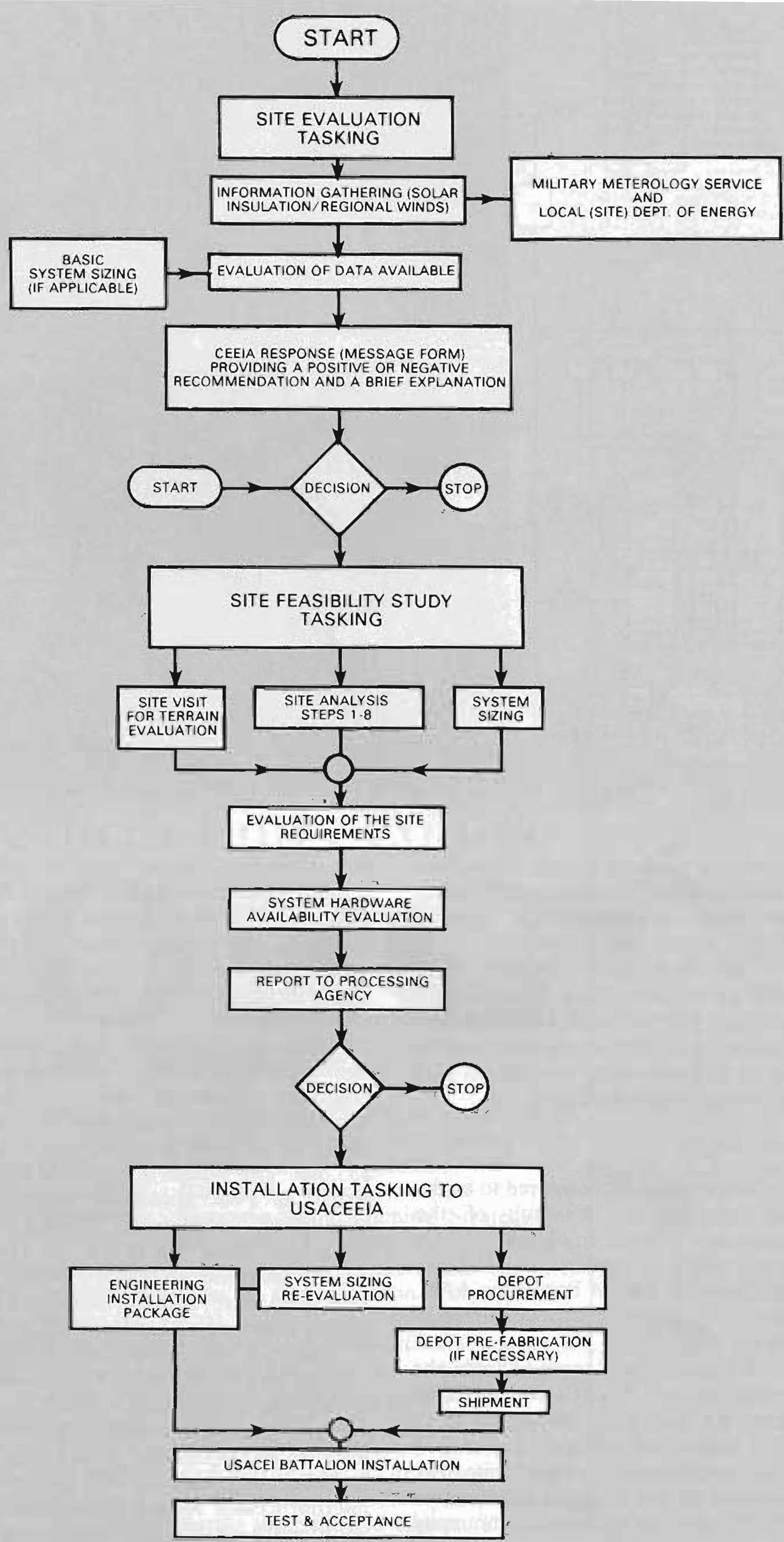
USACEEIA is also working with other engineers in Hawaii on a system to be installed there. Only 12 items outside of the normal military inventory have been identified so far. Upon the completion of the USACC-WESTCOM's remote solar system for the Bradshaw AAF, Hawaii, the unique items will be incorporated into the normal military inventory.

The quick maintenance concept is simplified with a microprocessor unit that will provide control, monitoring and alarms. Maintenance personnel will be automatically alerted to problems such as low battery charge, battery overheating, shelter overheating, security (shelter intrusion and solar panel theft), dust on the solar array, or failure of a component within the system itself.

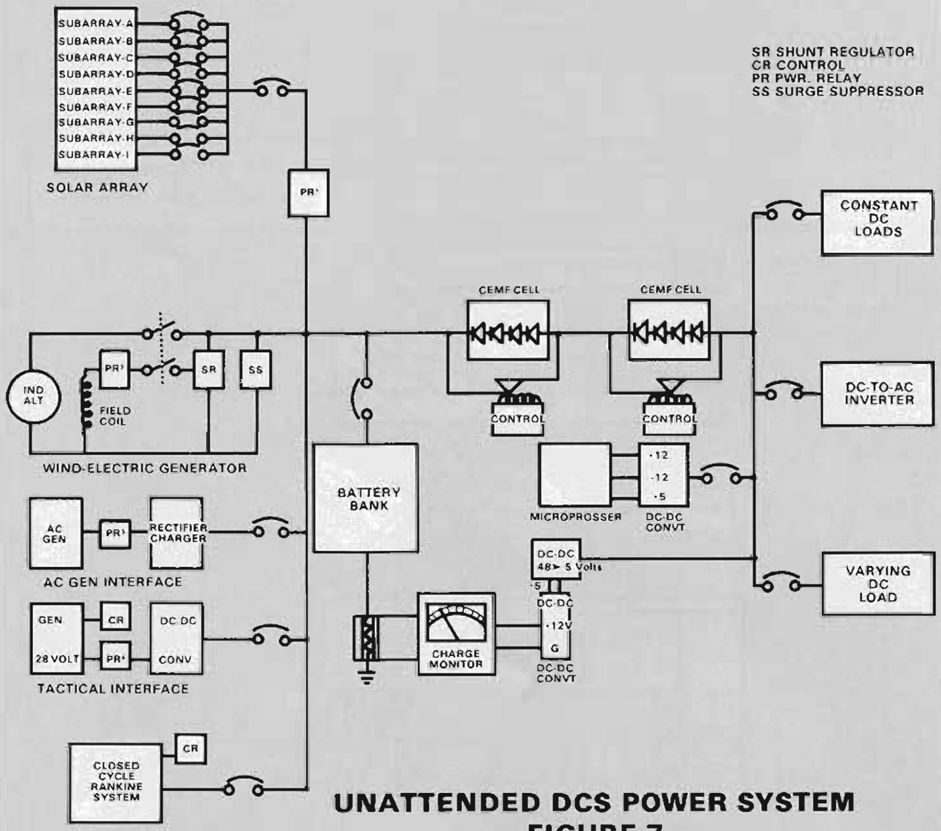
The radio receiver and alarm display locations are miles away from the system at a manned site. These sites will even be alerted to the failure of the monitoring system itself. The maintenance personnel in charge of the site will be required to check the system only two to four times yearly. Repairs needed will be performed on location. In the case of failure, the microprocessor would be sent back to the manufacturer for exchange. The site personnel would change only the card itself in this event. Ease of installation, maintenance and repair is a major objective in the design.

System deployment

To deploy the alternative energy system, USACEEIA has researched a variety of proven system sizing methods developed by government agencies and private concerns. The agency has consolidated a variety of proven approaches into its own sizing method. The new approach, however, determines the individual and combinational sizes of solar array, wind-electric generator, fossil fuel generator, and synthetic fuel generator necessary to support a specific load at a given location. The engineer then selects the best system as a function of cost, geography, sites peculiar restrictions, survivability factors and other variables. The methods used by USACEEIA are effective, and the



UTILIZATION CONCEPT FIGURE 6



UNATTENDED DCS POWER SYSTEM
FIGURE 7

system should be deployed in the field by 2nd quarter FY83. The system sizing flow chart is presented in figure 6 entitled "Utilization Concept."

The flow chart reflects three distinct steps addressing the utilization concept: general evaluation of the situation, feasibility study and production of an engineering installation plan and subsequent installation.

Case study

This method is considered to be the most practical as a result of the experience gained in USACEEIA's current effort to engineer and install a solar powered load at Bradshaw AAF, Hawaii. The effort began as depicted in figure 6.

A message was received from the commander of USACC-WESTCOM requesting that solar energy, or some other means, be sought to power a recent installation at a remote site. The command at that time was faced with a $200,000 cost for installing commercial power to this remote location. The Transmission Interface Division (XET) of USACEEIA was directed to study the matter in view of the division's current involvement with the "Unattended DCS Power System" project. XET accepted the tasking.

Engineers reviewed the location and discovered its high potential. A feasibility study of the site then determined that a solar powered load could be installed at the site for about $85,000. The system is currently being tested at Fort Huachuca. After its installation in Hawaii, USACEEIA hopes to assist USACSA to type-classify the device so that it can then be assembled in any military depot and be readily deployed, as needed, worldwide.

The US Army Electronic Proving Ground at Fort Huachuca is presently testing and maintaining USACEEIA's system. The basic modular system is installed and functioning as expected. It is being upgraded to incorporate a microprocessor for redundant control, additional early-warning monitoring of temperature extremes, security, and device failure. The system will be installed at the Hawaiian site after it has passed full testing under actual use at Fort Huachuca. In addition, other energy sources that could be deployed with the system are under consideration. Approval to install and test some promising sources has been received, which will computerize the time-consuming process of system sizing/selection.

A new device, the Closed Cycle Rankine System, will also be added to the system and tested at Fort Huachuca. Upon the completion of this testing phase, the system will be augmented by an additional 6000 watt solar array, inverters, and associated control hardware to evaluate the use of alternative energy sources in conjunction with existing ac power grids. Such an arrangement will reduce a site's dependence on commercial power, provide additional energy during emergency power failures and provide this while saving the government money by reducing energy costs.

The ultimate objective of USACEEIA is to provide a modular, easily deployable system that can be deployed worldwide with great flexibility. The prototype is depicted in figure 7. Flexibility over voltages, a combination of energy sources and the ability to operate independently, or to interface with conventional power systems, will soon insure a readily usable system, for deployment anywhere in the world.

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1st Lt. Dunn is a 1979 graduate of Mississippi State University. In addition to his degree in Electrical Engineering, he earned his commission from the university's ROTC program. After completing the Signal Officer Basic Course at Fort Gordon, Ga., he was assigned to the US Army Communications-Electronics Engineering Installation Agency at Fort Huachuca, Arizona.