SECTION 4

DISPERSED ENERGY SOURCES AND COMMUNITY SURVIVAL

DISPERSED ENERGY SOURCES AND COMMUNITY SURVIVAL

Introduction and Overview (4.1)

Reduction of national vulnerability through short and long range programs to encourage the utilization of dispersed and renewable sources of energy has not been traditionally considered an element of emergency and civil defense planning. However, as prior sections of this study note, decentralized energy and resource options are by their very nature less vulnerable to system disruption. Therefore, they constitute prime targets for contingency planning. With the additional advantage of renewable fuel capability, decentralized energy sources offer long range strategic advantages, including the reduction of dependence on imported resources and fuels.

Reduction of fuel dependence and improvement of energy system integrity are both elements of strategic counter-war planning. The pressures toward war frequently are related to critical dependence on and competition for scarce fuels; therefore, reduction in this dependence helps to reduce the liklihood of war.

Past civil defense programs have emphasized potential measures to reduce casualties, preserve essential resources (food, water, energy, etc.) and minimize industrial and economic damage. However, the major thrust of all past programs has been to (a) minimize fatalities and industrial damage in areas affected by nuclear attack, and (b) to relocate large numbers of people from potential target areas. Given the current budgetary constraints ($100+ million per year for all programs), it is very difficult to adequately plan for major contingencies such as continued supplies of food, water and energy for centralized systems.

As a result of U.S. inattention to civil defense activities on a large scale, the vulnerability of the U.S. to nuclear crisis and nuclear war has increased substantially. The minimally funded programs for crisis relocation, if California is an example (and, in theory, this state is said to be far ahead of others), are only just beginning to take into account critical resource planning (food, water and energy) that must necessarily accompany population evacuation. At present, the Federal Emergency Management Agency (FEMA) is empowered to deal with a wide variety of emergencies, crises and civil defense activities. Preliminary research efforts indicate that contingency planning can be integrated, so that resource plans for a number of crises and emergencies can be effectively merged to reduce vulnerability.

From the standpoint of civil defense planning considered in isolation, a considerable number of U.S. experts have concluded that years of inattention to population protection (shelters, etc.) has resulted in a serious U.S. strategic problem. In congressional testimony, Dr. Samuel Huntington, Director of Harvard University's Center for International Affairs, stated:

> By their words and actions, the Soviets have shown that they believe civil defense to be a critical element in deterrence. Given their belief, whether warranted or not, in the efficacy of civil defense, they can only perceive the United States as being weaker for absence of such a program. Given the importance they attach to damage limitation as a necessary element in a deterrent posture, they cannot assign a high level of credibility to a deterrent policy which does not attempt to limit damage to U.S. society if that policy had to be implemented. A substantial asymetry in survivability between Soviet and American societies in the event of nuclear war can only encourage the Soviets to question the seriousness of U.S. purpose and hence also encourage them to follow a more adventurous policy.
>
> ...In the event of a confrontation with the Soviet Union in which American society was considerably more vulnerable than Soviet society, the credibility of the U.S. nuclear deterrent with respect to Soviet military and diplomatic pressure on Western Europe military and diplomatic pressure on Western Europe would be greatly reduced in the eyes of both the Soviets and the Western Europeans. This does not imply that this U.S. disadvantage would lead the Soviets to risk lightly nuclear war...(However,) in an age of strategic parity, the greater the vulnerability of American society, the less the credibility of the U.S. strategic forces as a deterrent to Soviet military action in Europe or elsewhere.[1]

There is considerable controversy over the efficacy of civil defense programs, to "save" a substantial number of people in the event of nuclear war. Obviously, in an all-out exchange such as that described in Section 1 of this report, in which 20 million to 160 million Americans would be killed immediately, even the best-funded CD programs would be hard-pressed to offer much in the way of survival options. Residual radioactivity alone would render most of North America uninhabitable and deaths on an unprecedented scale would follow for generations.

However, in the case of a more limited exchange of weaponry or isolated terrorist events using nuclear weapons or even conventional bombs which could create serious disruptions to centralized energy, food, and resource supply systems, massive shortages causing injuries and deaths could be minimized, if not eliminated, by properly planned CD programs incorporating effective energy and resource contingency planning.

It is somewhat surprising that local, decentralist approaches to population vulnerability and defense planning have not been taken as seriously as decentralist approaches to the protection of nuclear weapons systems. A key strategic objective in weapons system planning is the protection of large numbers of weapons (carried by submarines, bombers and missiles) for retaliatory reasons. Dispersal of nuclear weapons to prevent destruction by enemy targeting of weapons in centralized locations has historically been a key factor in military planning. The newest nuclear missile system, the MX, planned for use by the U.S. in the 1980s, is designed to be housed in multiple and movable shelters in order to disperse potential targets and reduce "first strike" destruction. This concept is based on the ability to hide any one of the proposed 200 missiles in one of 23 shelters. This forces enemy targeting of all 4,600 missile shelters in the MX system to assure destruction of all the missiles during an attack. Taking the decentralist approach to nuclear weapons protection another step, defense consultant Richard Garwin has proposed a water based submarine version of the MX system. This proposal would involve the building of a fleet of mini-submarines (called SUM - Shallow Underwater Submarines), each capable of carrying two MX missiles. According to his analysis, the planned land-based MX system is too centralized, and a 1980s fleet of 77 submarines would be more decentralized, less expensive, and could "protect" the weapons equally as well.*[2]

There has been little attention to similar issues of dispersal and decentralization in planning for population survival, especially in areas of resource contingency planning. Prior U.S. research has concentrated on the protection of weapons, military installations, major target areas and the like.

In a strategic sense, the population dispersal issue has been raised by physicist Theodore Taylor, who would use modern technology to disperse and decentralize major cities, "so that there aren't targets like Tokyo and London and Leningrad any more."[3] On this point, Nigel Calder, author of a recent analysis of nuclear war prospects, counters:

> The snag is that to target villages is just a matter of subdividing the payloads of missiles into more and more independently targetable warheads, or else relying upon radioactive fallout to kill people over huge areas. A village and even a city would be safer from attack or threat of attack if it were not part of a nation-state itself may disappear in the nuclear age. It could conveivably give way to a world empire, run by one power with a monopoly on nuclear weapons, or a global police state engineered by frightened consensus, or a benign and nonbureaucratic world government ministering to Taylor's "globe of villages."[4]

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*It is interesting to note that both in the case of the land-based MX system, and Garwin's SUM substitute, alternative energy sources such a fuel cells (for the submarines) and solar energy (for the land MX) are proposed for energy sources. Although civilian planners may not be overly concerned with the development of alternate, renewable energies, the military has taken this into account.

However valid Calder's points may be on the overall impacts of such a massive population dispersal, he fails to address the salient points of decentralization as a strategic energy/vulnerability option. In Sections 1, 2, and 3, the overwhelming vulnerability of the U.S. to serious resource shortages is addressed. Such vulnerability exists whether or not nuclear war occurs. Enhancing the overall security of the U.S. by decentralizing and dispersing energy resources to better serve local populations may well serve as a primary deterrent to nuclear war. Policies of conservation, dispersion and accelerated reliance on renewable, local and more efficient fuel and power options would accomplish the following:

- Reduce reliance on imported fuels, thereby decreasing chances of international war (over scarce fuels)
- Reduce reliance on strategic materials, through reduction in imports and lessened demand, thereby decreasing chances of international war (over scarce materials)
- Reduce vulnerability and dependence on centralized energy and resource systems, thereby reducing likelihood of attack (or sabotage) on central systems
- Reduce dependence on centralized systems, thereby increasing local self-sufficiency, thereby protecting population in case of crisis, disruption or attack
- Increase reliability of local energy and resource systems, thereby insuring a more rapid and higher rate of community recovery from disruption in central systems

Community Survival and Recovery: Background (4.2)

In the 1960s and the 1970s, a number of studies were completed for U.S. civil defense agencies on supplying emergency power to communities affected by centralized power disruptions. In the field of electrical power and natural gas, the key studies were performed for the Office of Civil Defense by URS corporation.[5,6,7]

The studies addressed the problem of emergency power requirements ranging from needs for public shelters, energy facilities, public services, industrial facilities and other key needs. Damage from a nuclear attack would result in serious failures of electric equipment, including the effects of electromagnetic pulse (EMP), and destruction of facilities and grids. Three scenarios indicating the need for emergency power are summarized below:

> EXAMPLE 1: Providing Ventilation for a Large Shelter
> A shelter occupied by 5,000 persons receives minimal blast damage but moderate fallout. Shortly after the attack, commercial power is not available. Battery-powered lighting is immediately activated and, since the shelter if at full capacity, standby manual ventilation equipment is put into immediate operation. After several hours the battery-operated lighting units begin to fail and the effective temperature in the shelter rises dangerously close to 85°, despite the utilization of all available means of ventilation. The shelter manager is now faced with the possibility of evacuating some or all of the occupants through an unsafe (e.g., radioactive) environment or staying and risking serious overheating problems. If this shelter had been provided with an engine generator set (or its equivalent) sufficient in size to maintain a ventilation rate of 15 cfm per person and a lighting level of 5 foot candles (a 75-kw generator would suffice), the problem would not have arisen.
>
> EXAMPLE 2: Emergency Power for Shutdown Operations
> The superintendent of an oil refinery (100,000 barrel/day capacity), recognizing the value of a rapid shutdown procedure in the event of natural or nuclear disaster, had made necessary plans for such a shutdown. Since the power-generating station was nearby and the refinery was served by three separate incoming services, power failiures had never been a problem. Therefore, he decided to rely upon commercal power for the shutdown procedure. However, the attach came with little notice and, while not affecting the immediate locale, did temporarily disrupt the regional power grid, resulting in loss of power to the refinery for several hours. As a result, control systems were inoperable (although air-activated controls operated until pressure dropped), the steam supply (essential

to the shutdown operation) was rapidly used up, and cooling water pumps stopped. Serious thermal damage occurred in several of the large units, products solidified in pipelines, and one isolated unit caught fire and burned. Still, the plant superintendent considered himself very fortunate that explosions and fires did not occur through the plant. If sufficient emergency power (approximately 4,800 kw), had been provided to run essential controls, boilers, and cooling pumps, damage would have been minimal instead of extensive.

EXAMPLE 3: Maintaining Production Quotas
Some weeks after the attack, when recovery operations had begun, the superintendent of a "hot" mill was asked to begin the production of can stock for the upcoming canning season. Since the facility was undamaged and raw materials were available, production seemed assured. However, as production resumed, it was found that the availability of commercial power presented a major constraint. Because the commercial power system was still being repaired and demands were numerous, the system was overloaded, with consequent frequent outages. It finally became necessary to enforce quotas for consumers. The result in the mill was that the production of can stock was sharply reduced and, concomitantly, the reject rate sored, due primarily to instability in the hot processes. To increase the amount of power available and to improve the reliability, the plant adopted the concept of providing supplementary power by "underdriving" a portion of its large motors. This required connecting diesel prime movers, with appropriate controls, to eight of the large motors in the plant. These prime movers were then routinely run to provide approximately 15 percent of the total operational load. Further, they were so connected that when power outages occured they could serve as emergency generators to maintain control over the hot processes. Under this system, production approached anticipated levels and the reject rate declined sharply.[8]

The studies found that major needs for emergency power would come from shelters, mass-care centers, utilities and industry. In the event of failure of conventional systems emergency power sources would be engine generator sets, industrial generators (isolated from main grids), and unconventional sources. Such unconventional sources would include synchronous motors (found in industry) which could be "reversed" to provide emergency generators (locomotive and ships). Specific studies were done on the feasibility of converting induction motors to run backwards as induction generators.*

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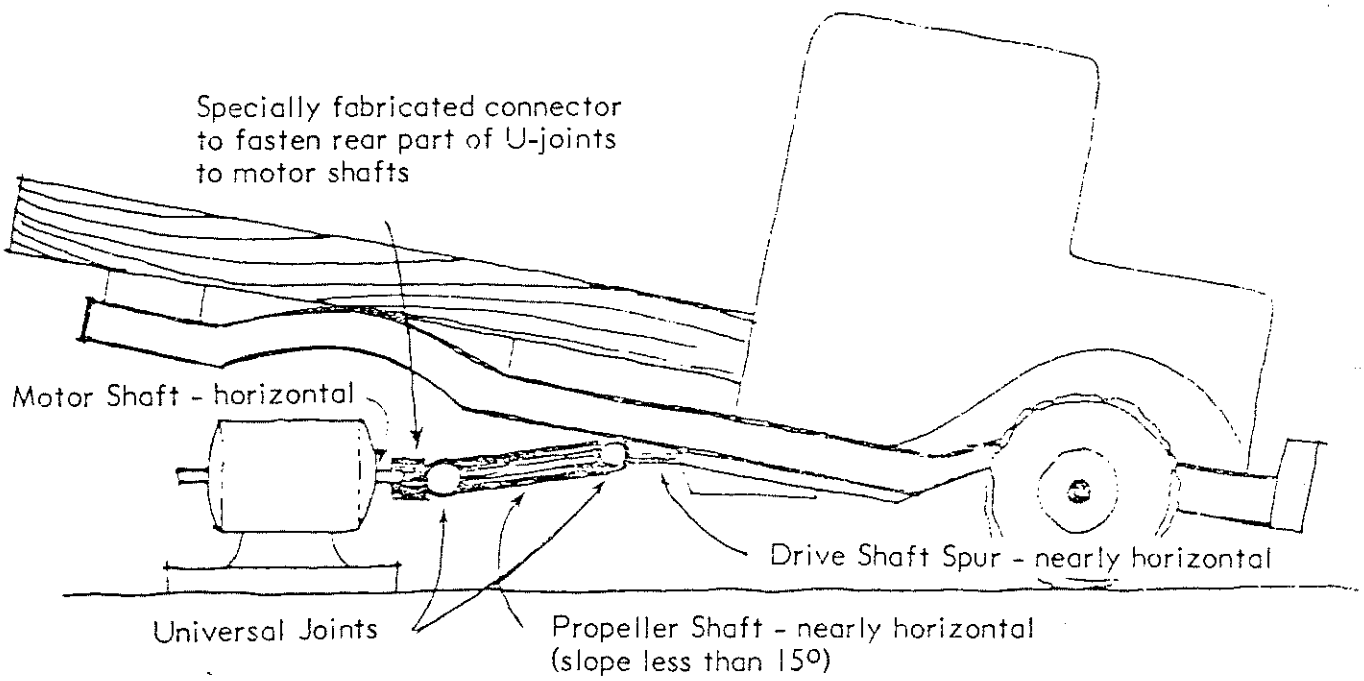
*The basic principle of the induction generator is easily understood when one considers that the energy flow in induction machines is a reversible

The URS study on induction motors found that 10-150 horsepower motors are common in many industries and commercial facilities. Components to construct induction generators are commercially available; they include induction motors, power capacitors, motor controllers, engines, equipment to connect drive shafts of engines to motor shafts, and fuel and coolant sources. Figure 4.2-1 and 4.2-2 illustrate the connection of a truck engine to an induction motor for induction generation, and a schematic of the load connection.

Figure 4.2-1[10]

CONVERSION OF TRUCK ENGINE TO INDUCTION MOTOR



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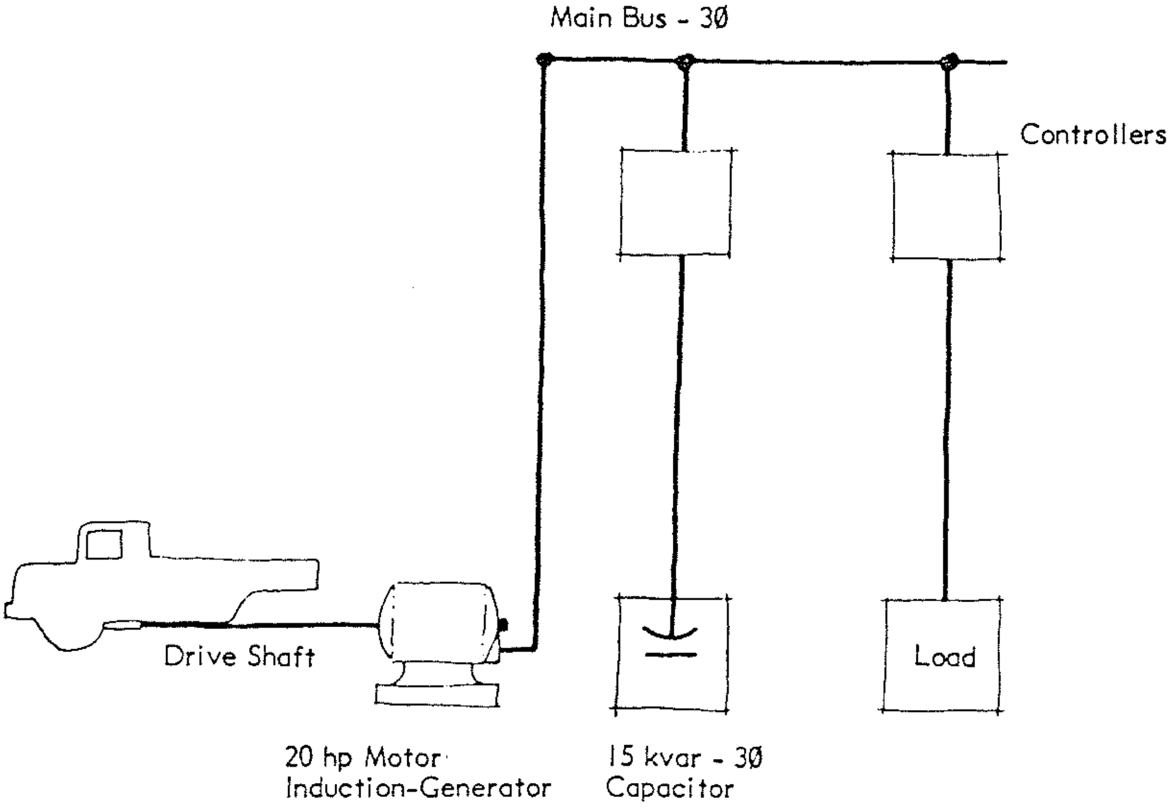
process. An induction motor energized from a power source develops mechanical power by running at a speed slightly less than its synchronous speed. Conversely, an induction motor driven in the same direction at a speed slightly greater than its synchronous speed will deliver electrical power when connected to a power system. If the machine is driven above synchronism by the same rpm that the machine normally operates below synchronism, the generator will deliver approximately rated current at rated voltage and rated efficiency, and the electric power output will be approximately equal to the rated shaft motor power. However, the generator power factor will be much lower than when operated as a motor.[9]

Figure 4.2-2[11]

SCHEMATIC OF LOAD CONNECTIONS



The URS study found that improvised induction generators can develop useful electric power to fill a wide variety of needs during power shortages. Electric motors, heaters, fluorescent lamps, and other devices can be operated. The safety of the systems and other considerations were addressed, as well as connecting these dispersed systems into local grids. The study developed a manual and training program which should be a valuable addition to emergency and civil defense programs. The conclusions were as follows:

- The skills of competent craftsmen are required at some stage of assembling or using an improvised source of electric power. The skills required for improvising an induction generator are an electrician, a welder, and a mechanic. Pre-disaster planning and an exercise can substantially reduce these skill requirements during an emergency.

  It is important to define electric power requirements specific to each facility, especially with regard to rapidity of response (how fast must power be restored), reliability (cost of an unscheduled shut-down), maximum load, and degree of power regulation. If these requirements are very stringent, then an improvised power plant—either an induction generator or a rental engine generator set—is very likely unsuitable. A stand-by power plant that is permanently installed and with a transfer switch will be necessary to meet stringent requirements. It must also be tested regularly to maintain operability.

An induction generator is the preferred source of improvised electric power when:

- All of the major or expensive parts are available
- Time and resources can be made available to set up and test it
- Equipment to be served can function adequately with the power developed by the machine
- An interval without power, while assembling the induction generators, is acceptable
- Renting or leasing an engine generator set is either unattractive or impractical
- Maintaining engine generator sets is either too expensive or impractical

Despite the practicality and convenience of using induction motors as induction generators, the idea probably would not occur to most of those who could benefit from it either during pre-disaster planning or during a prolonged power outage.[12]

Electromagnetic Pulse Protection

One of the key issues in planning for protection of electrical facilities and grids in the event of nuclear attack is EMP (electromagnetic pulse) effects. High altitude detonations of nuclear weapons create EMP, an electromagnetic burst of extremely short duration (a fraction of a second). Similar to lightning, EMP exhibits a rise in voltage a hundred times as fast; thus, conventional equipment designed to protect electric equipment against lightning cannot be effective against EMP, because it works too slowly. High altitude nuclear bursts produce extremely high EMP, which can affect communications and electrical systems for thousands of miles. When the U.S. tested a hydrogen bomb in space above Johnson Island in the Pacific in 1962, EMP caused havoc in Honolulu, resulting in failure of streetlights and various electronic circuits (including burglar alarms).[13]

Many of the components of modern communications, electronics and power technology are highly vulnerable to EMP. For this reason, military B-52 bombers* use antiquated vacuum tube components, rather than more modern but more vulnerable transistors, since they are expected to serve in a "nuclear environment."

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*The Pentagon has recently decided to combine fuel cell technology with MX missile EMP protection. In order to reduce EMP damage to missiles in the MX system, fuel cells will be used, rather than back-up engine generator sets, to power the missile launch centers. By using the fuel cells, each missile facility will be isolated from EMP effects on electric lines and related equipment; the fuel cell provides a "chemical fluid interface."[14]

EMP can cause actual physical damage to electrical system components, as well as create instabilities in grids which cause systematic failures. Disturbances in electric systems may be categorized in these six major areas:

1. Faults on overhead lines: Voltages induced on overhead lines can cause numerous faults in distribution, including substations.

2. Lock out of reclosers and reclosing circuit breakers: These protection systems on distribution lines can interpret EMP as "permanent faults" and lock out the system, resulting in sudden load loss.

3. Destruction and malfunction of relays: Solid state electronic relays in electric systems can fail in "unsafe mode," causing the line to trip out.

4. Generator trip out: Generators can be tripped out in two ways. First, EMP may induce voltages and currents in generator control circuits causing generator trip out. Second, disturbances in the power system can cause trip out by creating overspeed/underspeed in the generator.

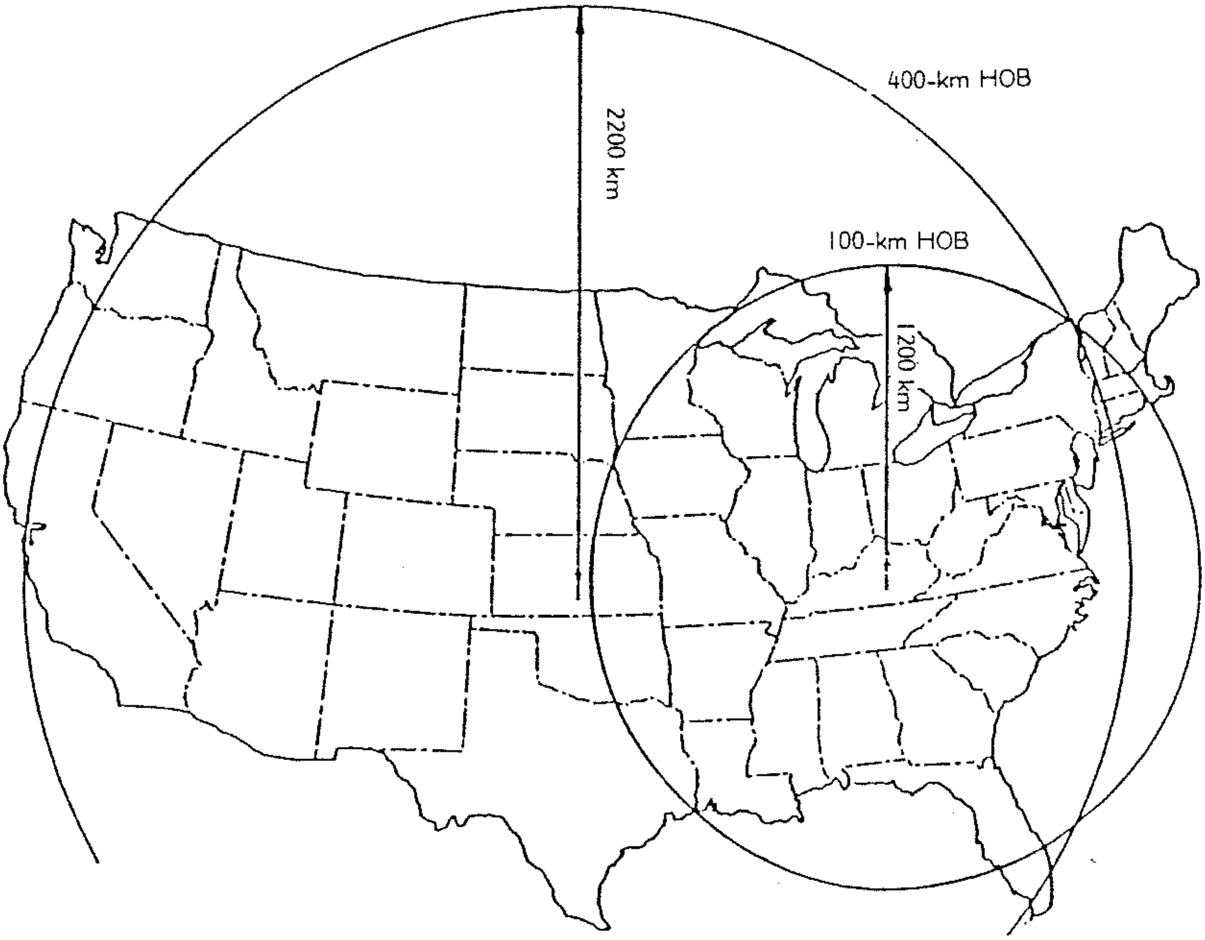
5. Monitor and control interference: Damage to monitor/control circuits by EMP can be direct, or can cause transmission tie lines to be servered by EMP-induced power flows.

6. Damage to computer control and dispatch centers: Computer memory can be erased by EMP; therefore, central computer centers for dispatching and load control can malfunction, causing loss of system control.[15]

The map of the U.S. shown in Figure 4.2-3 shows the vast extent of possible EMP damage from a 400 kilometer (248 mile) air burst, and a 100 kilometer (62 mile) air burst. As a recent Department of Energy study noted, the EMP "covers a large percentage of the nation's power system at essentially the same instant, rather than a single line or substation."[16]

Figure 4.2-3[17]

AREA OF COVERAGE OF EMP FROM HIGH ALTITUDE DETONATIONS



According to the Department of Energy study:

> Many power system components will not be damaged unless they are relatively close to a target (within four to twenty-two miles). Apparently no quantitative analysis has been made to use these data with an assumed list of targets

> and weapon yields to determine the percentages of power components that would be damaged. Depending upon the number of weapons, it is conceivable that a sizable portion of the nation's power system would escape damage from the blast, unless targeted, but would be subjected to damage by EMP.
>
> One could envision the possibility that the combined effects of faults caused by lines broken or knocked down by blast effects and faults induced by EMP could lead to a nationwide blackout. Little can be done to alleviate the effects of the blast. However, the combined effect of moving some of the vulnerable equipment off-line (thus reducing the number of EMP-induced faults) and placing the power system into a more secure state could avoid a nationwide blackout.[18]

Because of the unique damage which would be imparted to highly sophisticated centralized utility systems by nuclear weapons effects (especially EMP), the DOE report suggests a policy which may be likened to emergency dispersion and decentralization:

> Depending upon whether the nation's power system remains in synchronism or not, the post-attack recovery could be from one of two states. The worst case would be from a completely shut down system. In this case, one would be recovering from a nation-wide blackout similar to the 1965 Northeast blackout and the 1977 New York blackout with the following complications:
>
> 1. Lack of help from neighboring utilities who are busy experiencing the same problems.
> 2. Loss of some system facilities, permanently damaged by heat and overpressure.
> 3. Poor communications due to possible damage to the telephone system.
> 4. Impending threat of radioactive fallout.
>
> The best state from which to recover would be one in which the generation had remained in synchronism, in spite of faults caused by heat, overpressure and EMP-induced effects on vulnerable equipment that had not been isolated by the proposed switching operations. The generation would be operating at a relatively low percentage of its rating due to the pre-attack measures.
>
> Attempting to keep the entire nation in synchronism during the combined effects of overpressure, heat and EMP may not be realistic. It may be more practical to sever tie lines between companies and even allow the systems of individual

> companies to break into islands. Comparisons between these two divergent philosophies require very complex analysis. Utility personnel are generally in favor of maintaining synchronism, if at all possible. Maintaining synchronism seems to be something of an all or nothing philosophy.[19]

Many components of systems can be protected against weapons effects, including EMP, but drawbacks are primarily the added costs of such equipment. Protected measures and policies suggested in recent studies include:

- "Hardening" and burying key components and distribution lines
- Stockpile vulnerable parts, for replacements
- Employ "surge arresters" and specialized equipment to protect distribution/transmission systems
- Protect and harden vulnerable solid-state components
- Provide back-up communications systems
- Improve training and emergency shut-down procedures.[20,21]

The DOE study notes that other key problem areas involve protection of nuclear power plants which may experience "loss of reactor control due to EMP." A utility representative referred to in the study "suggested that they might consider shutting down their nuclear units upon notice of an attack. ...Officials of one large utility expressed doubts that it would be possible to bring one of their large units down from near rated load to auxiliary load level and stop there."[22]

Obviously, these effects affect small systems as well as large systems and many components of decentralized grids would be damaged by EMP and other weapons effects even if the components were located hundreds, and perhaps thousands of miles from air detonation.

A special interest in dispersed systems is the protection of complex control systems utilized in modern wind-electric generators, solar photovoltaic systems, and other modern alternative energy systems. Photovoltaic systems may be vulnerable to EMP, but no specialized studies have been conducted on this problem.*

Early civil defense studies are significant precursors to a more comprehensive approach to community energy management and strategic dispersal. The early studies point out the following energy trends:

- Central systems may be disrupted by weapons effects to a greater degree than most general studies acknowledge.

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*Photovoltaic (DC) panels are voltage-protected by bypass diodes in one direction, and industry experts believe that EMP protection can be developed.[23]

- Protection can be provided to many components of central systems, but reliability cannot be guaranteed.
- Local energy approaches can be developed to greatly assist in emergency situations.
- Training programs and knowledge of local power sources, to be effective, must be developed in advance.
- Available power systems in communities can be tapped in times of emergency, if adequate training and stockpiles of key parts are available.

Selection of Alternative Fuels and Electric Power Sources (4.3)

Increasing the energy self-sufficiency of communities and regions can be accomplished by integrating a combination of available dispersed and renewable energy technologies. The Energy and Defense Project has developed criteria for rating the available technologies* (fuels and electricity). The two matrices following this introduction illustrate the properties of the major technologies discussed in Section 3.

Categories in the matrices are judged from a strategic perspective, based on criteria of available (local and regional), current and projected costs, and overall flexibility. The rank is from 10 (best) to 0 (worst). The categories are expressed primarily as Y (yes) or N (no, not applicable). Alternative categories are L (low), M (medium), H (high); in some cases, a range is expressed (L-H), or dual flexibility (Y/N).

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*Ranking of the various technologies discussed in the report was determined by research, and confirmation at the Project's September 1980 technical seminar.

Figure 4.3-1[24]

FUELS MATRIX

DERIVED FUELS	Rank	Dispersed	Central	Renewable Feedstock	Feedstock Flexibility	Grid-Connected	Grid-Independent	Operation and Maintenance Costs	Local Feedstock	Site-Dependent	Regional Components	Local Maintenance	Capital Intensive	Short Lead Time	Mobility	Storage	End Use Flexibility	Scale	$/Million BTUs
Gasoline[1]	3	N	Y	L	H	Y	N	H	L/H	Y	N	N	Y	N	N	H	H	L	5.50 to 7.50
Diesel[2]	6	N	Y	L	H	Y	N	H	L/H	Y	N	N	Y	N	N	H	H	L	5.50 to 8.00
Crude Coal[3] Crude Shale	5 9	N	Y	L	M	Y	N	L/H	H	Y	Y/N	Y/N	Y	Y/N	N	H	L	M/L	5.00 to 7.00
Methanol[4]	8	Y	Y	M	H	Y	Y	M	H	Y	N	N	Y	N	Y/N	H	H	S/L	6.00 to 8.00
Ethanol[5]	10	Y	Y	H	M	Y	Y	H	H	Y	Y	Y	Y	Y	N	H	H	S	8.00 to 12.00
Low BTU Gas[6]	9	Y	N	H	H	N	Y	M	L/H	N	Y	Y	N	Y	Y	L	M	S/M	4.00 to 5.00
Med BTU Gas[7]	9	Y	Y/N	H	H	Y	Y	H	L/H	N	Y	Y	Y	Y	Y	L	M	S/L	4.50 to 5.50
Biogas[8]	7	Y	N	H	M	N	Y	L	H	Y	Y	Y	Y	Y	N	L	M	S	4.50 to 8.00
SNG[9]	7	N	Y	L	H	Y	N	M	L/H	Y	N	N	Y	N	Y/N	M	M	L	5.50 to 8.50
Hydrogen[10]	1	Y	Y	H	H	Y	Y	H	L/H	Y	Y/N	Y/N	Y	N	N	L	H	S/L	7.00 to 50.00
Biomass Oils[11] & Lubricants	6	Y	N	H	L	N	Y	L	H	N	Y	Y	N	Y	Y	H	H	S	8.00 to 12.00

NOTES: FUELS MATRIX

1. Gasoline

Gasoline is a premium fuel which can be used in stationary or mobile applications. However, in current refining practices, lower quality heavy crude oil will not produce as much gasoline as lighter crudes (previously in greater abundance). It can be produced from methanol (via Mobil Oil Company process), however, allowing significant resource flexibility (bimoass, coal, natural gas, shale, heavy crudes, tar sands, etc.)

2. Diesel

Diesel oil is a middle distillate. This category (on the matrix) includes all middle distillates, from aviation fuel to kerosene. It is a more difficult fuel to produce from feedstocks other than crude oil, and is not as versatile a fuel, from a strategic standpoint.

3. Crude Oil

Crude oil is a natural oil (as is shale oil), and can be made from coal, tar sands, wood and other carbonaceous feedstocks. The lower rating (5) relates to coal production, and the higher rating (9) relates to production from new domestic oil resources. Shale oil is a more attractive feedstock than heavy crude oil.

4. Methanol

Methanol can be made from all hydrocarbon feedstocks through partial oxidation (gasification). This is an extremely versatile fuel, but catalysts are required to convert producer gas to methanol. This limits production flexibility, and reduces local production capabilities. To insure continuous production, an inventory of catalytic materials would be required.

5. Ethanol

Ethanol can be made from non-renewable resources, but is typically made from biomass-derived sugars and starches. This is an immediately available premium fuel, which can be used as an independent fuel or blended with other products such as gasoline. The conversion technology is commercially available with locally available components.

6. Low Btu Gas (LBG)

LBG is gas with a maximum heat value of 200 Btu/ft^3, made from hydrocarbon feedstocks. It is made through partial combustion in an air-blown gasifier. This gas can be used in internal combustion engines, but cannot operate gas turbines (with current technology). It can substitute for most natural gas uses.

7. Medium Btu Gas (MBG)

MBG is a partially combusted hydrocarbon gas with a heat value of 200-500 Btu/ft^3. It requires pure oxygen in the gasification process, which increases costs and requires additional equipment. This gas can be used as a feedstock for synthetic fuels (methanol, SNG, gasolines, etc.) and as a fuel in gas turbines and other heat engines (boiler, etc.).

8. Biogas

This is a methane-rich (CH_4) gas with a heat value of 500-700 Btu/ft^3, and can be used as a boiler fuel in gas turbines and other heat engines. It is a substitute for natural gas. It is typically produced by decomposing organic material which are locally available.

9. Synthetic Natural Gas (SNG)

SNG is a high-heat value gas (1,000 Btu/ft^3), which is a direct substitute for natural gas in essentially all applications. It is made through cataytic conversion of MBG. Feedstocks include oil, coal, shale oil and biomass. SNG can also be made by purifying biogas.

10. Hydrogen (H_2)

Hydrogen can be extracted from coal via gasification processes, or it can be made by the electrolytic decomposition of water. It is a volatile, high quality fuel which can substitute for natural gas. However, conversion processes are highly energy-intensive, and significant infrastructure problems stand in the way of widespread utilization (storage, distribution, etc.).

11. Biomass Oils and Lubricants

These are vegetable oils which can be derived from locally available oil-producing plants (sunflower, safflower, jojoba, etc.). These oils have been used successfully to substitute for diesel fuel, although their strategic significance stems more from their value as lubricants than fuels.

Figure 4.3-2[25]

DISPERSED ELECTRICITY MATRIX

	Rank	Dispersed	Central	Renewable	Fuel Flexibility	Grid-Connected	Grid-Independent	Local Fuel Supply	Site-Limited	Local Components	Local Maintenance	Capital Intensive	Short Lead Time	Mobility	Operation and Maintenance Costs	Size Range (MW)	Intermittent	Cost ($/kw) Capacity
Cogeneration[1]	10	Y	Y	Y/N	Y	Y	E	Y/N	N	N	Y	N	Y	Y	L	0-50	Y/N	500-1500
250MW Small Fossil Plants[2]	10	Y	Y	Y	Y	Y	E	N	N	N	Y	Y	Y/N	Y/N	H	0-250	N	500-2000
Small Hydro[3]	10	Y	N	Y	N	Y	E	Y	Y	Y	Y	N	Y	N	L	0-30	Y/N	600-1000
Wind[4]	7	Y	Y	Y	N	Y	D	Y	Y	Y	Y	Y	Y	Y	L	0-5	Y	1000-2000
Photovoltaics[5]	4	Y	Y	Y	N	Y	D	Y	N	N	Y	Y	Y	Y	L	0-10	Y	10,000+
Biomass Steam[6]	8	Y	Y	Y	Y	Y	E	Y	Y/N	Y	Y	Y	Y	Y/N	M	.2-50	Y/N	500-1500
Biomass Low BTU Gas[7]	7	Y	Y	Y	Y/N	Y	E	Y	Y/N	Y	Y	N	Y	Y	M	0-5	Y/N	500-1200
Geothermal[8]	10-6	N	Y	N	N	Y	D	Y	Y	Y	Y	Y	N	N	H	5-50	N	700-4000
Fuel Cell[9]	3	Y	Y	Y/N	Y	Y	E	Y/N	N	N	N	Y	N	Y	H	0-5	N	5000+
Waves[10]	1	N	Y	Y	N	Y	D	Y	Y	N	Y	Y	N	Y	H	?	Y	15,000+
OTEC[11]	1	Y	Y	Y	N	Y	E	Y	Y	N	Y	Y	N	N	H	?	N	15,000+
Low Temp Solar Thermal[12]	5	Y	Y	Y	N	Y	E	Y	N	N	N	Y	N	Y/N	L	0-5	N	4000+
High Temp Solar Thermal[13]	4	Y	Y	Y	N	Y	E	Y	N	N	N	Y	N	Y/N	M	0-10	Y	6000+
Fossil Gasification[14]	10	Y	Y	N	Y	Y	E	N	N	Y	Y	Y	Y	Y	M	5-50	N	1500-4000

NOTES: DISPERSED ELECTRICITY MATRIX

1. Cogeneration

Cogeneration is the generation of electrical or mechanical power and the production of useful heat from the same primary source of fuel. A typical configuration is the use of steam from a fossil-fired boiler to drive a turbine-generator, and the subsequent use of the exhaust steam for space or water heating.

2. Small Fossil Plants

Small fossil plants are defined as any fossil-fired electric generating plant with an output capacity of less than 250 megawatts. These are primarily steam-driven turbine-generators.

3. Small Hydro

Small hydro is an electrical generating system with an output capacity of less than 30 megawatts powered by falling or moving water. This source may represent the most thoroughly developed technology included in this discussion; plants of virtually any size are readily available from commercial vendors.

4. Wind

Any one of numerous Wind Energy Conversion Systems (WECS) use wind-powered propellors or blades to drive an electric generator. Small systems are commercially available at this time; however, systems in the megawatt range are still in the development and testing state. The size range given here is for individual towers, much larger outputs might be obtained from wind "farms" of 25 or more units.

5. Photovoltaics

Photovoltaic power involves the direct transformation of sunlight into electricity through the excitation of various semiconductor materials. Very small systems are currently in use, but the high cost of high-grade photovoltaic materials currently limits an otherwise wide range of applications.

6. Biomass Steam

Biomass steam is any plant material or waste from plant material that is combusted in a boiler. Such a system may use a Rankine-cycle heat generator to produce electricity or a conventional turbine-generator with fossil-fuel backup.

7. Biomass Low Btu Gas

Biomass Low Btu gas is produced by partially combusting biomass fuel in a reactor to break the fuel down into its hydrogen and carbon-monoxide components. These two combustible gases may then be burned in boilers or certain combustion engines.

8. Geothermal

Geothermal-electric power may be produced by utilizing the heat within the earth resulting from either tectonic activity or radioactive decay. The most developed technology uses naturally created steam. These systems, however, are limited by relatively few sites and problems associated with the chemistry of geothermal steam. The U.S. enjoys extensive "hot dry rock" resources—requiring the injection of water to produce steam—but the required technology is still in the early stages of development.

9. Fuel Cells

A fuel cell is an electrochemical device which chemically combines hydrogen and oxygen to produce electricity and water. The system has been utilized in specialized applications such as space vehicles but large-scale applications are in the early development stages.

10. Waves

The energy of waves may be converted into electricity by the use of wave pumps, pneumatic devices, motion devices, underwater pressure field devices, and facilities powered by the mass transport of water from breaking waves. Very small systems are currently being developed; however, technological obstacles have inibited full-scale development of this source.

11. Ocean Thermal Energy Conversion (OTEC)

OTEC produces power from the thermal layer differences between warm surface water and colder deep ocean water. Serious engineering obstacles and a limited number of sites have inhibited development of this source.

12. Low Temperature Solar Thermal

The most common low temperature solar technology is the solar pond which uses salinity layers in a body of water to absorb and trap solar energy and convert that heat into electricity through a Rankine-cycle turbine. The technology is in commercial use in several countries and in the testing stage in the U.S.

13. High Temperature Solar Thermal

High temperature solar thermal systems use concentrating collectors to focus solar energy on a target. The sunlight can be concentrated sufficiently to produce temperatures up to 2,000°F (1,093.3°C). Water in the receiver is thus boiled to produce steam for turbine-generators. Very small high temperature systems are commercially available but larger systems are in the testing and development stages.

14. Fossil Gasification

This system uses an oxygen-blown gasifier to convert fossil fuels such as coal or heavy oil into their carbon monoxide and hydrogen components which are subsequently used in a combustion system to generate electricity.

NOTES: CHARACTERISTICS OF DISPERSED FUELS AND ELECTRIC POWER TECHNOLOGIES

1. Rank

Rank is evaluation on a scale of 1-10, with 10 having the highest value, judged from a strategic perspective. In fuels, high ranks designate the suitability of a fuel from a local and regional production and use basis. Flexibility, renewability, ease in production, and other key characteristics affect the ranking. In electricity, the same strategic evaluation applies, with some technologies which are inherently dispersed and commercially available, having high rank (cogeneration, small fossil plants, etc.). Technologies such as photovoltaics and wind power are renewable and available, but are ranked lower because of current low production and high costs; however, from a community/regional perspective, these are important technologies to integrate in emergency and energy planning.

2. Dispersed

This describes the local and regional production possibilities for fuels and electric power. For example, gasoline, diesel fuel, crude oil and synthetic natural gas are all fuels that require considerable capital investment in high technology production facilities and are most economically made in large bulk quantities (i.e., production runs greater than 3,000 tons or 2.7 million kilograms per day). These fuels are therefore best produced in large centralized facilities (i.e., not dispersed) and require distribution networks to reach their ultimate consumers. Methanol, ethanol, biogas and the other fuels listed in the fuels matrix are more easily produced and are thus evaluated as being good potential candidates for dispersed or decentralized supply systems. It is also economical to produce them in smaller lot quantities (i.e., less than 1,000 tons or .9 million kilograms per day). On the matrix, all of the technologies for electricity are capable of dispersion with the exception of geothermal and waves, which are site-specific.

3. Central

In addition to dispersed fuels (or systems) and electrical technologies, centralized technologies may also apply to many of the same categories. For example, cogeneration systems may occur in central as well as dispersed locations; methanol and ethanol fuels can be either dispersed or centralized.

4. Renewable (Renewable Feedstocks)

In fuels and electricity, renewable characteristics refer to solar, biomass, wind, water and other renewable technologies. All of the fuels listed can be made from bio-feedstocks, so they are rated as low, medium or high potential for commercial production. Electrical technologies are characterized on a simple yes/no basis.

5. Feedstock/Fuel Flexibility

In fuels, high flexibility refers to use of a variety of feedstocks (biomass and fossil origin). In electricity, flexibility is high if different fuel sources can be used for each category of electrical technology.

6. Grid-Connected and Grid-Independent

Some fuels and electrical technologies may be either grid-connected or local, and not connected. If a fuel is normally distributed through central systems (pipelines and distribution), it is rated (Y) for grid-connected. In electrical systems, all the technologies can be grid-connected, but for grid independence, some are rated (E) for ease in isolated operation. Some systems are more difficult to operate outside the grid. However, all electrical systems can be designed for local operation, independent of central grids.

7. Local Fuels and Feedstocks

These fuels and sources for electrical power are rated (Y/N) for electricity, based on local availability. For fuels, use of locally available feedstocks is rated (L-H) low-high.

8. Site Limited and Site Dependent

Site dependent fuels require large fuel stocks and capital investment, as opposed to non-site dependent sources such as Low Btu gas, which can be made in a mobile gasifier transported to dispersed locations. Site dependent electrical technologies such as geothermal or wind are not flexible, like cogeneration systems.

9. Local and Regional Components

This refers to the availability of key components and spare parts of technologies which may be found either locally or within the region where the fuel/electrical process is located. As an example, the production of methanol requires a catalyst material usually not available locally. Likewise, small fossil plants require sophisticated components and spare parts that would not be available locally.

10. Local Maintenance

Some fuels and technologies can be produced and operated using the local/regional labor force. The ratings are based on the likelihood of availability of this expertise.

11. Capital Intensive

Capital intensity refers to the range of installed costs and the strategic material intensity of the fuel processes and technologies. As can be seen, the production and use of dispersed Low Btu gas is one of the highest rated dispersed fuels and technologies.

12. Short Lead Time

In general, this refers to fuel processes and technologies which can be ordered and delivered for energy production within three years. Gasoline and SNG facilities require many years to license and construct, as opposed to Low Btu gas facilities which can be built quickly. Likewise, micro-cogeneration systems can be built quickly, unlike geothermal or solar thermal facilities, which require years.

13. Mobility

This refers to fuels in cases where the production facility can be located at the source of the fuel. In electricity, mobility refers to the flexibility of the power plant's location. Some technologies, such as small hydro, are definitely not transferable from specific sites.

14. Operation and Maintenance Costs

These costs are rated H-L. Maintenance is self-explanatory; operations costs also include labor, capital depreciation, feedstocks and costs of transportation.

15. Storage (Fuels)

Storage capability is rated high if storage facilities are locally available, and if it makes sense to store the fuel. Hydrogen, for example, is rated low because it is difficult and expensive to store for an appreciable length of time.

16. End Use Flexibility (Fuels)

A fuel is considered to have a high flexibility if many different converters can be adapted to use of the fuel (boilers, turbines, internal combustion engines). Obviously, fuels such as gasoline have high flexibility.

17. Scale (Fuels)

The scale of production for fuels is rated L (large) for production processes which are greater than 3,000 tons/day (2.7 million kg) equivalent, M (medium) for processes operating at 1,000-3,000 tons/day (.9-2.7 million kg) equivalent, and S (small) for processes less than 1,000 tons/day (.9 million kg) equivalent.

18. Size Range (Electricity)

The size of average technologies and processes is expressed in MW (one megawatt = 1,000 kw); photovoltaics, for example, are used in an average configuration of panels that are small (a few kilowatts), but can be up to ten MW in power "farms." The same is true for wind generation.

19. Intermittent (Electricity)

This refers to technologies which may be seasonal in nature, such as small hydro, or operate only during sunlight (solar systems), thereby requiring energy storage for baseload operation.

20. Costs

Fuel costs are expressed in current dollars/million Btus for fuels at the refinery gate or production site. These costs include amortization of capital investments. Electricity costs are expressed in capital costs per installed kilowatt of capacity ($/kw). These costs represent current costs, not estimates of future costs of the technologies.

These matrices are designed to be used by local, regional and national planners concerned with the local and regional implementation of decentralized, dispersed and renewable fuels and electric technologies. Prior civil defense studies of the energy system and local recovery characteristics encourage the development of training programs and early implementation of measures which will later become important in an emergency situation. We concur in this generic observation found in prior studies.

The Federal Emergency Management Agency (FEMA) is empowered to consider an attempt to mitigate the potential effects of a number of crisis situations ranging from hurricanes, earthquakes, and nuclear power emergencies to nuclear war. In almost all cases, an effective local and regional approach to dispersal and decentralization of energy sources will serve immediately and in the long range to mitigate effects of disruptions of central resource supply systems.

In addition to FEMA's responsibilities in the energy area, there are similar charges to other federal agencies, including the Department of Energy (DOE) and the Department of Transportation (DOT). The Emergency Energy Conservation Act (EECA) enacted in November 1979 created a framework for a national response to future energy supply interruptions. Title I establishes the basis for standby gasoline rationing to be implemented in the event of a twenty percent shortage of gasoline. Title II creates a federal-state system for dealing with severe, but lesser, shortages through voluntary and mandatory demand restraint or emergency conservation measures.

Title II of EECA authorizes the President to determine that the nation is faced with a severe energy supply interruption or that a severe interruption is imminent. In the event of such a finding, the President may establish national and state-by-state monthly emergency conservation targets for any fuels or energy sources affected by the interruption. Within 45 days after the establishment of emergency targets, the state governors are required to submit plans to the Secretary of Energy indicating the approach the states will take in meeting these targets.

As long as a state meets its targets, it would continue to implement its plan. However, if the President finds that a state is not substantially meeting its targets, and it is unlikely that they will be met, he may, after consultation with the governor, invoke any or all parts of a standby federal plan within the state. A state plan may incorporate virtually any measures which the governor finds suitable, subject to the approval of the Secretary of Energy, and may include measures contained in the standby federal plan.

In order to fully implement this federal conservation plan, DOE is considering the utilization of renewable fuels to meet petroleum shortages. The matrix developed by this Project indicates that local ethanol production facilities offer an available opportunity to increase self-reliance; this is one example of its use. Through effective coordination, local agencies can evaluate a range of energy measures which can reduce vulnerability and contribute to national security. On a national level, there is a demonstrated need for use of this information by FEMA, DOE and DOT (in addition to other federal groups). A coordinated federal effort would be helpful to local communities. The conclusions of this report suggest a mechanism to accomplish this.

Conclusions and Recommendations (4.4)

The Energy and Defense Project has identified and ranked available dispersed, decentralized and renewable energy resources and technologies that can be utilized on a local and regional basis to enhance security and meet community needs in time of crisis. In order to initiate local, regional and national programs, a process for implementation should be identified and established within FEMA (acting in concert with other federal agencies).

[illegible]

Alternative energy technologies exist, and are commercially available for a wide variety of local and regional uses. However, no comprehensive programs exist to encourage their use for purposes of reducing national vulnerability, increasing self-reliance, and providing a local resource base in time of crisis.

Table 4.4-1 summarizes the recommendations of the Energy and Defense Project. This table is based on developing local and regional programs to (a) inventory energy resources within regions, and (b) implement available dispersed, decentralized and renewable technologies.

existence, essence 实体

To initiate such programs on a local level, we suggest the creation of local/regional entities called "Defense Energy Districts" (DEDs), which would be administratively responsible for categorizing, inventorying, and coordinating the implementation of dispersed, decentralized and renewable energy resources technologies.

At present, the authority for emergency energy planning is split between a number of federal agencies (FEMA, DOE, DOT, etc.) on the national level and a wide variety of state and local agencies. As prior civil defense studies have shown, an essential need in emergency planning is developing data and workable plans well ahead of anticipated crises. The United States is facing a series of potential crises in supply of imported energy and materials at the present time, yet no coordinated effort has been developed to implement local and regional technologies and plans to counter this vulnerability.* In fact, the existence of many uncoordinated federal programs may hinder the development of local self-sufficiency, rather than assist it.

Funding of DEDs need not be centralized in any one federal, state or local agency. Already established programs under a number of state and federal laws are in existence and provide funding for a range of conservation and alternative energy technologies and programs.

The responsibilities of Defense Energy Districts would incude the following:

1. Conduct a complete local inventory of locally and regionally available alternate fuel sources, energy technologies, and energy conversion equipment (motors, cogeneration systems, power facilities, prime movers, critical components supplies, and necessary skills and personnel who have them.

Table 4.4-1[26]

NATIONAL ACTIONS AND POLICIES TO ENHANCE REGIONAL ENERGY SECURITY

1980 - 1985

1. Conduct a national inventory of regional dispersed energy sources, fuels and technologies.
2. Integrate this inventory and consolidate energy planning into existing civil defense policies and plans.
3. Identify priority needs for energy supplies and technologies within regions (such priorities should be coordinated with needs for food, communication, other resources).
4. Identify and establish "Defense Energy Districts" within regions, based on energy inventory and priority energy needs criteria.
5. Within DEDs, accelerate implementation of federal, local, and state actions to increase energy conservation (to reduce overall demand) and promote widespread use of dispersed, renewable energy sources and technologies.
6. Establish regional demonstration programs for community energy systems. Establish stockpile and purchase program within regions for high-ranked, commercially available, dispersed energy technologies.
7. Accelerate R&D for all dispersed technologies and integrate purchase programs with ongoing government commercialization efforts.

1985 - 1990

1. Act on initial studies and demonstration programs to made programs available to all DEDs, including stockpiles and available technologies.
2. Accelerate demonstration programs to include all regions.
3. Bring more dispersed energy technologies into mass production; as this occurs, add to local stockpiles and programs.
4. Provide additional incentives and policies to fund DEDs for energy assistance efforts. Such incentives and policies would include acceleration of DOD purchase program for photovoltaics to local governments (and extension of program to include other dispersed energy sources).

2. Identify priority uses in event of crisis or central system disruption and conduct local training programs for use of existing alternate facilities and equipment.

3. Coordinate available funding and develop stockpiles of key energy components, fuel storages, parts and alternate equipment which would be needed in an emergency.

4. Serve as a local coordinating agency for federal emergency energy contingency programs. This would help eliminate wasteful, redundant current programs, and would improve local capability of response to a crisis (petroleum shortages, system disruptions, etc.).

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*The Energy Security Act, Title IV, provides for a short-term analysis of demonstrating "self-sufficiency in one or more states" within the next three years. This could be the starting point for a more unified national energy strategy in the interests of national security.

Already, many available alternative technologies are available which can be immediately implemented on the community level to provide dependable alternate fuel and power in time of crisis. In the field of emergency communications alone, photovoltaic technology provides a range of dependable power back-up for voice and data telecommunications equipment, emergency transmitters, field radios, distribution system equipment and various signal devices. This equipment can be purchased now by local and regional organizations concerned with emergency energy contingency planning. A new study for the Department of Energy, performed by Science Applications, Inc., points out that photovoltaic, wind and solar thermal systems will be available on a full commercial basis for the institutional market within five years. Table 4.4-2 compares the commercial readiness of these alternative energy technologies.

Table 4.4-2[27]

DISPERSED USER SOLAR ELECTRIC TECHNOLOGY OPTIONS

Technology	Appropriate scale (kWp)	Rating of case analyzyed (kWp)	Year of commercial readiness for each market segment				
			Residential	Commercial	Institutional	Industrial	Agricultural
Photovoltaics							
. small flat panel	15-50	10	1985	1985			1985
. intermediate flat panel	50-5000	100		1985	1985	1985	1985
. intermediate line focus	50-5500	100		1985	1985	1985	1985
Solar thermal							
. dish organic Rankine	22-2200	220		1990	1990	1990	1990
Wind							
. small horizontal axis	10-40	10	1985	1985			1985
. small vertical axis	10-30	10	1990	1990			1990
. intermediate horizontal axis	200-1500	300		1985	1985	1985	1985
. intermediate vertical axis	200-500	220		1985	1985	1985	1985

Many other technologies identified in this study are commercially available today and offer great potential in energy contingency planning. An example is load management technology, which can meet both the needs of energy conservation on a dispersed basis and also meet the needs of emergency communication. Remote devices connected to residences, commercial enterprises, public agencies and industries can accomplish load control as well as two-way communications. Such equipment is available today and tests are being performed by a number of electric utilities. An immediate use for such technologies is coordination of FEMA nuclear plant safety evacuation planning with remote load management devices designed for emergency communications. Thus, energy demand can be reduced simultaneously with the development of modern contingency communications technology.

Use of available alternative technologies by local and regional organizations is an important tool in energy emergency planning. The evaluation methodology (i.e., the fuels and electricity matrices) developed can be adapted for use by local and regional organizations.

Summary

The Energy and Defense Project has evaluated a number of dispersed, decentralized and renewable energy sources which offer a potential for reducing of national vulnerability (energy, resources, materials, war), increasing the self-sufficiency of local communities, and strengthening national security.

Recognition of the strategic value of policies to implement local and regional energy decentralization and increase deployment of renewable sources is a primary consideration and conclusion of this study. In summary, the major findings are:

- Current U.S. energy systems (fuels and electricity) are highly vulnerable, due to requirements for imported resources and due to the centralized nature of the systems themselves.
- Dispersed, decentralized and renewable energy sources can reduce national vulnerability and the liklihood of war by substituting for vulnerable centralized resources.
- National policies and goals need to be developed to strengthen current inadequate energy emergency contingency planning and incorporate decentralized and renewable energy sources in planning.
- Local policies and goals need to be developed to implement the range of programs described in the concept of the Defense Energy District.

- National energy self-sufficiency programs (including synfuel development and the Strategic Petroleum Reserve) are highly centralized, thus highly vulnerable. A better strategic opportunity is the development of dispersed local and regional approaches.
- Current funding levels (both private and public) for decentralized and renewable energy are inadequate. National priorities should reflect the strategic value and importance of the decentralist/renewable energy opportunity.

SECTION 4

DISPERSED ENERGY SOURCES AND COMMUNITY SURVIVAL

FOOTNOTES

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FOOTNOTES (Continued)

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Energy & Defense Project, DCPA Contract 01-79-C-0320

Sections 1 & 2 of this report contain background information on centralized energy systems and the relationship between vulnerability of these systems, energy planning, and existing civil defense programs.

Sections 3 & 4 contain an extensive investigation, review and categorization of alternative approaches to centralized, vulnerable energy systems; a review of dispersed and renewable technologies which can be appropriately implemented at the local level; and matrices for evaluation of these technologies for emergency and crisis planning. Specific recommendations to the Federal Emergency Management Agency are included on the use of localized energy approaches for emergency response and recovery situations.

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DISPERSED, DECENTRALIZED AND RENEWABLE ENERGY SOURCES: ALTERNATIVES TO NATIONAL VULNERABILITY AND WAR, Unclassified

Energy & Defense Project, DCPA Contract 01-79-C-0320

Sections 1 & 2 of this report contain background information on centralized energy systems and the relationship between vulnerability of these systems, energy planning, and existing civil defense programs.

Sections 3 & 4 contain an extensive investigation, review and categorization of alternative approaches to centralized, vulnerable energy systems; a review of dispersed and renewable technologies which can be appropriately implemented at the local level; and matrices for evaluation of these technologies for emergency and crisis planning. Specific recommendations to the Federal Emergency Management Agency are included on the use of localized energy approaches for emergency response and recovery situations.

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