DOCUMENT RESUME

02165 - [A1452456]

Emergency Power Generators Used and Managed Inefficiently by Department of Defense. LCD-77-406; B-133361. May 20, 1977. 32 pp.

Report to Secretary, Department of Defense; by Fred J. Shafer, Director, Logistics and Communications Div.

Issue Area: Facilities and Material Management: Operation and Maintenance of Facilities (708); Energy: Federal Efforts to Conserve Energy (1602).
Contact: Logistics and Communications Div.
Budget Function: National Defense: Department of Defense - Military (except procurement & contracts) (051).
Organization Concerned: Department of the Navy; Department of the Army; Department of the Air Force.
Congressional Relevance: House Committee on Armed Services; Senate Committee on Armed Services.

The Department of Defense (DOD) needs to make improvements in the management and use of the emergency power generators, which provide backup power for vital DOD facilities, such as hospitals, if normal power sources fail.
Findings/Conclusions: DOD needs to provide standard guidelines to the services on how to best manage and use emergency power generators. More stringent Department and service criteria on the authorization and use of emergency power generators could reduce many of the problems noted at the installations visited, such as generator capacities greater than required, unnecessary and duplicate generators, inconsistencies in generator use, and unnecessary costs to maintain duplicate systems.
Recommendations: The Secretary of Defense should: (1) provide criteria for determining which users should have priority access to emergency power and how the needs of these users can best be met; (2) strengthen the process for reviewing and justifying the need for all generators in order to permit the initial need for a generator to be adequately justified, to permit those users which can be serviced by smaller generators to be identified, and to permit generators no longer necessary to be made available to other users; and (3) instruct installations to share generators, when appropriate, as an alternative to buying or retaining unnecessary generators. (Author/SC)

UNITED STATES
GENERAL ACCOUNTING OFFICE

Emergency Power Generators Used And Managed Inefficiently By Department Of Defense

Emergency generators provide backup power for vital Department of Defense facilities, such as hospitals, if normal power sources fail. This report discusses inconsistencies in the management and use of emergency power by Defense and points out how generators can be managed better.

LCD-77-406

MAY 20, 1977

UNITED STATES GENERAL ACCOUNTING OFFICE
WASHINGTON, D.C. 20548

LOGISTICS AND COMMUNICATIONS DIVISION

B-133361

The Honorable
The Secretary of Defense

Dear Mr. Secretary:

This report discusses your Department's needed improvements in managing and using emergency power generators at military installations. The report identified inconsistencies and weaknesses in the management and use of emergency power systems and points out opportunities for your Department to consolidate power needs, where appropriate.

This report contains recommendations to you on page 15. As you know, section 236 of the Legislative Reorganization Act of 1970 requires the head of a Federal agency to submit a written statement on actions taken on our recommendations to the House Committee on Government Operations and the Senate Committee on Governmental Affairs not later than 60 days after the date of the report and to the House and Senate Committees on Appropriations with the agency's first request for appropriations made more than 60 days after the date of the report.

The Department should provide the proper management emphasis to our recommendations. Otherwise the Department and the military services could later invest in new, unneeded systems or retain existing systems which could be consolidated with other requirements or which could accomplish a mission with a smaller, less expensive generator. The Department should act promptly and decisively to avoid or minimize this situation.

We are sending copies of this report to the Director, Office of Management and Budget; the Secretaries of the Army, Navy, and Air Force; and the Chairmen, House and Senate Committees on Appropriations and Armed Services, the House Committee on Government Operations, and the Senate Committee on Governmental Affairs.

Sincerely yours,

Fred J. Shafer
Director

GENERAL ACCOUNTING OFFICE
REPORT TO THE SECRETARY
OF DEFENSE

EMERGENCY POWER GENERATORS USED AND MANAGED INEFFICIENTLY BY DEPARTMENT OF DEFENSE

D I G E S T

Most military installations have emergency backup generators to keep essential equipment and activities--such as aircraft navigational aids, fire stations, command posts, and hospitals--operating when normal power sources fail.

The Department of Defense needs to provide standard guidelines to the services on how to best manage and use emergency power generators.

The Secretary of Defense should:

--Provide criteria for determining which users should have priority access to emergency power and how the needs of these users can best be met.

--Strengthen the process for reviewing and justifying the need for all generators. This will permit (1) the initial need for a generator to be adequately justified, (2) those users which can be serviced by smaller generators to be identified, and (3) generators no longer necessary to be made available to other users.

--Instruct installations to share generators, when appropriate, as an alternative to buying or retaining unnecessary generators. (See p. 15.)

The Department has invested large sums for emergency power generators. A large part of this investment is in permanently installed, rather than mobile, generators. The Department also uses mobile generators in emergencies. Most are purchased for tactical purposes, but several are used for backup power. GAO has no information

on how many mobile generators are in use or employed for emergency power uses.

The Department's mobile generator inventory is valued at about $760 million. The cost to operate and maintain these generators involves many millions of dollars. Total value of permanently installed generators cannot be measured. (See p. 1.)

ADEQUATE CRITERIA NEEDED

Each service has regulations specifying which users can be supported by generators, but any facility not specified may have generators if it is deemed necessary. Therefore, many types of facilities are given generators.

More stringent Department and service criteria on the authorization and use of emergency power generators could reduce many of the problems noted at installations visited. Problems included generator capacities greater than required, unnecessary and duplicate generators, inconsistencies in generator use, and unnecessary costs to maintain duplicate systems. (See pp. 6 to 10.)

GENERATOR JUSTIFICATION AND PERIODIC REVIEWS

In requesting a generator, many users submit insufficient data, mentioning that the generator is essential but seldom explaining why. In addition, although service regulations require installations to determine whether emergency power needs are being met, installations do not consider whether a continuing need exists for the generators. (See p. 11.)

To alleviate these problems, an adequate system is needed for (1) determining whether users are properly

justifying their initial requests for generators and (2) reviewing generators periodically, to see if they are being used efficiently. Only mobile generators are inspected by command reviewers. As a result, only a small percentage of emergency power generators are reviewed. If permanently installed generators were reviewed, the possibility of sharing generators would be increased and the likelihood of buying or retaining generators unnecessarily would be reduced. (See p. 12.)

SHARING GENERATORS

At several installations emergency power generators could be shared. (See p. 12.) A $67,000 rehabilitation project for five facilities, each having a generator, was deferred because one had a generator large enough to provide backup power for all. (See pp. 13 to 15.)

The Department and the services need a policy which requires or encourages such consolidation.

AGENCY COMMENTS

The Department believed GAO's recommendations merited consideration and is reviewing criteria standardizing the authorization and use of emergency power for specific facilities.

However, the Department indicated that GAO's report should have recognized basic differences between tactical mobile generators and auxiliary electrical power systems, readiness requirement during mobilization or national emergencies, and degrees of criticality or reliability of these systems.

Obviously, adequate backup power is needed for critical facilities during power failures, disasters, or national emergencies. However, the Department should have a management system which guarantees that

emergency power needs are justified, and the Department should consolidate such needs where appropriate.

This report clearly shows that the services could strengthen their management of emergency power systems. GAO strongly urges the Department to act decisively on the recommendations in this report to avoid or minimize unnecessary investments in these systems.

Contents

ABBREVIATIONS

DOD	Department of Defense
GAO	General Accounting Office

CHAPTER 1

INTRODUCTION

Primary electrical power is supplied to most military installations within the continental United States by commercial or municipal utility companies. The commercial power is delivered over one or more separate transmission lines to one or more substations at the installation perimeter, where it is then fed into the Government-owned distribution system which supplies the installation. Where multiple delivery points are available, the Government distribution systems sometimes provide a looping arrangement which permits each delivery point to supply all or part of the power requirements served by the other delivery points, should they fail.

The need to rely on primary power varies from installation to installation. However, even in the best systems, such as those providing looping multiple primary sources, power outages sometimes occur. Thus most installations have emergency backup generators to support activities for which power is essential. Aircraft navigational aids, fire stations, command posts, and hospitals are a few examples of the activities typically supported with such power systems.

Emergency generators are classified as either fixed (installed) or mobile. Fixed generators require special foundations and protection from the elements to be operational. They are part of a facility and, as such, lose their specific identity. All other generators, including skid-mounted, wheel-mounted, or portable generators, are classified as mobile. Deciding whether a mobile or installed generator is required in meeting an emergency usually involves determining the needed response time. Thus the necessity for immediate response would preclude using a mobile emergency generator which, during a power outage, would have to be transported to and connected at the requiring activity.

The Department of Defense's (DOD's) current inventory contains about 175,000 mobile generators valued at about $760 million. We have no information on how many of these are in use or employed for an emergency. During our review we noted that while many mobile generators are purchased for tactical reasons, many are also being used at military activities as emergency generators. The investment cost data is unavailable for fixed generators because they are

part of the total project cost. However, the investment in fixed generators is considerable.

Total DOD cost of maintaining and operating this extensive inventory of generators is also not available but is undoubtedly substantial. For example, at 10 of the bases visited, we conservatively estimated that the costs to operate and maintain generators for 1 year amounted to $548,000. At 1 Air Force base, 46 full-time civilian and military personnel maintained and operated the base's 48 emergency generators. The fuel tanks for these generators had a continuous requirement of about 176,000 gallons. Generators with automatic start devices had a constant requirement for commercial electrical energy for internal engine heaters to keep the oil and coolant at the required starting temperature.

Since the specific identities of fixed generators are merged with the facilities of which they have become a part, no DOD-wide management control is exercised over their existence and use. Instead, responsibility for managing these generators is assigned to the individual commands which operate the military bases where they are located.

MOBILE ELECTRIC POWER PROJECT

Mobile generator management is more centrally assigned. In 1967 DOD established the Project--a joint defense agency project for managing mobile generators. The Project's objective is to save money by limiting the number and types of generator sets used by the three services and standardizing them. There are many makes and models, and, depending on the specifications involved, they range in price from a few hundred dollars to over $100,000.

Under the Project, each service has been designated, as shown below, as DOD's primary provisioning agent for a specific power range of mobile generators.

	Power range (kilowatts)
Army	0.5 to 60
Air Force	60 to 200
Navy	200 to 1,500

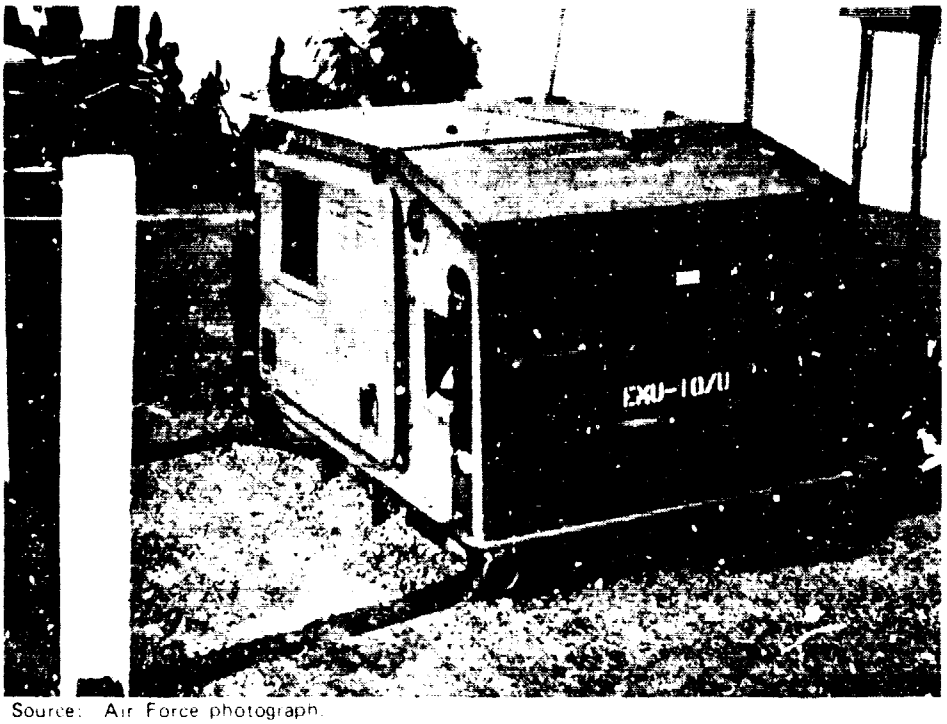
The primary provisioning agents procure all mobile generators within their assigned power range. They redistribute and dispose of all excess mobile generators.

In establishing the Project, DOD intended that each of its agencies would retain most of its operational responsibility. As a result, each service continues to maintain operational and inventory control over the worldwide use of mobile generators assigned to its organization. The responsibility for operational control of mobile generators has been redelegated by the services--much the same as for fixed generators--to the individual command where the generators are assigned. The inventory responsibility for mobile generators, however, is centralized in each service.

Installed generator requirements are recommended by the base engineer as part of a facility's construction plan and are approved at the command level. Requirements for mobile emergency generators originate with the user and are submitted to the base engineer for initial approval. If the base engineer decides that the generator is necessary, he justifies its need to the inventory control point, which determines the total requirement for that service.

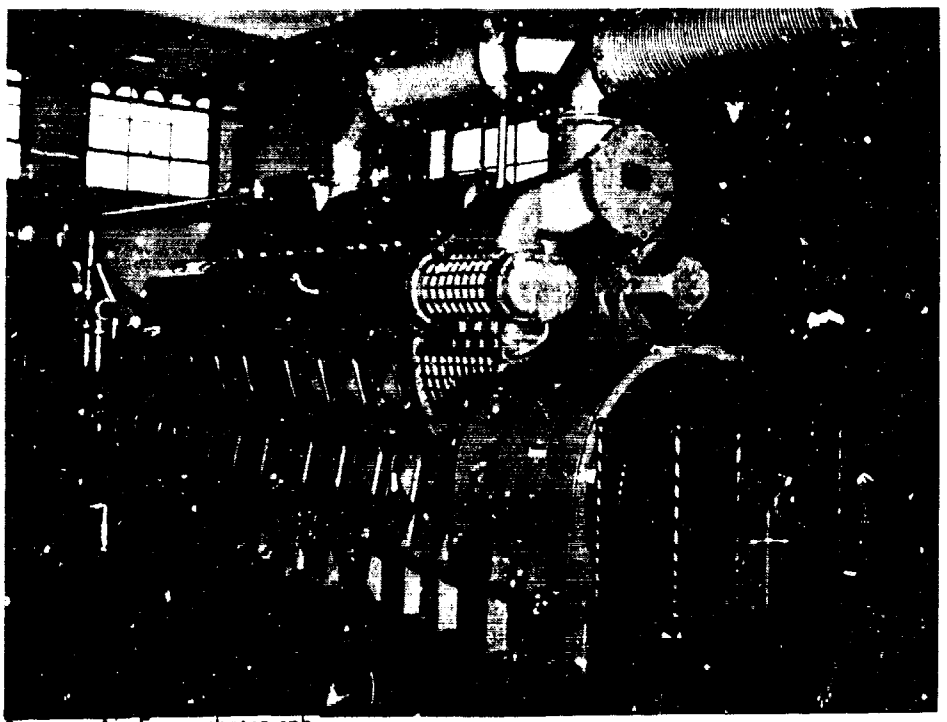
REVIEW OBJECTIVES

Because generators used for emergency purposes are expensive to buy, operate, and maintain, we wanted to determine the extent to which installations needed them and to evaluate how the military managed them. Chapter 3 lists the installations visited. Photos of a 10-kW gasoline-engine-driven generator and a 1,000-kW diesel-engine-driven generator follow.



Source: Air Force photograph

10-kW gasoline-engine-driven generator. This generator is permanently wired to the building and is equipped with an automatic start device activated by a commercial power failure.



Source: Air Force photograph

1,000-kW diesel-engine-driven generator. This generator is one of two 1,000-kW generators supporting a transmitter facility. Six personnel operate and maintain these generators.

CHAPTER 2

EMERGENCY POWER SYSTEMS CAN BE MANAGED BETTER

The Department of Defense needs to provide definitive guidelines to the services on the proper management and use of emergency power generators. While the individual services have some criteria for selected aspects of managing emergency generators, we found specific areas needing more attention:

--Criteria for authorization and use of emergency generators.

--Justification for acquisition of generators and periodic reviews of continued need.

--Consolidation of emergency power requirements.

CRITERIA NEEDED ON GENERATOR AUTHORIZATION AND USE

DOD had not provided specific criteria to help installations determine which activities should have priority for emergency power requirements, nor had it emphasized meeting these requirements efficiently and effectively through consolidation or other alternatives. If reasonable criteria were provided on how installations could best consider meeting emergency power needs, DOD and the services could minimize or avoid unnecessary investments in generator equipments.

The services have regulations authorizing certain types of activities to have emergency power generators. For example, the Army authorizes auxiliary generators for hospitals; fire alarm systems; communication facilities; confinement facilities; automatic data processing equipment; heliport and airfield facilities; storage and operating facilities for nuclear weapons; and legal requirements, such as for sewage pumping stations. The Air Force recommends essentially the same functions, in addition to utility plants, base weather stations, and surveillance and warning systems. The Navy includes support for fallout shelters, antiaircraft devices, and harbor defenses.

However, these regulations permit any facility not specifically listed to have generator support if deemed

necessary. Because decisions on which vital functions should be supported are based largely on independent judgment, many different types of facilities are provided support, and in some cases, such facilities may not need emergency generators.

At McClellan Air Force Base, California, for example, a 15-kW mobile generator was assigned to provide emergency power to a boiler plant. This unit was justified on the basis that the boiler provided steam to critical functions at an aircraft paint hanger, a laboratory, a plating shop, a technical operations squadron, and general purpose shops. We pointed out that since none of these industrial facilities had emergency power, they would have no use for steam during a power blackout. Base civil engineering officials agreed. They told us the generator would be made available for other uses.

Adequate DOD and military service criteria on the authorization and use of emergency power generators can reduce many generator-related inefficiencies at installations, such as (1) generator capacities greater than required, (2) unnecessary and redundant generators, (3) inconsistencies in generator use, and (4) unnecessary costs to maintain redundant systems. Examples of these conditions follow.

Generator capacity

At many installations we visited, generator capacity far exceeded the power load requirement. (See app. II for examples.)

The different generator sets listed below illustrate that, generally, the larger models, in terms of kilowatt capacity, cost more than the smaller ones.

National stock number	Generator model	Capacity (kilowatts)	Unit cost
6115-00-017-8240	MEP 017A	5	$ 2,600
6115-00-118-1241	MEP 004A	15	9,900
6115-00-118-1243	MEP 006A	60	12,700
6115-00-133-9101	MEP 007A	100	15,100
6115-00-689-4489	MB 15	150	32,100
6115-00-133-9104	MEP 009A	200	35,800

Having generator capacities much greater than the load being supported is unnecessarily costly, where a smaller, less expensive generator could assume the same load.

The Army, for example, does not have criteria specifying the generator capacity for the amount of support required. At Fort Ord, California, a facilities engineer said the local policy requires the capacity of installed generators to be at least three times larger than the load. This may have resulted in the excessive capacities for 14 of 18 installed generators at Fort Ord, as described below, and in the procurement of larger, more expensive generator units.

Activity	Capacity	Load	Percent load to capacity
	(kilowatts)		
Firing range radar	5	1.0	20
Stockade	125	36.0	29
Boiler room	10	2.4	24
Commissary	25	2.0	8
Booster station	10	0.9	9
Transfer house	5	0.4	8
Military amateur radio service station facility	5	0.7	14
Presidio headquarters	10	0.7	7
Telephone building	150	38.0	25
Federal Aviation Administration tower	60	16.0	27
Installation headquarters	60	14.0	23
Outer marker	10	3.3	33
Federal Aviation Administration middle marker	5	0.5	10
Ground control approach radar	10	1.0	10

At Moffett Field, Naval Air Station, Sunnyvale, California, four activities had generators whose capacity exceeded the load. Base engineering officials informed us that no action would be taken to resize these units until they became due for replacement.

Unnecessary and redundant generators

Under certain operational and weather conditions, navigational aids are essential to safety of flight. They are provided power sources sufficient to provide high reliability service to user aircraft. These systems may include Radar Approach Control, Ground Controlled Approach Radar, Instrument Landing System, Terminal VHF Omnidirectional Range, Tactical Air Navigational System, and associated equipment.

Most Air Force bases have more than one landing system which backs up their primary system. Air Force regulation 91-4 provides that where a combination of navigational systems are installed, the one complete system providing the lowest approach landing minima 1/ will be given high reliability power.

At eight installations having generators which support navigational aids, the way the generators were assigned varied widely. Most of the bases had four separate navigational aid systems in use which were backed up by generators. (See app. III.) At all eight, however, the one complete system providing the lowest aircraft landing approach minima included the control tower, the Ground Controlled Approach Radar, and the Radar Approach Control. This means that these navigational systems can adequately provide the necessary navigation services on a "worst case" basis, if needed, to enable any aircraft to land safely even during a power outage.

Therefore, we believe that the generators backing up the other systems at these installations should not have been authorized. Kelly Air Force Base, Texas, for example, had five unnecessary generators backing up three additional navigational aid systems.

Some installations also provided redundant backup power to certain navigational aids. For example, at

---

1/ That point on the final approach (usually 100 feet above the ground and a quarter mile from touchdown) at which the pilot of an aircraft being assisted by Ground Controlled Approach Radar must abort his landing if he does not have the runway clearly in sight and cannot land the aircraft visually.

Mather and Castle Air Force Bases, California, the glideslope and localizer each have battery backup systems in addition to installed generators. At Hill Air Force Base, Utah, the generator supporting the airfield lighting provides prime backup for the glideslope, Ground Controlled Approach Radar, and Tactical Air Navigational System facilities, each of which also has installed generators to be used if the prime backup generator fails.

Finally, the Air Force does not consider using nearby bases as alternate landing facilities instead of supporting navigational aids with generators. For example, McClellan Air Force Base--where some navigational aids are necessary only a few days of the year--is within 40 miles of three Air Force bases and one major metropolitan airport. If alternate landing facilities were used where feasible, we believe the number of generators providing emergency backup power to navigational aids at these installations could be reduced.

The Air Force questioned some installations having mobile units as a backup to authorized generators, and it proposed to eliminate this redundancy. We noted this variation in generator use at Tinker Air Force Base, Oklahoma. The communications and hospital facilities there had secondary generators backing up the primary units. In the event of an outage, both units were to start automatically, but only one was used if the other operated satisfactorily. At the time of our survey, the Air Force was considering eliminating these redundancies. Subsequently, the Air Force advised DOD that the generators involving the hospital at Tinker were needed and that there was no redundancy.

Inconsistencies at aircraft fuel-dispensing facilities

Vagueness in Air Force regulations has resulted in instances when certain facilities at an installation are supported with emergency power, whereas similar facilities at other installations are not. These inconsistencies can be costly, and they raise doubts as to whether these facilities are actually essential for having generator support.

For example, at Tinker Air Force Base, four generators were installed at fuel-dispensing areas at a total cost of about $71,000. However, the need for these generators is questionable because primary commercial power has failed

only two or three times during the last 30 years. Additionally, the dispensing facility has experienced power outages of only nine-tenths hours annually, caused by failures within the base distribution system. These generators were justified on the basis that they were needed in the event of a national emergency or for other potential causes of power failure.

At Robins Air Force Base, Georgia, and Hill and Kelly Air Force Bases, Texas, outages were more frequent, but dispensing facilities did not have installed emergency generators.

We believe mobile generators can back up appropriate facilities, in many cases, when outages are intermittent instead of investing in installed generators. In these cases, available mobile generators having sufficient capacity could be more economical to use.

Unnecessary generator maintenance costs

Supporting unneeded and redundant generator systems also results in unnecessary expenditures to maintain them. If such systems could be minimized or even avoided, DOD activities could devote their generator maintenance programs to the more critical systems. An example follows.

At Beale Air Force Base, California, five 650-kW generators remained from the Semi-Automatic Ground Environment system which supported the Distant Early Warning System. These systems were in operation from about 1958 through 1969 at this installation. These five generators, with a total capacity of 3,250 kWs, currently support reconnaissance, computer, and cryptographic activities.

The base civil engineer informed us that while only two of these units were needed to satisfy emergency backup requirements, a third unit might be needed to back up the first two. The annual cost of maintaining these unneeded generators would be $13,000 each.

The base civil engineer informed us that he would determine whether the third generator was needed and the least expensive method of removing the unneeded generators from service. These methods range from complete removal to decommissioning and storage in place until needed by another installation.

NEED FOR ADEQUATE JUSTIFICATION AND PERIODIC REVIEW OF GENERATORS

DOD does not have an adequate system for (1) determining that potential generator users are properly justifying initial requests and (2) reviewing generator use periodically to see if they should be retained or removed.

An adequate system could help DOD assure that generator needs are accurately validated and that those no longer necessary are removed from service and made available to other activities. Also, it could identify generators with excessive capacity which can be replaced by smaller, more efficient units.

Air Force regulations require that installations annually determine whether emergency backup power requirements are being satisfactorily met at specified activities. These regulations, however, do not require consideration of whether a continuing need exists for the generators. Neither do the Army and Navy regulations. We believe that a periodic review by the command or service, to include such factors, is essential.

Initial authorization review

Mobile generators are reviewed at the major command level only when initially requested by an installation. Once a mobile generator has been approved, it is added to the installation's table of distribution and allowances or table of allowances.

In requesting an initial authorization, installations must submit complete justification to the command level. We reviewed initial authorization requests to see to what extent the need was justified. More justification data was necessary for a proper review. In many cases, generator users only mention that the generator is essential to their type of facility, but they seldom explain why. Command level reviewers have access to more complete information upon which to base their decisions, such as historical data on the extent and duration of power outages, the extent to which equipment was inoperable due to outages, and the various generator sizes and supporting loads facilities were carrying. Such data was not considered before initial requests for mobile generators were approved.

Installed generators may be approved by the installation commander as small construction projects if the cost is less

than $60,000 for Army projects and $50,000 for Air Force and Navy projects. Since only the very large installed generators exceed the above criteria, only a few would be subject to critical review beyond the base level. Independent reviews could increase the chances of possible consolidation of the smaller units at nearby facilities.

Periodic reviews

Both the Army and Air Force provide for the periodic review of table of allowance equipment to fully justify equipment acquired and retained. The Army's inspection is conducted every 3 years at the installation level, and the Air Force's inspection is made annually.

Inspections of generators are limited to mobile generators. As a result, only a small percentage of emergency power generators are reviewed. For example, Fort Ord, California, had 18 installed generators; McClellan Air Force Base, with 48 generators, had 33 installed generators; and Sacramento Army Depot, California, with 10 generators, had 6 installed generators. As pointed out on page 13, consolidating installed generator requirements can produce large savings without reducing the degree of support. If both mobile and installed generators were adequately covered during periodic reviews, even more could be saved.

POTENTIAL TO CONSOLIDATE EMERGENCY POWER REQUIREMENTS

Determining which emergency power requirements can be consolidated could preclude the acquisition of unneeded generators and could reduce the costs of maintenance labor, material, fuel, and commercial energy. DOD should establish a policy which requires or encourages consolidation of emergency power requirements at individual bases.

Officials at several installations told us that in many cases consolidation is not only feasible but practicable. At McClellan Air Force Base we pointed out two instances when it would be feasible and cost effective to consolidate.

In one case, consolidation could save an estimated $125,000 to $177,000 in annual personnel costs, depending upon which of two facilities is retained to provide emergency backup, in addition to undetermined savings in

fuel and maintenance costs. At both facilities, generators are manned 24 hours a day. Capacity and load data for the facilities follow.

Building	Generator capacity	Load	Excess generator capacity
	(Kilowatts)		
7	1,850	200	1,650
262	1,320	600	720

Base civil engineer officials agreed that the generators in either building could satisfy the requirements of both buildings. Based upon data provided by these officials, we computed the following estimated benefits of consolidation.

	Retain generators in building	
	262	7
Annual personnel savings	$125,000	$177,000
Less one-time cost to consolidate	39,000	81,000
First-year savings	$ 86,000	$ 96,000
Annual recurring savings	$125,000	$177,000

A picture of one of the building 7 generators follows on page 14.

Although base officials agreed that this consolidation was feasible, they told us it will be deferred pending a determination of the power requirements for a proposed new project which has been in the planning stages for 3 years and which will affect the consolidation. Installation officials had no idea when this project would be finalized. We believe that, since 3 years of potential savings have already been lost, the project power requirements should be quickly determined in order to achieve these substantial benefits.

In the second instance, a generator had excessive capacity at one McClellan facility and could serve four other facilities. All five facilities are served by the

Source: Air Force photograph.

This generator is one of three in building 7 at McClellan. Three generators with a total capacity of 1,850 kWs satisfy an emergency power requirement of about 200 kWs.

same electrical distribution circuit, and each is supported by its own standby generator. The base civil engineer personnel said it was possible to eliminate four generators by consolidating emergency power requirements and agreed that the generator requirements for the five facilities could be consolidated.

They told us that instead of a planned rehabilitation project involving these facilities, they are considering this consolidation at a cost savings of $67,000 for the project. Consolidation will also save an estimated $3,600 in annual maintenance costs, in addition to

savings in fuel and electric heater energy applicable to the generators to be removed from service. Although these four generators were classified as installed, they can be disengaged for use elsewhere.

CONCLUSIONS

DOD needs to provide the services the criteria for determining which functions should have emergency power and which should not. Then an adequate system for reviewing and justifying generators is necessary to see whether a continuing need exists or whether current generator capacity is excessive. DOD should emphasize to the services that generator resources should be consolidated, when appropriate, rather than buying or retaining unnecessary generators.

RECOMMENDATIONS

The Secretary of Defense should:

--Provide criteria for determining which users should have priority access to emergency power and how the needs of these users can best be met.

--Strengthen the process for reviewing and justifying the need for all generators. This will permit (1) the initial need for a generator to be adequately justified, (2) those users which can be serviced by smaller generators to be identified, and (3) generators no longer necessary to be made available to other users.

--Instruct installations to share generators, when appropriate, as an alternative to buying or retaining unnecessary generators.

AGENCY COMMENTS

DOD's comments on our preliminary report dated November 22, 1976, are included as appendix I. The Acting Assistant Secretary of Defense (Installations and Logistics), in his March 16, 1977. reply, stated that our recommendations merited consideration. He said that the Air Force recently issued criteria standardizing the authorization and use of emergency generators for specific facilities and that such facilities are being reviewed in relation to the needs of the Army, Navy, and Defense Logistics Agency.

The Acting Assistant Secretary felt that the management of auxiliary electrical power systems supporting fixed facilities was well defined since it was covered by construction criteria and reviews but that DOD will review and issue appropriate guidance on the use of these systems. He added, however, that the management of mobile equipment under the installation engineer's control and used for support of fixed facilities needed improvement.

The Acting Assistant Secretary was concerned over several aspects of our preliminary report which, in his opinion, tended to present an unbalanced account of the use of auxiliary electrical power systems. According to DOD, we should have differentiated between mobile generators having tactical applications and auxiliary electrical power systems, since both types have somewhat different uses. Tactical mobile generators are used to support weapons systems, radar, communications, and field hospitals, while auxiliary electrical power systems directly support fixed installations. Since many of the nontactical mobile generators are also used for purposes unrelated to auxiliary electrical power systems for facilities (such as cable testing and thawing of drains), DOD felt that these matters should have been recognized. DOD further contended that the numerous examples of improvements we identified would be completely unacceptable during major disasters, large power failures, a national emergency, or full mobilization.

DOD took exception to our references to redundant generator systems. It cited instances in which the use of two separate power sources is quite practical, especially in critical installations such as hospitals. DOD considered it good engineering design to use a minimum of two generators for many critical facilities because electrical generation equipments are not completely reliable, and problems can occur when facilities are remotely located from primary power sources, and severe weather problems are encountered.

DOD believed that, during the 1965 massive power failure in the northeastern United States, its mission essential operations did not suffer because it had a sound policy on using auxiliary electric power, particularly for instrument landing systems and runway lighting of DOD airfields. DOD said one of the lessons learned from this experience is that there is no substitute for adequate electrical power systems in an emergency.

Concerning generator loading, DOD stated that, in most cases, good engineering design would result in an auxiliary

system load ranging from 75 to 90 percent of generator capacity. DOD pointed out, however, that load growth is particularly difficult to evaluate, especially in the communication and radar fields. Further, when a new function moves into a facility with existing generators, it rarely matches the current mission. It concluded that the Government's overall cost is lower through use of existing generators rather than buying new ones, and incurring the cost to remove the old and install the new.

Finally, DOD agreed in principle with the objective of consolidating auxiliary electrical power systems. It pointed out, however, that this objective was normally difficult to achieve since facilities entitled to the systems were widely separated, such as hospitals, airfield runways, and confinement areas. DOD cited other restrictions, such as possible damage to power lines from adverse weather conditions, accidents, or sabotage.

OUR EVALUATION

DOD's comments are directed to certain specific conditions where it could determine that redundant or excessive power capacity is necessary for military activities to operate satisfactorily.

Although we fully recognize the necessity for having adequate backup power for critical facilities during power failures, disasters, or national emergencies, it is just as important for DOD to have a management system which insures that emergency power needs are justified. While redundant backup systems certainly provide more confidence that emergency power will be available, DOD should place more emphasis on the economic considerations of providing and managing expensive equipment for emergency power purposes. Our intent in evaluating the management of this equipment was to see whether DOD's policies and criteria for authorizing and using it were adequate to limit emergency power systems to essential requirements and to prevent future unnecessary investments.

Although most mobile units have tactical uses, the services can, and do, use them for emergency power failures. We found them, however, being used inefficiently at the installations we visited, along with permanently installed units. We feel management improvements can be made in both types of generators used for emergency power purposes.

We believe DOD, particularly the Air Force, did not have a valid need for the generator equipment to the degree to which it was being used. The Air Force's current action should help to reduce this condition. The examples we used throughout this report clearly showed that all the services can strengthen their management of emergency power systems without suffering a loss of mission by keeping such systems to the minimum necessary and consolidating them where appropriate.

The Acting Assistant Secretary's reply did not mention what specific actions DOD planned to take to strengthen its criteria for authorizing and using generators for emergency power, to improve the justification and review of such equipment, or to achieve greater consolidation of emergency power requirements. His reply seemed to be directed more toward various factors which would inhibit DOD in fully implementing our recommendations.

For example, we questioned the need for a generator to back up the boiler plant at McClellan Air Force Base, California. (See p. 6.) We said it was unnecessary because the industrial activities it supported had no emergency generators for electric power failures. The Acting Assistant Secretary's response cited the potential damage to the heating and water systems in these activities if temperatures got below freezing levels for prolonged periods.

The Sacramento, California, area, where McClellan is located, has not had a history of prolonged periods in which temperatures were consistently below freezing. Also, McClellan has had only one multiple source commercial outage for longer than 6 seconds in the past 10 years, and this outage lasted 14 minutes. Providing a backup power system for every conceivable contingency due to adverse weather conditions would require extensive investments in generator equipments. The Air Force must ask itself whether investments for these types of situations are warranted.

Concerning DOD's nonconcurrence with some of the load data in the report, we wish to emphasize that the data we used was prepared and provided by base personnel during the early part of our review. Even if the data DOD cited

in its reply were used, most of the examples would still show excessive generator capacity. 1/

Unless it provides the proper management emphasis to our recommendations, DOD and the services could later invest in new systems they do not really need, or retain existing systems which could be consolidated with other requirements or which could accomplish a mission with a smaller, less expensive generator. Therefore, we urge DOD to act promptly and decisively on the recommendations stated on page 15 to avoid or minimize this situation.

1/DOD's reference on this matter appears on pp. 26 and 27. The examples DOD takes issue with appear on pp. 28 and 29. Except for the airfield lighting at Minot Air Force Base, North Dakota, which needed 80 percent of the capacity, the activities' needs were still 40 percent or less of capacity. With the exception of one generator operating at 60 percent of capacity and two which were turned in, the remaining activities' needs at Beale were 45 percent or less of capacity.

CHAPTER 3

SCOPE OF REVIEW

We made this study to determine the extent to which military installations needed auxiliary power-generating capability and to evaluate their management of these systems. We reviewed each service's instructions and regulations on auxiliary electrical power systems. At each installation, we reviewed records on primary and auxiliary power, interviewed officials, and inspected auxiliary electrical power units. Finally, we looked into the maintenance of auxiliary electrical power units.

We visited the following installations:

AIR FORCE

McClellan Air Force Base, California
Mather Air Force Base, California
Castle Air Force Base, California
Beale Air Force Base, California
Robins Air Force Base, Georgia
Minot Air Force Base, North Dakota
Tinker Air Force Base, Oklahoma
Kelly Air Force Base, Texas
Hill Air Force Base, Utah

ARMY

Sacramento Army Depot, Sacramento, California
Fort Ord, California
Oakland Army Base, Oakland, California

NAVY

Lemoore Naval Air Station, Lemoore, California
Naval Air Rework Facility, Alameda, California
Naval Facility Engineering Command, San Bruno, California
Moffett Field, Naval Air Station, Sunnyvale, California

APPENDIX I

ASSISTANT SECRETARY OF DEFENSE
WASHINGTON, D.C. 20301

INSTALLATIONS AND LOGISTICS

16 MAR 1977

Mr. F. J. Shafer
Director, Logistics and
Communications Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Shafer:

This is in response to your letter of November 22, 1976, to the Secretary of Defense requesting comments on your draft report entitled "Improvements Needed in the Management and Use of Auxiliary Electrical Power Systems," GAO Code 947207 (OSD Case 4484).

The DoD believes the three recommendations made in the draft report merit consideration. In fact, the Air Force, in June of 1976, issued criteria standardizing the authorization and use of emergency generators for specific facilities. This list of facilities is now being reviewed in relation to the needs of the Army, Navy and Defense Logistics Agency. On balance, we believe that the management of installed auxiliary electric power systems is reasonably well defined since such systems are generally covered by construction criteria and are subject to reviews of construction projects. We would agree that in the case of mobile emergency equipment under the control of the installation engineer and used for the support of fixed facilities, there is need for improved management. The use of auxiliary electric power systems for installation support will be reviewed and appropriate guidance as required will be issued.

We wish to point out, however, that the DoD is concerned with three major aspects of this draft report which tend to present a misleading account of the use of auxiliary electrical power systems.

GAO note: Page number referencing may not correspond to the pages in this final report.

APPENDIX I

First, the report uses data relating to mobile generators while its examination is limited to emergency power generators. Secondly, we do not believe that the report gives sufficient consideration to mission readiness requirements in a period of full mobilization, nor to the requirements for such equipment during major disasters or major power failure situations. Lastly, the report does not appear to recognize the various methods used to achieve auxiliary electrical power systems, the degrees of criticality of such systems, or the reliability factor for engine-generators. A fuller statement of our position on these and other aspects of the draft report is enclosed.

Sincerely,

DALE R. BABIONE
Acting Assistant Secretary of Defense
(Installations and Logistics)

COMMENTS ON DRAFT REPORT

1. The number and value of "emergency power generators" is stated in a misleading manner. In the second paragraph (page i) of the Digest, the first sentence discussed "emergency power generators" and the very next sentence switched the subject to "generators" in such a manner that it could be concluded that the large sums noted apply to emergency generators which is not the case. Also, in the second paragraph (page 2) of the Introduction, the subject is switched from "emergency generators" to "mobile generators." While the statement that the Army had 155,200 mobile generators valued at $432 million is correct, these data are irrelevant in a discussion of emergency generators. The data source for the 155,200 mobile generators identifies 171 (valued at $2,385,000) of these as non-tactical units which are under the control of Facilities Engineering. Similarly, the current Air Force inventory identifies 3,005 mobile generators authorized for Civil Engineering and 14,098 authorized for other functions such as flight line support for aircraft, mobile communications facilities and war readiness material. Of the 3,005 units, many are used for Prime Beef construction teams, cable testing, thawing of drains and other uses not related to auxiliary electrical power systems for facilities. The report is remiss in not differentiating between tactical mobile generators numbering in the hundreds of thousands, and used for such purposes as weapon systems, radar, communications, and even field hospitals, and auxiliary electrical power systems numbering in the thousands, and used directly in support of fixed installations.

2. The thrust of the report deals entirely with the normal peacetime activities of the Military Departments. The report appears to give no consideration to the basic mission of the DoD and the mandatory requirement to be fully operational in time of national emergency. The report contains numerous examples of improvements needed in the use of auxiliary electrical power systems, based on the normal peacetime situation which would be completely unacceptable for mission accomplishment during major natural disasters, large power failures, a national emergency or full mobilization.

3. There are various methods used to obtain auxiliary electrical power systems, various degrees of criticality of these systems, and a relationship between the reliability of the system to the reliability of a single engine-generator. The report does not take these factors into account. There are many applications of auxiliary electrical power systems which require an instantaneous response such as emergency lighting in a hospital

operating room. Batteries may be used for such lighting. However, the battery has a short life and therefore an engine-generator would be required to provide lighting over a long period and to recharge the battery system. Accordingly, the use of a battery pack and an engine-generator in combination may be needed for response time and may be the more economical solution. The use of two separate power sources in this case is not redundant but is a good example of an auxiliary power system. To illustrate, it is good design practice in critical installations to provide two or more generators since reliance on only one unit is impractical. In hospitals, for example, one generator is designed to supply the critical, the life support and the life safety requirements during an emergency, and the second generator is designed to supply the essential equipment requirements. Both are necessary (see National Electric Code) and used in the event of a power failure. However, should the first generator fail to start or fail during operation, the second generator would automatically be switched over to supply the more crucial need. The report frequently criticizes the use of a second generator or an alternate auxiliary electrical power system without giving any recognition of the fact that electrical generation equipment is not 100% reliable. For example, the prime capacity of every utility generating plant in the United States is calculated on the basis of the largest generator being out of service. It is considered good engineering design practice to use a minimum of two generators for many critical applications such as hospitals, fixed radar facilities, and communication centers. Moreover, depending on the remoteness of the facility, the length of the electrical transmission lines, weather problems such as sleet, freezing rain and thunderstorms, and the criticality of the mission, good engineering practice may dictate three generators with any two capable of carrying the emergency load. As an example, the Air Force has advised this office regarding the case involving the hospital at Tinker AFB (page 12a of the report), that both generators are needed and that there is no redundancy.

4. Another example of the need for emergency power is the boiler plant at McClellan AFB (discussed at page 8 of the report). As recently as December 1972, the temperature at McClellan reached 19°F and any power failure during a prolonged period below freezing would result in substantial damage to both the heating and water systems in all the buildings served by this boiler plant. Furthermore, an extended power outage during sub-freezing weather could result in the freezing of the boiler plants since in the typical plant all fans, pumps, burners and controls are electrical. It is the position of this office that officials at McClellan were premature in agreeing that there was not a valid requirement for this generator. In the criteria now being developed for auxiliary electric power systems, there will be a specific requirement

APPENDIX I

for all boiler plants of reasonable size, located in climatic areas where the heating design temperature is 32°F or less, to be equipped with an emergency power source. No better example of the need for this requirement can be found than in the recent weather situation in the eastern half of the nation where extreme southern cities experienced record low temperatures and the daily news was replete with accounts of frozen and severely damaged heating systems. To argue that a mobile generator could be installed during an emergency is contrary to the point of the report to reduce the number of auxiliary electrical power systems.

5. One of the lessons learned by the DoD and the entire civilian sector from the massive power failure of November 9, 1965 is that there is no substitute for adequate auxiliary electrical power systems in an emergency. The thousands of these systems which were installed by the civilian community in the wake of that great power failure is adequate testimony for this point. Furthermore, during that power failure, which caused a black-out in the entire northeastern United States, the DoD, because of a sound policy on the use of auxiliary electric power, did not suffer any loss of mission essential operations. It is our understanding of the situation at that time that DoD airfields, with adequate electrical standby generating equipment for both instrument landing systems and runway lighting, were the only fully operational airfields for large aircraft within 200 miles. The largest electrical generating plant of Consolidated Edison, which serves New York City, could not be started up again until a mobile generator was borrowed from an outside source and moved to the plant. It appears to this office that these examples clearly indicate the over-all wisdom of the Defense policy on the use of auxiliary electric power systems and the real danger of applying civilian criteria to the use of such systems in military installations.

6. The report emphasizes the point that many auxiliary electric power systems have generators which do not match the load. In the majority of cases, good engineering design would result in an auxiliary system load in the range of 75% to 90% of the generator capacity. The type of load (resistive or inductive), the diversity factor calculations, the allowances for load growth, the lack of knowledge of what the customer might "plug in" the system are all factors affecting the judgment of the designer. The standard sizes offered by industry also influence the size of the unit selected inasmuch as normally the next largest standard size must be used. Load growth is particularly difficult to evaluate especially in the communications and radar fields. Another factor involved in the existence of partially loaded generators is an attempt by the DoD to use existing equipment rather than purchase new generators. Still further is the situation which results when a new function moves into a facility with existing generators which rarely are a proper match for the current mission. It is the opinion of this office that in most cases the lower over-all cost to the Government

would be achieved through the use of existing equipment or the existing situation rather than incur the expense of new generators and the cost of removing the old units and installing the new units. In several cases we are not able to concur with the load data in the report. For example, a follow-up survey by base personnel at Minot AFB and Beale AFB indicated larger generator loads than those shown on pages 22 and 24 of the report. The correct loading is detailed in enclosure 2.

7. With regard to the consolidation of auxiliary electrical power systems, this office agrees in principal with this objective. In practice, however, this normally is difficult to achieve since facilities entitled to such systems are widely separated. For example, hospitals, airfield runways and confinement facilities are usually far apart. In most cases emergency power is generated at the using voltages of 120/208v and it is impractical to transmit power more than a few hundred feet at these voltages. Other restrictions include the possible damage to power lines from adverse weather conditions, accidents or sabotage.

APPENDIX I

GENERATOR LOADING FOR AUXILIARY ELECTRICAL POWER SYSTEMS

Minot AFB

ADC Ammunition Bldg	40.0 KW
POL Pump House #1	40.3 KW
POL Pump House #2	40.0 KW
POL Bulk Storage	60.0 KW
Airfield Lighting	200.0 KW
Alert Area I	25.0 KW
TVOR	10.0 KW

Beale AFB

Weapon Storage Area Generator #1	45.0 KW
Weapon Storage Area Generator #2	45.0 KW
Communications Service HQ	Turned into supply
9th Strategic Reconnaissance Wing	Turned into supply
Civil Engineer Control	6.0 KW
Ceilometer #1	3.0 KW
Ceilometer #2	3.5 KW

EXAMPLES OF EXCESSIVE EMERGENCY POWER CAPACITY

MINOT AIR FORCE BASE, NORTH DAKOTA

Activity	Generator capacity	Load	Percent load to capacity
	(kilowatts)		
Air Defense Command ammunition building	100	10.1	10
POL (note a) pump house #1	150	40.3	27
POL pump house #2	150	18.0	12
POL bulk storage	150	22.8	15
Airfield lighting	250	50.2	20
Alert Area I	60	12.1	20
Terminal VHF Omnidirectional Range	30	7.5	25

a/Petroleum, oil, and lubricant.

The Deputy Chief of Operations and Maintenance at Minot stated that the Air Defense Command ammunition generator was oversized for current needs since the building had formerly been used for a different purpose. He did not have information on the maximum load for the other buildings or an explanation for the disparities.

Also the required annual review was not being made to determine whether essential requirements were being supported by auxiliary power generators.

MOFFETT FIELD, NAVAL AIR STATION, CALIFORNIA

Activity	Generator capacity	Load	Percent load to capacity
	(kilowatts)		
Transmitter	30	5.2	17
Precision approach radar #2	60	14.3	24
Aircraft communication	75	14.3	19
Fallout shelter	30	0.7	2

Base engineering officials informed us that these units would not be resized until they become due for replacement.

BEALE AIR FORCE BASE, CALIFORNIA

Activity	Generator capacity	Load	Percent load to capacity
	(kilowatts)		
Weapon storage area generator #1	100	15.0	15
Weapon storage area generator #2	100	15.0	15
Communications service headquarters	25	5.0	20
9th Strategic Reconnaissance Wing	5	0.5	10
Civil Engineer Control	10	3.0	30
Ceilometer #1	10	2.5	25
Ceilometer #2	10	2.5	25

These generators had excessive capacity. Base civil engineering officials said they would review individual generator requirements, perform capacity/load analyses for each unit, and take corrective action.

CASTLE AIR FORCE BASE, CALIFORNIA

We were told that to determine whether a continuing requirement exists for generators, the base civil engineer each year verbally asks all generator users whether their missions have changed. In our opinion, this method does not result in an effective determination of continuing need. For example, one activity had a 3-kW requirement supported by a 30-kW generator. We told the base civil engineer that a 30-kW generator was meeting a 3-kW requirement. As a result, the civil engineer told us the base would remove the 30-kW generator and replace it with a 5-kW unit from another activity. The 30-kW generator will be used to fill another requirement for which the acquisition of a $4,000 generator was proposed.

At this same installation, a 30-kW generator supported a 7.5-kW load. However, the base civil engineering personnel said this generator could not be replaced with a smaller generator without the approval of the major command user because it supported a navigational aid facility.

APPENDIX II

McCLELLAN AIR FORCE BASE, CALIFORNIA

Two mobile 30-kW generators provide emergency power to two BAK-9 aircraft arresting barriers--one at each of the north-south runway. These generators must be connected and manually started when needed. McClellan officials said that they are used about once each year to power the electrical motors used to retract the barriers after use.

We questioned the need for two generators. Since emergency power is necessary only during a primary power failure, and then only to retract the barrier after use, one generator apparently could be used at either barrier as necessary.

According to the base civil engineer, the barriers are classified as navigational aids and are required by regulations to be supported with emergency power. We reviewed the regulations and found no reference to arresting barriers. Moreover, we do not believe the base civil engineer's comments address the issue of whether one or two generators are necessary. In our opinion, one generator can safely support the emergency power requirements of both barriers since its use would be necessary only after a barrier had been used.

ROBINS AIR FORCE BASE, GEORGIA

At this base an activity was being supported by a 100-kW generator. The base civil engineer processed a work order to replace the existing generator with a $4,000, 30-kW unit. However, we pointed out that no current need for the proposed 30-kW generator existed, since the previous user which had initially justified the 100-kW unit had relocated in 1972. As a result, base civil engineering officials informed us that the 30-kW unit would not be installed at this activity.

At this installation, annual reviews required under Air Force regulations were not being made. Base civil engineering officials informed us that as long as complaints were not received, they considered that all needs were being satisfactorily met.

GENERATORS SUPPORTING NAVIGATIONAL AID SYSTEMS

Air Force Base	System #1 (lowest approach minima)			System #2			System #3	System #4
	Control tower	GCA (note a)	RAPCON (note b)	Glide slope	Localizer	Middle marker	TACAN (note c)	TVOR (note d)
	(kilowatts)							
Beale	30	60	(e)	10	10	(e)	30	10
Castle	f/175	30	60	5	15	(g)	30	(e)
Hill	(h)	60	100	30	15	10	30	(e)
Kelly	60	60	100	15	15	5	30	30
Mather	60	60	(e)	150	10	10	30	(e)
McClellan	f/350	60	150	15	15	15	(e)	i/60
Robins	60	60	j/175	5	10	(e)	(e)	(e)
Tinker	75	60	100	30	15	5	30	30

a/Ground Controlled Approach Radar.
b/Radar Approach Control.
c/Tactical Air Navigational System.
d/Terminal VHF Omnidirectional Range.
e/No navigational aid at this location.
f/Generator also supports other equipment.
g/Facility at this location not supported with emergency power.
h/Supported by a generator installed at another facility.
i/Maintains and operates a system similar to a Terminal VHF Omnidirectional System.
j/Includes three generators.

APPENDIX III

APPENDIX IV

PRINCIPAL OFFICIALS RESPONSIBLE FOR ACTIVITIES DISCUSSED IN THIS REPORT

	Tenure of office	
	From	To
DEPARTMENT OF DEFENSE		
SECRETARY OF DEFENSE:		
Dr. Harold Brown	Jan. 1977	Present
Donald H. Rumsfeld	Nov. 1975	Jan. 1977
James R. Schlesinger	July 1973	Nov. 1975
William P. Clements, Jr. (acting)	Apr. 1973	July 1973
Elliott L. Richardson	Jan. 1973	Apr. 1973
ASSISTANT SECRETARY OF DEFENSE (INSTALLATIONS AND LOGISTICS):		
Dale R. Babione (acting)	Jan. 1977	Present
Frank A. Schrontz	Feb. 1976	Jan. 1977
John J. Bennett (acting)	Mar. 1975	Feb. 1976
Arthur I. Mendolia	June 1973	Mar. 1975
Hugh McCullough (acting)	Jan. 1973	June 1973
DEPARTMENT OF THE AIR FORCE		
SECRETARY OF THE AIR FORCE:		
John C. Stetson	Apr. 1977	Present
John C. Stetson (acting)	Jan. 1977	Apr. 1977
Thomas C. Reed	Jan. 1976	Jan. 1977
James W. Plummer (acting)	Nov. 1975	Jan. 1976
Dr. John L. McLucas	June 1973	Nov. 1975
Dr. Robert C. Seamans, Jr.	Jan. 1969	May 1973
DEPARTMENT OF THE ARMY		
SECRETARY OF THE ARMY:		
Clifford Alexander	Feb. 1977	Present
Martin R. Hoffmann	Aug. 1975	Jan. 1977
Howard H. Callaway	July 1973	Aug. 1975
Robert F. Froehlke	Jan. 1971	Apr. 1973
DEPARTMENT OF THE NAVY		
SECRETARY OF THE NAVY:		
Gary D. Penisten (acting)	Feb. 1977	Present
Joseph T. McCullum	Feb. 1977	Feb. 1977
David R. MacDonald	Jan. 1977	Feb. 1977
J. William Middendorf	June 1974	Jan. 1977
J. William Middendorf (acting)	Apr. 1974	June 1974
John W. Warner	May 1972	Apr. 1974