14. ALTERNATIVE ENERGY & FUEL

14.01 Energy:

Our access to normal sources of energy can be disrupted by a disaster and we should therefore plan to provide for critical energy needs. Relatively inexpensive and simple equipment and supplies can help us address critical needs when normal sources are disrupted.

14.02 Electricity:

Electricity is probably the most important type of energy we need after a disaster to provide for critical lighting and communication needs. A small DC power system can address most of these requirements.

In order to decide how much energy is needed we must understand how energy is measured when it is produced, stored or used. In order to understand this we will have to define some terms:

- **Amperage (Amps)** - the amount of electricity (electrons) that flow through a given electrical circuit per unit of time
- **Voltage (Volts)** - the energy associated with each electron as electricity flows
- **Wattage (Watts)** - unit of power defined as volts x amps which is a measure of power or energy usage per unit of time
- **Watt - hour** - the amount of energy that is used by powering a one-watt piece or equipment for one-hour. We are normally billed for electricity by the kilowatt-hour which is a flow of 1000 watts for one hour or 100 watts for 10 hours, etc.

To illustrate the previous definitions we will address some practical problems:

Problem 1: How long can a 0.5 amp 12 volt light run on a 100 amp-hour 12 volt lead acid battery?

First of all, we do not want to totally discharge a 100 amp-hour lead acid battery so we will only plan on using 50 amp-hours before charging the battery.

50 amp-hours/ 0.5 amps = 100 hours

The battery will store enough energy to power a 0.5 amp light for 100 hours.

Problem 2: How long can the same battery operate a 50 watt light bulb?

50 amps hours x 12 volts = 600 watt (amp x volts) hours capacity
600 watt hours/50 watts = 12 hours

The battery could only power a 50-watt bulb for twelve hours.

Problem 3: What size solar panel would be required to power a 50 watt bulb for 4 hours each night?

A solar panel can be expected to provide its rated output for an average of 6 hours per day when cloudy day's indirect lighting during morning and evening hours and seasonal variations are taken into consideration. This varies with climate and latitude.

> 50 watts x 4 hours = 200 watt-hours
> 200 watt-hours/6 hours = 33.3 watt solar panel

When inefficiencies in battery storage and power conversion are taken into account, a 40 watt solar panel would be required.

Critical needs for electricity would be for lighting, communication, and even entertainment. Small rechargeable batteries are ideal for most lighting and communication needs. With the current availability of light-emitting-diode (LED) lighting a personal flashlight can operate hundreds of hours on a set of 2000 milliamp-hour (mAh) batteries with one charge. Small AM, FM or shortwave radios can operate many hours on a set of similar rechargeable batteries. Ham radios can also be operated in the receive mode on a few watts of power with up to 100 watts being required for transmitting. There are many types of battery operated equipment that might be used. It is up to the individual to choose good quality equipment along with enough redundancy to ensure that critical needs will be met.

14.03 Electrical Generating Equipment:
Small energy requirements can be addressed by relatively small and inexpensive power generating equipment. A small solar panel is a good start for a small system. The panels are relatively light, portable and rugged and produce their rated power output when exposed to full sun. Solar panels can b purchased for roughly $5 per watt of rated power generation capacity and they can last for decades if undamaged. A small wind turbine is also very practical for such applications. They can be mounted on a relatively small pole and produce useable power in winds as low as 5 mph. They cost roughly $1 per watt of rated capacity and are also quite durable and portable. They are prone to mechanical problems since they do have moving parts but a well-built wind turbine should last for many years with relatively little maintenance.

Human powered generators can also be very useful to address low usage electrical generating needs. They are especially useful in emergency shelters where power from the sun and wind are not accessible. An individual can produce over 100 watts of power for an extended period of time. Such generators are available for a few hundred dollars.

A gasoline or diesel powered generator is very useful for short term high power requirements. Such generators vary widely in cost, quality and fuel efficiency but are generally available for roughly $0.20 per watt of rated capacity. They require roughly 0.25 gallons of fuel per kilowatt (1000 watts)-hour of energy produced. They also generate a significant amount of heat and toxic exhaust. A gasoline or diesel powered generator should never be operated in an enclosed area unless the exhaust is piped outside. A source of combustion air and cooling air is also required.

Diesel powered generators tend to be more fuel efficient, heavier and last longer than gasoline powered generators but they also tend to be more expensive. Again, there is a significant variety of equipment and some time should be invested in researching individual needs and available equipment before a purchasing decision is made.

14.04 Electrical Energy Storage:
Batteries are an essential part of any alternative power system in order to allow storage of electricity energy and to stabilize system voltage for both generating and power using equipment.

Lead-acid batteries are very common and can be used for many years if used properly. Lead-acid batteries vary widely in size, capability and design. We are very familiar with automotive batteries that are used to start cars but such batteries are designed to deliver high amperage for a very short period of time and then receive an immediate recharge. Such batteries do not operate well in alternative power applications. Deep cycle batteries designed for use in industrial or commercial applications such as golf carts or floor scrubbing machines are the best for providing a relatively small amount of power over a long period of time with deep discharge cycles. Even industrial lead acid batteries should not be discharged below 50% of their rated capacity because it will significantly shorten the life of the batteries. Lead-acid batteries should not be charged or discharged at a rate greater than 5% of their rated capacity per hour to prevent damage to the batteries. The batteries should have enough capacity in Amp-hours to provide needed power between charges.

Wet Cell (flooded), Gel Cell and Absorbed Glass Mat (AGM) are various versions of the lead acid battery. The wet cell comes in 2 ways, serviceable and maintenance free, both are filled with electrolyte and I prefer one that I can add water and check the specific gravity of the electrolyte with a hydrometer. The Gel-Cell and the AGM batteries are specialty batteries that typically cost twice as much as a premium wet cell. However they store very well and do not tend to sulfate as easily as wet cell. There is no chance of a hydrogen gas explosion or corrosion using these batteries.

Most Gel-Cell and some AGM batteries require special charging rate, especially the deep cycle models. Careful consideration should be given to the AGM battery technology. Applications such as Marine, RV, Classic and Performance cars just to name a few. If you don't use or operate your equipment daily; which can lead to premature battery failure; or depend on top-notch battery performance then spend the extra money. Gel-Cell batteries still are being sold but the AGM batteries are replacing them in many cases. There is a little confusion about AGM batteries because different manufactures call them different names; a couple of popular ones are regulated valve and dry cell batteries. In most cases AGM batteries will give double the life span and many more deep cycles than wet cell battery.

Battery Maintenance is an important issue. The battery should be clean. Use baking soda and water mix. Cable connection needs to be clean and tightened. Many battery problems are caused by dirty and loose connections. Serviceable battery needs to have the fluid level checked. Use only mineral free water, distilled water is best. Don't overfill battery cells especially in warmer weather. The natural fluid expansion in hot weather will push excess electrolytes from the battery.

To prevent corrosion of cables on top post batteries, use a small bead of silicon sealer at the base of the post and place a felt battery washer over it. Coat the washer with high temperature grease or petroleum jelly (Vaseline). Then place cable on post and tighten, coat the exposed cable end with the grease. Most folks don't know that just the gases from the battery condensing on metal pats cause most corrosion.

Smaller power requirements are addressed with rechargeable nickel-metal hydride (NiMH) or Nickel-Cadmium (NiCd) batteries. In general NiMH batteries last longer and do not develop a "memory" if the batteries are not completely discharged before recharging. These batteries should be discharged completely before recharging to maintain proper operation and to minimize the number of charge cycles. Such batteries have a rated capacity in "milli" or 1/1000 of an amp-hour. A "AA" size battery can be rated as high as 2500 mAh for example. NiMH or NiCd batteries require a specific type of charger as well as lead acid batteries. It is prudent to gather a reasonable amount of information and to select good quality battery charging equipment before purchasing. It is also prudent to operate the equipment before a disaster to ensure that the equipment is functional and that proper operation of the equipment is understood.

14.05 Charge Control Equpment:
Electricity generating equipment such as solar panels and wind turbines can overcharge batteries in hooked to a battery directly. A charge controller should be placed between the battery and the generating equipment to prevent overcharging which can damage a battery. The charge controllers monitor battery voltage and reduce charging rate accordingly until charging is stopped at full charge

14.06 Energy Conversion Equipment:
Electrical appliances and equipment require specific voltages and types of electrical current to operate. For example, most household appliances use 120-volt alternating current (AC) electricity. Small portable electrical equipment use batteries that are much lower in voltage providing a direct current (DC) or constant voltage. Most battery chargers convert 120 volt AC to a lower voltage DC current in order to charge the batteries. There are also inverters that convert 12, 24, 36 or 48 volt DC voltage from battery banks to 120 volt alternating current. Inverters are useful in using DC batteries that are charged by various power generating equipment into a useful form for normal household equipment.

14.07 Space Heating:
It is a significant undertaking to store enough fuel for heating a home for an entire heating season but many individuals do it on a regular basis. The amount of fuel varies depending on climate and

size of the structure. Wood, coal, and home heating oil can be stored for a significant amount of time and function well if the proper stoves or furnaces are available.

There are viable alternatives to heating a large structure in a disaster situation. First of all, underground living spaces do not require heating in most climates and would provide an adequate living space. Second, the proper clothing can provide adequate protection from cold temperatures without requiring any fuel.

14.08 Cooking:

Cooking is accomplished by heating food to a target temperature and holding it for a specified time. If the temperature is higher the cooking time is decreased. An increase of 18 degrees Fahrenheit can halve the cooking time. Steaming, cooking in oil, or using a convection oven decrease cooking time by decreasing the time that it takes to attain the cooking temperature.

There are many different types of cooking equipment and all can be effective. It is important to obtain viable stoves or other types of equipment and to store enough fuel for cooking for an extended period. An individual should practice with the cooking equipment prior to the disaster situation to ensure proper function of the equipment and adequate proficiency of the operator.

Alcohol fueled stoves should be considered due to the clean burning nature of the fuel and long shelf life.

The sun can be used as a heating source for cooking. A solar oven can be constructed using cardboard, aluminum foil, and a piece of tempered glass. The basic function of the oven requires reflecting as much light from the sun into an insulated box as is required to reach the appropriate cooking temperature. There are several commercial solar ovens on the market and detailed information about building a sun oven is available from several sources.

A large cast iron pot with a tight fitting lid known as a "dutch oven" is useful for many types of alternative cooking methods. A pressure cooker can also help conserve fuel by raising cooking temperatures and significantly reduce cooking time.

An insulated box, otherwise known as a "hay box", can also be very useful for conserving cooking fuel. Once a pot is heated to the appropriate temperature it can be placed in an insulated box where it will maintain the cooking temperature for up to 12 hours. A "hay box" can be constructed of any structurally sound box with a relatively tight fitting lid. The box should be large enough to allow placement of at least 3 inches of rigid foam insulation on the bottom, sides and lid. The foam insulation should have foil faced on the inside layer to help reflect radiant heat back into the cooking container. A piece of wood should be placed on the inside bottom of the container to prevent damage to the soft insulation from the cooking container.

A "hay box" works particularly well on stews and soups. Once the ingredients are brought to a boil the pot is placed in the "hay box" for several hours until it is cooked. It will hold the food at serving temperature after it is cooked for many more hours.