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MCRP 3-40D.17

ELECTRIC POWER GENERATION AND DISTRIBUTION

JULY 2018

DISTRIBUTION RESTRICTION: Approved for public release; distribution is unlimited.

This publication supersedes TM 3-34.45/MCRP 3-40D.17, 13 August 2013.

Headquarters, Department of the Army

Foreword

This publication has been prepared under our direction for use by our respective commands and other commands as appropriate.

ROBERT F. WHITTLE, JR.
Brigadier General, USA
Commandant
U.S. Army Engineer School

ROBERT S. WALSH
Lieutenant General, USMC
Deputy Commandant for
Combat Development and Integration

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Electric Power Generation and Distribution

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Preface

ATP 3-34.45/MCRP 3-40D.17 is a compilation of tactics, techniques, and procedures found in doctrine, lessons learned, and other reference material that, for the first time, provides an integrated systematic approach to electric power generation, distribution, and management. It codifies lessons learned over the past 16 years and serves commanders and their staffs as a comprehensive guide for planning, producing, distributing, and managing electrical power in support of military operations.

ATP 3-34.45/MCRP 3-40D.17 is suitable for Army and Marine Corps commanders/leaders and their staffs at all echelons, but the principal audience for this manual is the engineer staff, officers at brigade/Marine air-ground task force (MAGTF) headquarters and below, and planners who have staff proponency for electrical power generation and distribution. It is also a valuable reference for Army and Marine Corps trainers, educators, and combat developers and other Services.

Commanders, staffs, and subordinates ensure that their decisions and actions comply with applicable United States, international, and in some cases host-nation laws and regulations. Commanders at all levels ensure that their Soldiers/Marines operate in accordance with the law of war and the rules of engagement. (See FM 27-10 and ATP 3-01.15[FM 3-01.15]/MCRP 3-25E/NTTP 3-01.8/AFTTP 3-2.31.)

ATP 3-34.45/MCRP 3-40D.17 uses joint terms where applicable. Selected joint and Army terms and definitions appear in both the glossary and the text. Terms for which ATP 3-34.45/MCRP 3-40D.17 is the proponent (the authority) are italicized in the text and are marked with an asterisk (*) in the glossary. Definitions for which ATP 3-34.45/MCRP 3-40D.17 is the proponent publication are boldfaced in the text. For other definitions shown in the text, the term is italicized and the number of the proponent publication follows the definition.

ATP 3-34.45/MCRP 3-40D.17 applies to the Active Army, Army National Guard/Army National Guard of the United States, United States Army Reserve, Department of Defense Civilians, deployed contractors, and total force Marine Corps unless otherwise stated.

The proponent of ATP 3-34.45/MCRP 3-40D.17 is the United States Army Engineer School. The preparing agency is the Maneuver Support Center of Excellence (MSCoE) Capabilities Development and Integration Directorate (CDID); Concepts, Organizations, and Doctrine Development Division; Doctrine Branch. Send comments and recommendations on a DA Form 2028 *(Recommended Changes to Publications and Blank Forms)* to Commander, MSCoE, ATTN: ATZT-CDC, 14000 MSCoE Loop, Suite 235, Fort Leonard Wood, MO 65473-8929; by e-mail to <usarmy.leonardwood.mscoe.mbx.cdidcodddengdoc@mail.mil>; or submit an electronic DA Form 2028. Marine Corps readers of this publication are encouraged to submit suggestions and changes to Deputy Commandant for Combat Development and Integration, ATTN: C116, 3300 Russell Road, Suite 204, Quantico, VA 22134-5021 or by e-mail to <doctrine@usmc.mil>.

Introduction

Modern warfare relies on electrically powered systems, making electricity an essential element that supports warfighting functions. Mission command, intelligence, movement and maneuver, fires, sustainment and logistics, and protection/force protection depend on electricity for an array of capabilities, from communicating with Soldiers in the field to strategic missile defense assets protecting the United States and its allies. The mission command and communications systems within each echelon command post are highly reliant on electrical power. Administrative, Service health system support, sustainment operations, and even weapon systems are now dependent on electrical power to operate. The result of this growing dependence on electricity is an increase in the quantity and quality of power needed to support military operations. The indispensable nature of electrical power compels commanders and planners to recognize their electrical power needs and ensure that those needs are met.

From the military perspective, electrical power encompasses the entire spectrum of power generation, distribution, and management that supports military operations. This spectrum consists of tactical (low-voltage), prime (medium-voltage), and utility electrical power (commercial or host nation).

The Army protection warfighting function/(Marine Corps) force protection warfighting function are written in this manual as protection/force protection warfighting function.

ATP 3-34.45/MCRP 3-40D.17 contains the following five chapters and six appendixes that provide supplemental material:

- **Chapter 1** describes the role of electrical power that is in support of military operations and provides an overview of the electrical power source levels (tactical, prime, and utility). The chapter then summarizes the power management responsibilities and safety considerations.
- **Chapter 2** is an overview of tactical electrical power systems.
- **Chapter 3** focuses on prime power electrical systems and their role in supplying medium voltage.
- **Chapter 4** outlines the role of utility power support to military operations.
- **Chapter 5** discusses the planning, resourcing, and construction of power systems.
- **Appendix A** provides information on the capability of Army prime power units (power units).
- **Appendix B** provides information on the capability of Navy prime power units.
- **Appendix C** provides information on Air Force electrical power capabilities.
- **Appendix D** provides information on Marine Corps electrical power capabilities.
- **Appendix E** discusses the power resources available within the military Service.
- **Appendix F** lists Worldwide power (WWP) voltages, plug and outlet configurations, and frequency characteristics.

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Chapter 1

Electrical Power

This chapter discusses electrical power and Section 138C, Title 10, United States Code (10 USC 138C), which defines operational energy as the energy required for training, moving, and sustaining military forces and weapons platforms for military operations. The term includes energy used by tactical power systems and weapons platforms. The Department of Defense (DOD) considers energy used in military operations and in training as a means to support unit readiness for military operations (as operational energy). Unit power managers recommend the most efficient electrical power production and distribution systems necessary to meet the demands for continuous and reliable electrical power.

ELECTRICAL POWER SUPPORT TO MILITARY OPERATIONS

1-1. Military operations require electrical power. Command and control (C2) centers; medical support; communications systems; weapon systems; and other mission-related functions, facilities, and equipment require electricity. Sources of power range from batteries to mobile power sources to local commercial power. The demands for electricity steadily increase throughout the duration of an operation. The DOD uses a standard family of electrical power sources and distribution to provide the electrical power needed by commanders.

ELECTRICAL POWER SUPPORT TO OFFENSE, DEFENSE, AND STABILITY

1-2. During large-scale combat operations, military units execute a combination of offensive, defensive, and stability tasks to defeat an enemy and establish conditions that achieve the commander's desired end state. These operations involve the synchronization of many simultaneous unit actions. Aggressive execution, mobility, and surprise are the most effective means for achieving the tactical success of the offensive and defensive tasks. Modern-day battlefields require the capability of, and reliability from, electrical power. At the onset of combat operations, when operational tempo is high, units typically rely on organic low-voltage power capabilities to meet the electrical requirements needed to execute offensive, defensive, and stability tasks. As offensive and defensive operations shift to stability, the transition from tactical electric power to prime electric power enables commanders to reduce logistical requirements.

ELECTRICAL POWER SUPPORT TO DEFENSE SUPPORT OF CIVIL AUTHORITIES

1-3. Military forces support civil authorities at federal and state levels by performing defense support of civil authorities (DSCA) tasks. The U.S. federal military forces, DOD Civilians, contract personnel, National Guard forces, and other component assets provide support to request assistance from civil authorities for domestic emergencies, law enforcement support, and other domestic activities from qualifying entities with special events under the DSCA mission (ADP 3-28 and DOD Dictionary of Military and Associated Terms). DSCA includes tasks that address the consequences of natural or man-made disasters, accidents, terrorist attacks, and incidents in the United States and its territories. Military forces conduct DSCA tasks only after civil authorities have requested assistance and the Secretary of Defense has authorized it. DSCA actions are always subordinate to civilian authority control for additional information. See ADRP 3-28, ATP 3-28.1/MCWP 3-36.2/NTTP 3-57.2/AFTTP 3-2.67, and MCTP 3-03A.

1-4. The United States Army Corps of Engineers (USACE) manages components of the national public works infrastructure. This includes maintenance and management of the national waterways, environmental remediation and recovery operations, real estate, disaster recovery operations, and general project management functions. USACE is the primary agency for the National Response Frameworks emergency support function (ESF) #3, Public Works and Engineering. In this role, the Corps assists the Department of Homeland Security and Federal Emergency Management Agency by coordinating federal public works and engineering-related support and providing technical assistance, engineering expertise, and construction management to prevent, prepare for, respond to, or recover from domestic incidents.

1-5. Temporary emergency power is one of the missions within ESF #3. This temporary emergency power support ranges from technical expertise and assistance through the complete management of an emergency power mission, including the procurement, installation, operation, and maintenance of generators. Some of the technical expertise and assistance tasks include the following:

- Assessing conditions and capabilities of existing emergency generation equipment.
- Assessing damaged electrical distribution systems and equipment.
- Assessing emergency power requirements needed at a facility.
- Ensuring that all hazards emergency power planning is conducted.
- Ensuring that safety inspections of electrical distribution systems and equipment are conducted.
- Installing, operating, fueling and maintaining the emergency power generation equipment.
- Troubleshooting, repairing, and operating the emergency generation and distribution equipment.

1-6. The planning and execution of this temporary emergency power requirement involve the combined efforts of several partners, to include DOD military assets who are trained and equipped to perform tasks at medium- and low-voltage levels. The DOD assigns the ESF #3 temporary power mission to specially trained assets.

ELECTRICAL POWER SUPPORT TO FOREIGN HUMANITARIAN ASSISTANCE

1-7. *Foreign humanitarian assistance* are those Department of Defense activities conducted outside the United States and its territories to directly relieve or reduce human suffering, disease, hunger, or privation (JP 3-29). The U.S. military normally conducts foreign humanitarian assistance operations in support of another U.S. government department or agency, including Foreign-Disaster Relief operations, to alleviate the suffering of foreign-disaster victims. The U.S. military also conducts foreign humanitarian assistance activities in various steady-state programs as part of a geographic combatant commander security cooperation program or to achieve specific theater campaign plan objectives.

1-8. Foreign humanitarian assistance operations can be extremely engineer-intensive. The level of assistance can vary from limited, highly specialized teams to complete engineer units. Specialized engineering teams are used to assess damage or estimate engineering repairs and can assist in support roles, such as emergency electric power supply and distribution, utilities repair work, water purification, and well-drilling operations. In large foreign humanitarian assistance operations, engineer units provide essential general engineering support, including facility construction, structural repair, and base camp construction for deployed forces. These forces request military support (including engineering support) and should be initiated and coordinated through the lead federal agency.

OPERATIONAL ENERGY

1-9. Operational energy is a critical enabler for the range of military operational capabilities, from the Service member to strategic levels. Operational energy drives effectiveness through mobility, agility, flexibility, resilience, and sustainability. An effective strategy maximizes the efficiency of energy consumption, distribution, and production through energy-informed decisions. To be successful, operational energy strategies must be embedded into leadership, planning, acquisition, training, behaviors, and execution. These strategies include designing energy-efficient characteristics into equipment, considering energy requirements during operational planning, and managing energy conservation practices used by individuals and organizations. The informed use of energy enhances effectiveness, reach, mobility, agility, and sustainability; reduces risk to Soldiers; and lessens logistics-related disruptions.

ELECTRICAL POWER SOURCE LEVELS

1-10. The electrical engineering community defines a kilowatt as a measurement of power, a volt as the electrical pressure in a conduit, and an amp as the current flow. It is useful for planners to think of these terms as water within a pipe system. The water moving through a pipe is similar to the amp moving through an electrical conductor. The pressure in the pipe from the water is similar to the voltage. An electrical planner should think of voltage as being how far a system can send power and the kilowatt as how much power the system can consume. Another clear distinction that electrical engineers define within an electrical system is kilowatt, also known as the demand, and the kilowatt-hour, also known as the consumption. When a power system turns on, it must provide enough demand to meet system requirements and enough continuous flow of power to meet the consumption of a system.

1-11. Electrical power sources range from batteries and tactical generator sets to large prime power systems and complex national utility grids. The delineating characteristic between tactical and prime power is the level of voltage produced. Individual power, included in the tactical power, is the lowest level and is generally limited to batteries and small unit power sources less than 1 kilowatt. Tactical power includes sources through 200 kilowatts with voltages 600 volts and below, volt, alternating current (VAC). Prime power is composed of sources greater than 200 kilowatts with outputs of medium voltage (601 VAC–69 kilovolt). Utility power is civilian- or contractor-managed and -provided power systems. Each source varies in complexity, efficiency, and reliability but ultimately provides the user with electricity for mission needs. Table 1-1 shows the correlation between each capacity, unit responsibility, and voltage used. The expected durations are a guide derived from ATP 3-37.10/MCRP 3-40D.13 and JP 3-34 for planning purposes.

Table 1-1. Electrical power source levels

Power Level	*Tactical (including individual)*	*Prime Power*	*Utility*
Source output	≤ 200 kilowatts	> 200 kilowatts	Nation-dependent
Distribution	Up to 600 volts (low-voltage)	601 volts–69,000 volts (medium-voltage)	Up to 230,000 volts (low- to high-voltage)
Expected Duration	Initial (including organic) (up to 6 months)	Temporary or Semipermanent (up to 10 years)	Enduring
Responsibility	Unit	249th Engineer Battalion, United States Navy Mobile Utilities Support Equipment, Prime Base Expeditionary Engineering Force, Contract	United States Army Corps of Engineers contract

TACTICAL ELECTRIC POWER

1-12. Typically, initial phases of military operations use tactical electric power systems that are organic to the units. Tactical electric power systems have limited capacity and distribution, but they provide greater mobility. Also, tactical electric power systems include individually carried power sources (batteries and renewable power supplies) and low-voltage generators. Tactical power systems are typically standardized systems that are sized to meet unit requirements. Operational planners should anticipate power requirement changes and address energy requirements in the operational plan. Usually it is necessary to add more power production capacity to meet the demand. Other times, efficiencies are gained by consolidating unit power sources into a microgrid. See chapter 5 for the planning of electrical power and transitions between the levels of power.

1-13. The advantages of consolidated power generation and distribution include the following. See chapter 2 for tactical electric power consolidation planning:

- Consolidated security of power generation assets.
- Improved power system reliability.
- Increased cost efficiency per kilowatt-hour of power produced.
- Reduced fuel demands.
- Reduced wear on equipment not designed for long-term, continuous operations.
- Streamlined maintenance.

1-14. Tactical electric power is produced and distributed for user voltage and is installed, operated, and maintained by units. Tactical electric power sources include individual power, generators, alternatives and renewables, fuel cells, hybrid power, and electrical power storage.

1-15. Individual power is the lowest level of tactical power and comes from a variety of sources. These power sources supply electricity to operate individually worn or carried equipment. Most individual power is provided by batteries, fuel cells, small solar-photovoltaic panels, and lightweight portable generator sets.

1-16. The next level of tactical electric power comes from mobile power sets organic to units. The DOD developed a standard family of electrical power sources and distribution equipment to provide tactical electrical power. This standard family is listed in MIL-STD-633G.

1-17. Transitions to a prime or utility power source level are typically triggered by time, capacity, or events. Engineer prime power units provide technical support, expertise, and voltage transformation to support military operations and base camps.

Prime Electrical Power

1-18. Prime power sources are medium-voltage, centralized power plants that provide continuous, reliable power produced by more than 200 kilowatt. Prime power sources use transformers to step down medium voltage to a lower voltage for equipment usage. Military prime power systems are installed, operated, and maintained by prime power-trained Soldiers or are provided through a sustained contract solution. These systems are capable of generating and distributing power through several miles of transmission lines. Typically, prime power assets are employed to support critical infrastructure. This power is provided on an as-needed basis to support operations as directed by the theater Army or joint task force commander. Prime power fills the gap between tactical and utility power. In general, installing prime power systems is appropriate when it is not practical to use tactical generators or when utility power is not available or is unstable.

1-19. As the situation changes, a commander may direct transition to longer-term solutions. Responsibility for the operational control, sustainment, and maintenance of the existing power system is transferred to civilian, contracted, or host nation personnel. Life cycle equipment replacement and further expansion of the power requirement creates a site-specific power system that is typically composed of fixed, commercial generators and electrical equipment (or utility power, if available). These systems are operated and maintained by civilian or contract personnel. USACE is the primary source for all utility power contracts at deployed locations. USACE provides standards for construction, scalability guidance, standardization and modularity, and contingency standard design expertise. USACE also manages the WWP contingency contracts that provide power generation and electrical distribution services.

Utility Electrical Power

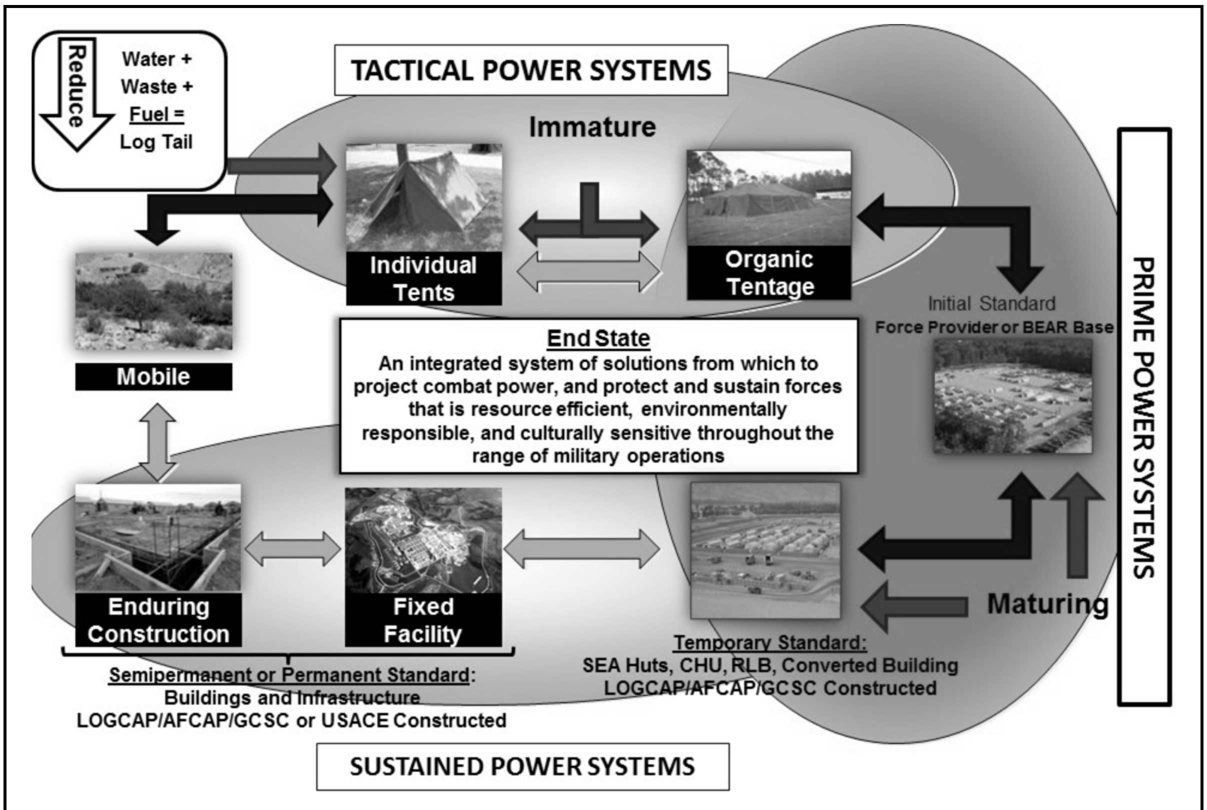
1-20. The national, regional grid fixed systems or contractor provide utility power. Their output capacity varies from a few megawatts to several gigawatts transmitted over medium- and high-voltage distribution lines to low voltages for user equipment. Utility power is an option if it is compatible with mission equipment and reliable enough to suit the unit needs in an area of operations. However, at the operational level, utility power is normally distributed through a civilian power grid. The sophistication and reliability of these systems vary widely across the globe. Medium-voltage qualified personnel make connections to commercial distribution networks, pending coordination and approval. Connections can also be made by coordination with the local utility company. Once connected, the system can provide continuous power service that is virtually maintenance-free. When operating on a utility power grid, a contract or host nation agreement is required.

POWER SOURCE LEVEL TRANSITIONS

1-21. As part of operational planning, considerations must be given to the location, duration, and end state of power requirements. Included in this planning is the potential transition between the electrical power source levels. The objective of transitioning power levels is to reduce the logistic burden.

1-22. There is no one-size-fits-all solution to supplying electrical power throughout the range of military operations. The capacity, mobility, and flexibility requirements of the electrical system for a C2 node during major combat operations are very different from those of a base camp or logistics hub. Typically, a site occupied at the cessation of combat operations develops into an enduring location as the phases of an operation change.

1-23. Figure 1-1 depicts an example of electrical power system transitions. The power systems are employed in a scalable fashion to use minimal resources to support changing electrical power demands. Typically, a power system begins with an organic tactical power system, transitions to the prime power system, and then ultimately transitions to a civilian or contractor-managed utility power system for enduring locations. These transitions can occur consecutively or concurrently. The goal is to employ power systems that support and build on one another while meeting mission requirements. See chapter 5 for additional information.



Legend:

AFCAP	Air Force contract augmentation program	LOGCAP (Army)	logistics civil augmentation program
BEAR	Base Expeditionary Airfield Resources	RLB	relocatable building
		SEA Huts	Southeast Asia
CHU	containerized housing unit	USACE	United States Army Corps of Engineers
GCSC	global contracting support contract		
Log	logistics		

Figure 1-1. Electrical power transitions

UNIT POWER MANAGEMENT RESPONSIBILITIES

1-24. To assist commanders in effectively and efficiently managing power, power managers should be appointed at echelons at the battalion level and above. The unit power manager must be familiar with unit power generation and distribution assets. Power managers should also be familiar with the equipment possessed by attachments assigned to the unit. During the planning phase, power managers ensure that the organic power assets are employed in the most efficient manner to satisfy unit power requirements. Microgrids can be employed to achieve the most efficient use of organic tactical generators. Units employ microgrids to achieve the most efficient use of organic tactical generators by increasing reliability through redundant power sources, increasing fuel efficiency by employing the right size generators, and decreasing maintenance requirements by ensuring that generator loads remain at 50 percent or greater. Operating diesel generators that are closer to their capacity prevent wet-stacking. Under-loading generators for long periods of time causes wet-stacking and, as a result, unburned fuel in the exhaust system.

1-25. As the electrical power system transitions from tactical to prime power and utility power, power management responsibility may transition to a supporting organization. For example, as the base camp development matures and the resident population size increases, power management responsibility for the base camp may transition to a military prime power unit through the theater Army engineer brigade. Under these circumstances, the prime power unit ensures that the base camp power generation and distribution system is expanded to address the current and estimated future demand. Some base camps may be designated to transition from prime power management to contract power plants and distribution systems. The military prime power unit retains responsibility for power management throughout the prime power and utility levels of base camp development. Subject matter experts from USACE and military prime power units aid the theater engineer staff officer in the design and installation of power grids to maximize the generation and distribution of operational energy across the base camp.

1-26. The key components to effective power management include—

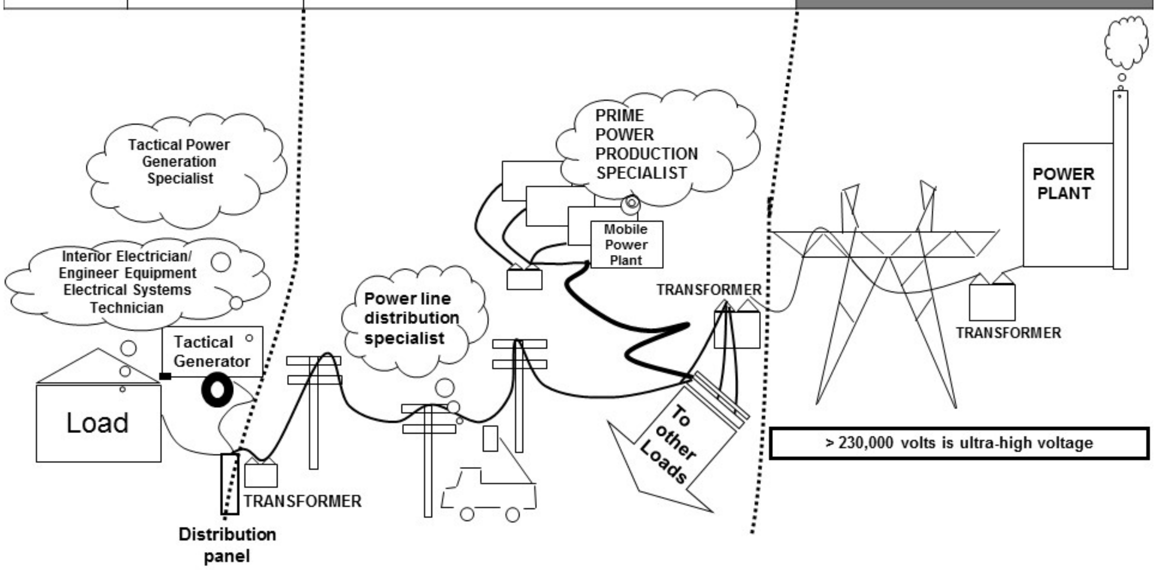
- Power demand assessment.
- Power distribution layout.
- Power source selection and location.

1-27. The authority that has jurisdiction over electrical matters is the organization, office, or individual responsible for approving equipment and materials needed for an installation or procedure, as required by the UFC 3-560-01. The authority that has jurisdiction is typically at the theater level. The authority that has jurisdiction possesses technical expertise and knowledge about electrical systems, applicable codes, and standards. The safety officer determines and establishes the requirements of the code or standard to be used for approving equipment, materials, installation, and procedures, and associated safety training and safety standards. Electrical safety trainings and definitions must comply with the AR 385-10 or MCO 5100.29B. The authority that has jurisdiction may assign delegates in writing to act on its behalf when deployed. This delegate works closely with the safety officer to ensure that electrical safety requirements are understood.

1-28. Prime power personnel are capable of performing electrical safety requirements but are not usually used for performing interior, low-voltage electrical work. This function should be performed by licensed or contracted electricians. When installing a secondary distribution system, prime power personnel provide electrical power service and make connections up to the first circuit panel overcurrent device or the first piece of service equipment. Service equipment that is installed by an interior electrician includes the main distribution panel, switched disconnects, manual transfer switches, automatic transfer switches, and switched fuse boxes at the structure.

1-29. Electric power generation and distribution responsibilities are delineated by the training that individuals received. Figure 1-2 depicts capability delineation between the military occupational specialties of the three levels of power.

	Low voltage • Interior wiring • Tactical generators • Micro-grids	Medium voltage • Power grids • Commercial generators	High voltage • Distribution lines • Power plants
Distribution	≤ 600 volts	600 volts—69,000 volts	69,000—230,000 volts
Typical Responsibility	Unit	249th Engineer Battalion, U.S. Navy Mobile Utilities Support Equipment, RED HORSE, Prime Base Expeditionary Engineering Force, Contract	Not a Service Competency
Military occupational specialty training	12R, 91D, 1141, and 1142	12P, 12Q, and ASI U4	



Legend:

ASI additional skill qualifier
U.S. United States

Figure 1-2. Power distribution responsibilities

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Chapter 2
Tactical Electrical Power

This chapter covers the tactical electrical power system requirements that are prevalent during all phases of electrical operations. During the initial phases of an electrical operation, units rely on organic assets for power. Tactical power is generated by unit organic power sources dedicated to supporting the missions of units engaged in military operations. DOD standard mobile electric power sources are rapidly deployed, produce low voltages, and do not require the use of transformers.

ELECTRICAL POWER SUPPORT TO OFFENSE AND DEFENSE

2-1. Large-scale combat operations against a peer threat are demanding in terms of operational tempo and lethality. Mobility, surprise, and aggressive execution are the most effective means for achieving tactical success when performing offensive and defensive tasks. Since mobility is a primary consideration during the offense and defense power, tactical electric power offers the most flexibility to the commander while meeting the unit electrical power requirements.

2-2. Enemy use of measurement and signature intelligence collection assets must be considered when placing and operating tactical electrical systems. Tactical generators emit electromagnetic, visual, auditory, and infrared signatures. The closer together the systems are, the more signature they collectively produce. The distance that tactical power systems can be from the source user equipment is approximately 300 feet. Maximizing tactical power system separation, camouflage, and concealment reduces signature and improves unit survivability. See chapter 5 for electrical power planning, and see ATP 3-37.34/MCTP 3-34C for more information on camouflage and concealment.

TACTICAL ELECTRIC POWER MANAGEMENT

2-3. Unit commanders determine the prioritization of employment for tactical electric power needed to support operations. The staff assists in planning and resourcing tactical electric power support. The unit power manager can assist the staff by coordinating for technical expertise as needed and for the equipment necessary to maintain electrical power. Additionally, the tactical electric power generation and distribution responsibilities rely on the unit organic personnel and the power manager.

UNIT POWER MANAGER

2-4. The unit power manager should be the commander’s representative for managing the unit tactical electric power and its components. As the unit tactical electric power planning expert, this individual must know the general capabilities of the unit organic power equipment and electrical demand. Also, the unit tactical electric power planning expert might not have an exhaustive knowledge of each tactical electric power system; however, this individual is responsible for planning, employing, and managing resources to meet mission demands.

2-5. The key task of the unit power manager is to maintain an ideal electrical power source-to-demand relationship. The optimal load for tactical generators is 80–100 percent rated capacity. Operating generator sets at light loads for extended periods of time reduces the efficiency of the power system and creates maintenance issues due to wet-stacking (operating under 50 percent rated capacity)

TACTICAL ELECTRIC POWER EQUIPMENT OPERATORS

2-6. Commanders, train and license assigned personnel in the unit as tactical electric power system operators, regardless of the personnel military occupational specialty (MOS). Marine Corps personnel licensed as incidental operators may only operate power generation equipment up to 20 kilowatts in size. Only personnel who hold MOS 1141 may establish power generation sites, operate power generation equipment over 20 kilowatts in size, or install power distribution equipment. Licensed personnel operate assigned equipment according to the operator instructions in technical manuals. Another source of information is this publication and related publications in the reference section. Operators who follow these instructions help ensure that critical equipment gets the power that it requires. Additionally, operators are responsible for operator-level preventive maintenance checks and services. Trained and licensed operators are the key to every power production and distribution system.

TACTICAL POWER GENERATION EQUIPMENT SPECIALIST

2-7. Units that are assigned tactical electric power systems have access to power production maintainers. Usually these individuals are assigned to the unit. Other times, these individuals reside in a supporting maintenance unit. MOS 91D and MOS 1141 personnel are capable of interpreting an automated distribution illumination system, electrical (AutoDISE) diagram and laying out the power generation and distribution equipment.

2-8. Army MOS 91D skill level 3 and USMC MOS 1141 2,000-level-event-qualified personnel are trained on AutoDISE planning software. These individuals are also the unit organic tactical power experts. Commanders should direct the unit MOS 91D and MOS 1141, or request supporting MOS 91D and MOS 1141, to train operators and assist unit leaders in drafting power production and distribution plans.

TACTICAL ELECTRIC POWER PRODUCTION

2-9. Electrical power production converts fuels or other energy sources to electricity. Generator sets convert petroleum-based fuels into electricity. Electricity is also produced from solar and wind energy.

GENERATOR SETS

2-10. The DOD standard family of mobile electric power sources can be deployed to theaters of operation, produce low-voltages, and do not require the use of transformers in a range of outputs from 1 kilowatt through 200 kilowatts. These generators are described in MIL-STD-633G. They provide standard user voltages and burn DOD standard kerosene-based fuels, such as jet propulsion fuel 8 and aviation fuel 24. These tactical electric power sources include skid-mounted generator sets and trailer-mounted power units or power plants. They are designed to distribute power for distances up to approximately 300 feet from the source to the user equipment. Greater distances can increase the voltage drops to unacceptable levels, adversely affecting the power-consuming equipment performance.

TACTICAL POWER DISTRIBUTION

2-11. The tactical power distribution transmits electricity from the generator to the end user. A tactical power distribution system has three main subsystems (the power source, feeders and distribution centers, and load cables). A single power source that delivers electricity directly to single or multiple loads is commonly called spot generation. Multiple, synchronizable power sources that deliver electricity to multiple loads through a distribution network are commonly called microgrids. Efficiencies are gained when multiple generators are connected to a distribution network to create the microgrid.

TACTICAL POWER DISTRIBUTION SYSTEMS

2-12. Power distribution systems subdivide and distribute electricity from power sources to multiple users. These systems are portable, surface-laid, and intuitively employable by end users with minimal tool requirements. The systems are easily configurable to user needs. Power distribution includes user power receptacles and lighting.

TACTICAL ELECTRIC POWER PRODUCTION AND DISTRIBUTION SCHEMES

2-13. The figure below illustrate common tactical electric power employment schemes. Although each scheme can meet power needs, some layouts are more economical and operate more efficiently than others. For example, an assembly area or base camp may contain multiple types of distribution schemes. They can also evolve from spot generation, to microgrid and power plant, to utility grids over time. When designing a tactical electric power layout, the primary goal is to satisfy the mission power needs while improving efficiency, which reduces logistical requirements. ATP 3-37.10/MCRP 3-40D.13 contains additional planning factors for determining tactical electric power requirements for base camps.

SPOT GENERATION

2-14. This configuration uses a generator set connected to single or multiple loads. A unit that uses a power plant composed of two generator sets is employing spot generation. There are many instances for which spot generation is the most suitable power distribution option. An example is a radar site in a remote location. Another example is a shop van and shelters with a variety of mission equipment connected to a single source through load cables and a distribution center. Figure 2-1 illustrates three examples of spot generation and distribution. Figure 2-1 (A) shows the simplest option, with a generator set connected directly to the load without any power distribution beyond the directly attached cable. Figure 2-1 (B) depicts a distribution center connected to multiple loads and including a feeder. Figure 2-1 (C) illustrates additional loads connected to the distribution center and including a feeder.

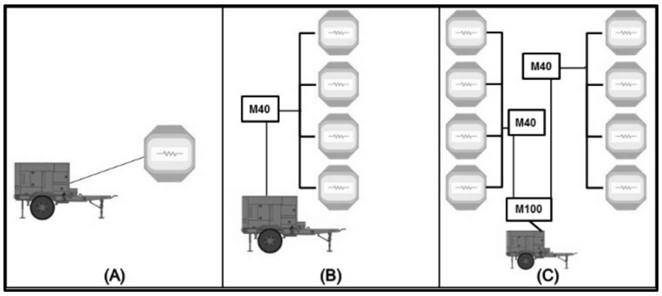

Figure 2-1. Spot generation

TACTICAL MICROGRID

2-15. Tactical microgrids use the unit organic power production and distribution equipment. Using the advanced medium mobile power source to establish a tactical microgrid system as an example, the microgrid control function and control panel are on the generator set. The microgrid automatically controls the starting and stopping of generators based on demand. Tactical microgrids consist of multiple power sources connected to electrical feeder systems that distribute power to multiple loads through distribution centers. Power sources are connected to electrical feeder systems. Power is distributed from the feeders to multiple loads through distribution centers. Microgrids are less labor-intensive and generally result in higher efficiencies because the power production is automatically matched with the load; therefore, they eliminate over-production. Organic microgrids can increase capacity by including up to a total of six 60-kilowatt generators. They can also transition to a prime power or utility grid as the mission load dictates. Figure 2-2, page 2-4, provides an example of a tactical microgrid.

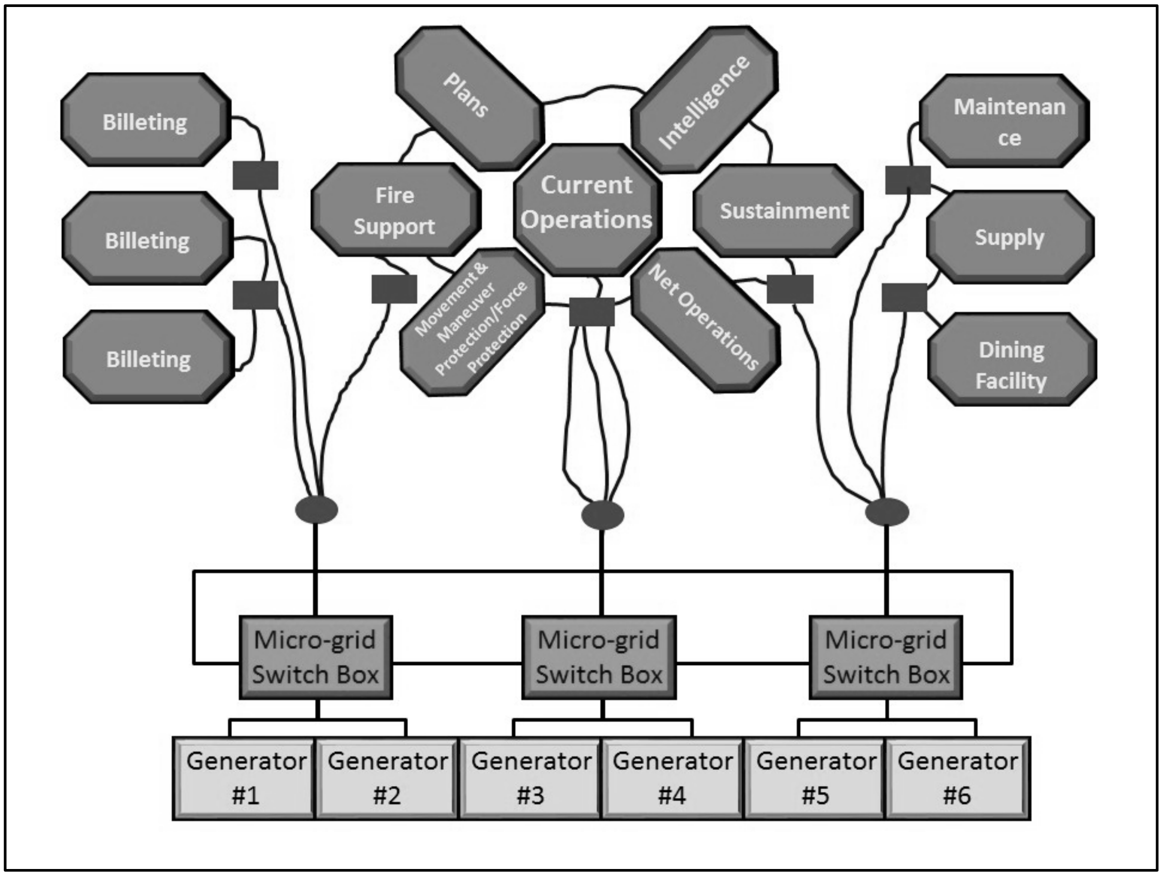

Figure 2-2. Tactical microgrid

SUPPLEMENTAL POWER SOURCES

2-16. Alternative and renewable power sources can capture energy from solar, thermal, wind, and water sources. For future use or when prevailing conditions interfere with power production, some systems may include a form of energy storage. The main advantage of these power source alternatives lies in reducing external requirements for fossil fuels. Depending on the mission variables and given suitable environmental conditions, these power sources can supplement conventional generator sets or replace them. Principal applications might include tactical radio power, protection and surveillance systems, and communications-electronics battery charging.

FUEL CELLS

2-17. Fuel cells chemically convert fuel to electricity through a noncombustion process. Fuel cells are similar to batteries because they produce electricity through a chemical reaction. However, battery chemical energy is self-contained, whereas fuel cells need an external fuel source to sustain the chemical reaction. For example, the fuel cell is similar to a fueled generator set. Consequently, fuel cells can produce electricity for as long as it is supplied with fuel, while batteries need recharging. The benefit of fuel cells is that they are more energy-dense compared to batteries, are potentially more energy-efficient compared to conventionally fueled power sources, are essentially silent, and release no harmful emissions.

HYBRID POWER SYSTEMS

2-18. Hybrid power systems combine multiple types of power sources with energy storage and control systems. Similar to the renewable power sources mentioned above, the hybrid system has an added generator. This generator set is an essential subsystem for power sources reliant on intermittent renewable energy inputs.

A key benefit of a hybrid source is the reduction fuel needed for power production. It essentially replaces a percentage of fossil fuel by using harvested solar or wind energy. A hybrid power system may consist of a military generator set integrated with a renewable energy source, a system controller, and energy storage.

ELECTRICAL POWER STORAGE

2-19. There are a number of ways to generate power, ranging from generator sets to renewable energy-based power sources. When a generating source produces power, the load must use the power at that time; this is a basic problem in power production. However, a means to store energy for later use has advantages. Energy storage systems range from individual, rechargeable batteries to larger utility scale storage systems used within a power grid. Typically, these systems capture and store energy for later use. For example, a generator set powers mission loads and an energy storage system during the day. At night, the unit turns off the generator and the energy storage system supplies a reduced load for off-peak demand. Microgrid configurations may include energy storage (see figure 2-3).

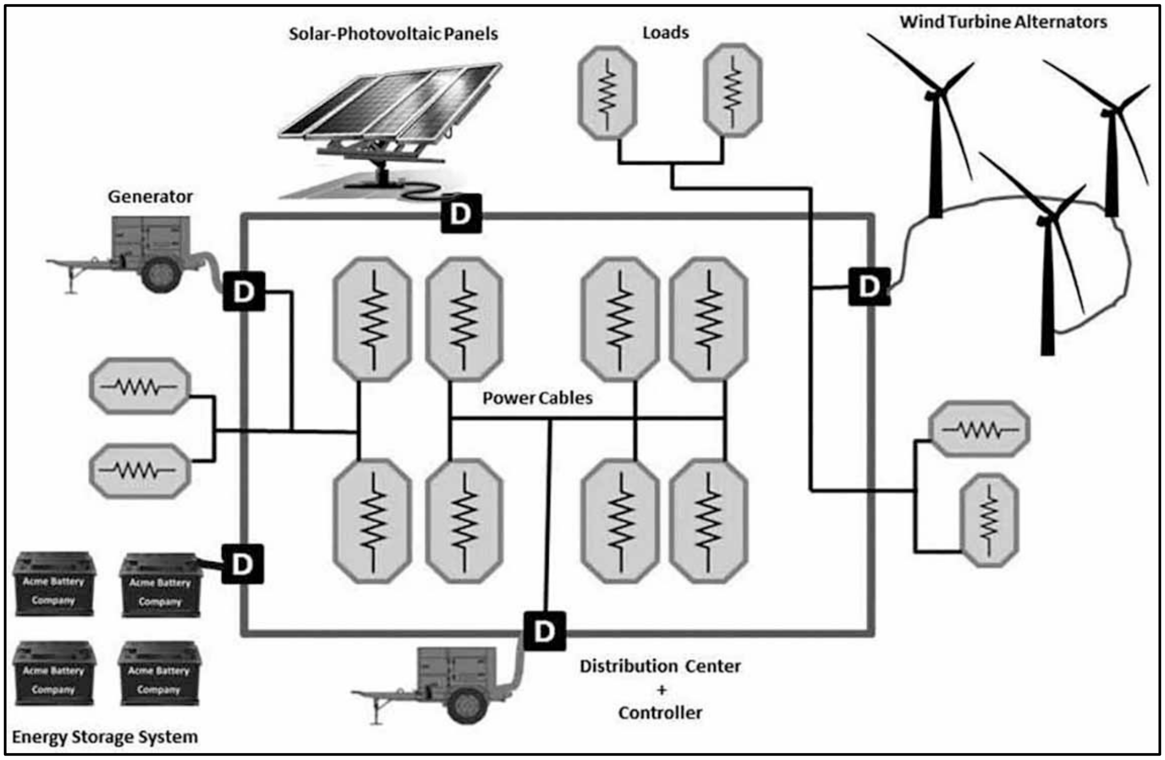

Figure 2-3. Future tactical microgrid

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Chapter 3
Prime Electrical Power

This chapter focuses on prime electrical power, which is a capability that provides continuous, reliable, commercial-grade, medium-voltage power and stepped-down- to-user-level power to support military operations. Prime electrical power is typically used to support critical infrastructure and fixed facilities when utility power is unavailable or where tactical power is impractical. The prime power capability must be closely integrated and synchronized with the overall general engineering plan for the theater of operations.

ELECTRICAL POWER SUPPORTING STABILITY

3-1. As units transition from major combat operations, they begin to focus their activities on the conduct of area security and stability tasks. *Stability tasks* are tasks conducted as part of operations outside the United States in coordination with other instruments of national power to maintain or reestablish a safe and secure environment and provide essential governmental services, emergency infrastructure reconstruction, and humanitarian relief (ADRP 3-07). It is during this transition that units may be assigned fixed areas of operation and begin executing operations from bases or base camps. Operating from bases and base camps affords U.S. forces the ability to employ more economical, reliable, and centralized power sources to meet mission requirements. This level of power is provided by prime power sources.

PRIME POWER

3-2. Prime power consists of a centralized power plant and medium-voltage distribution network, which provides continuous and reliable power. It uses transformers to convert power from medium voltage to user level voltages and is installed, operated, and maintained by prime-power-qualified Soldiers or through a contract. A primary benefit of medium-voltage prime power systems is the capability to distribute electricity over longer distances and larger areas than tactical generators.

3-3. Prime power assets are typically employed when there is a stand-alone requirement for commercial-grade utility power due to operations and are a requirement to support critical facilities or large base camps in forward areas. This level of power is provided as needed to support military operations when directed by the theater or joint force commander. Military prime power units generate electrical power and provide advice and technical assistance on all aspects of electrical power and distribution systems. Military prime power units are capable of electrical design, analysis, and surveys. They also operate, maintain, and perform repairs to power production equipment, to include host nation fixed plants.

3-4. Base camps with expanded and enhanced capabilities typically rely on prime power that uses power plants with distribution systems. Transition from tactical generation to prime power typically results in a cost savings and improved fuel use efficiency. Modular base camp life support sets, such as Force Provider and Harvest Falcon, include an organic generation capability that is generally sufficient for its internal components that are designed for a specific number of occupants. Reliable prime power should be used when possible with the appropriate amount of back-up power generation available when needed for critical facilities.

PRIME POWER MANAGEMENT

3-5. The prime power manager should be the commander's representative for managing the prime power and its components. As the prime power planner, this individual knows the capabilities of the prime power equipment and assesses the electrical demand. Prime power management involves planning, designing, installing, employing, maintaining, and managing power resources to meet mission demands. The theater engineer typically has a prime power subject matter expert at the engineering staff section of a joint staff cell to aid in coordinating prime power capabilities.

PRIME POWER EQUIPMENT OPERATORS

3-6. Military prime power personnel are specially trained in their MOS to operate and maintain prime power generation and distribution equipment. Military prime power personnel may also provide contracting officer technical representative (COTR) oversight for contracted prime power.

PRIME ELECTRIC POWER PRODUCTION

3-7. Prime power is uninterrupted electrical power that is continuously produced at a centralized power plant. Generators require periodic maintenance and service to avoid breakdown. To obtain a continuous source of prime power, multiple synchronizable generators are installed in parallel. This arrangement allows the performance of maintenance on one or more generators while the others produce power. The same principle is used in the production of utility power and can be used with some models of tactical generators.

POWER GENERATION

3-8. Prime power generation plants can range from 1.5 megawatts to 30 megawatts, depending on mission requirements. The prime power plant layout typically consists of areas for generation, a control center, fuel storage, primary switching, distribution, and transformation. The plant requires the following allotted spaces for petroleum, oil, and lubricants: distribution equipment storage and a maintenance area.

PRIME POWER DISTRIBUTION

3-9. Prime power-qualified personnel provide power distribution to networks to meet mission needs above tactical power capability and capacity. The following paragraphs discuss the two types of distribution networks: primary (medium voltage) and secondary (user voltage).

PRIMARY DISTRIBUTION

3-10. Primary distribution networks carry medium-voltage power from the power plant to the transformers or secondary distribution centers (SDCs). Primary distribution systems can be surface-laid, overhead, direct-burial, or ducted underground. Surface-laid primary distribution is the initial distribution format used due to its ability to be installed and removed quickly. It is a temporary distribution format and is typically replaced with direct burial or overhead distribution once mission allows. Direct burial utilizes primary switching centers, pad-mounted transformers, or SDCs and direct-buried cables. The direct-buried cable is constructed with an armored, shielded power cable that is also suitable as surface-laid cable. Overhead distribution utilizes utility poles; aluminum, steel-reinforced conductors; air switches; pole-mounted transformers; and pad-mounted transformers. See chapter 5 for distribution planning. Appendix E provides equipment information for service primary distribution systems.

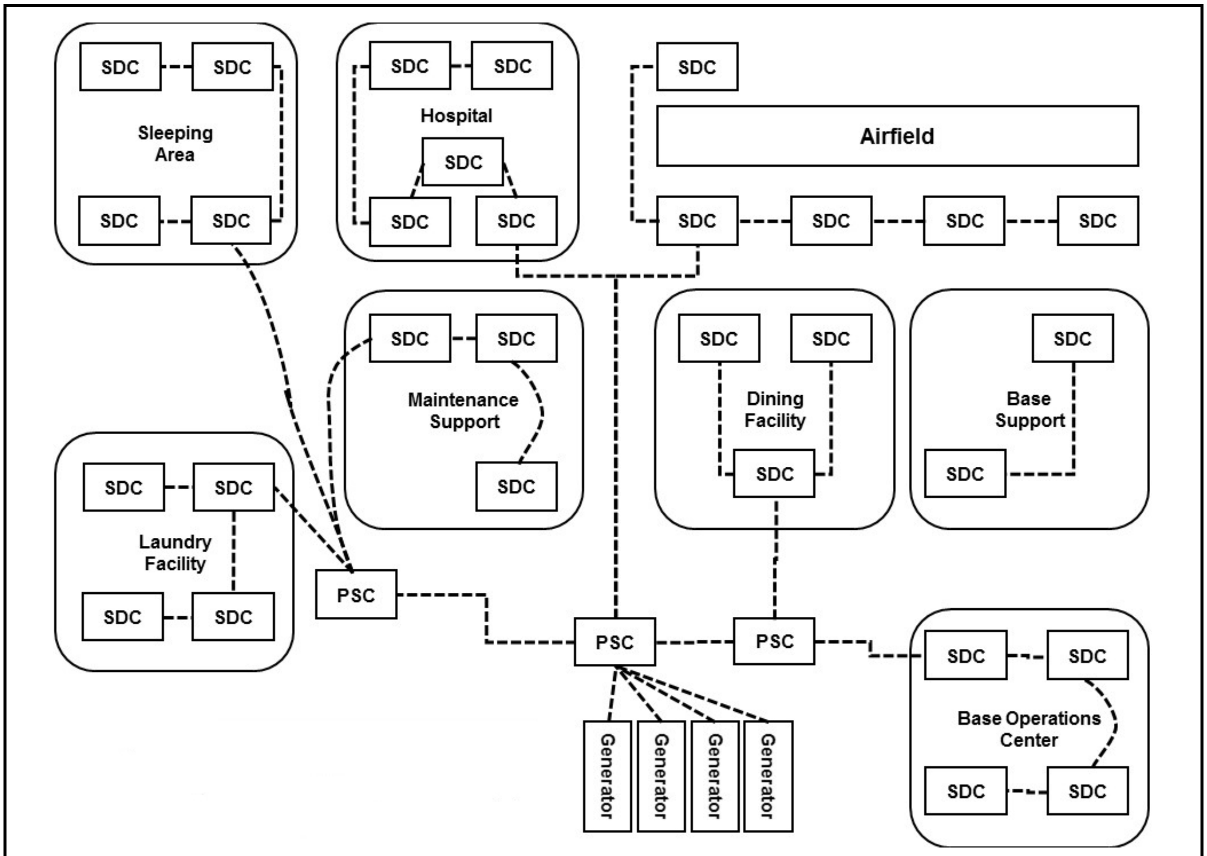
3-11. The components of the primary distribution system beyond the power plant are the—

- **Switchgear.** An electrical power switchgear enables the consolidation of power source inputs and the distribution to various output feeders and branch circuits. The primary switchgear for the Deployable Power Generation and Distribution System is called the primary switching center. It has six input or output circuits and can be networked in succession to provide more circuits. See appendix E for detailed information on the primary switching center.
- **Unit substation.** A unit substation consists of primary and secondary unit substations. Primary substations receive medium-voltage power input, which is transformed to a lower medium-voltage power output (such as 69,000 volts input, 13,800 volts output). Secondary unit substations receive the lower medium voltage input, which is subsequently transformed to a low-voltage output (such as 4,160 volts input, 120/208 volts output). The secondary unit substation for the Deployable

Power Generation and Distribution System is the SDC. The outputs of the SDC are compatible with low-voltage tactical power distribution equipment.

3-12. Distribution can be laid out in one of the following distribution systems:

- **Radial layout.** The radial power distribution system is the simplest, least-expensive, and quickest system to build. It is the predominant distribution configuration used in deployed power systems. A radial system has only one power source for a group of customers. A power failure, short-circuit, or damaged power line terminates power to all users. Figure 3-1 illustrates a radial power distribution configuration.

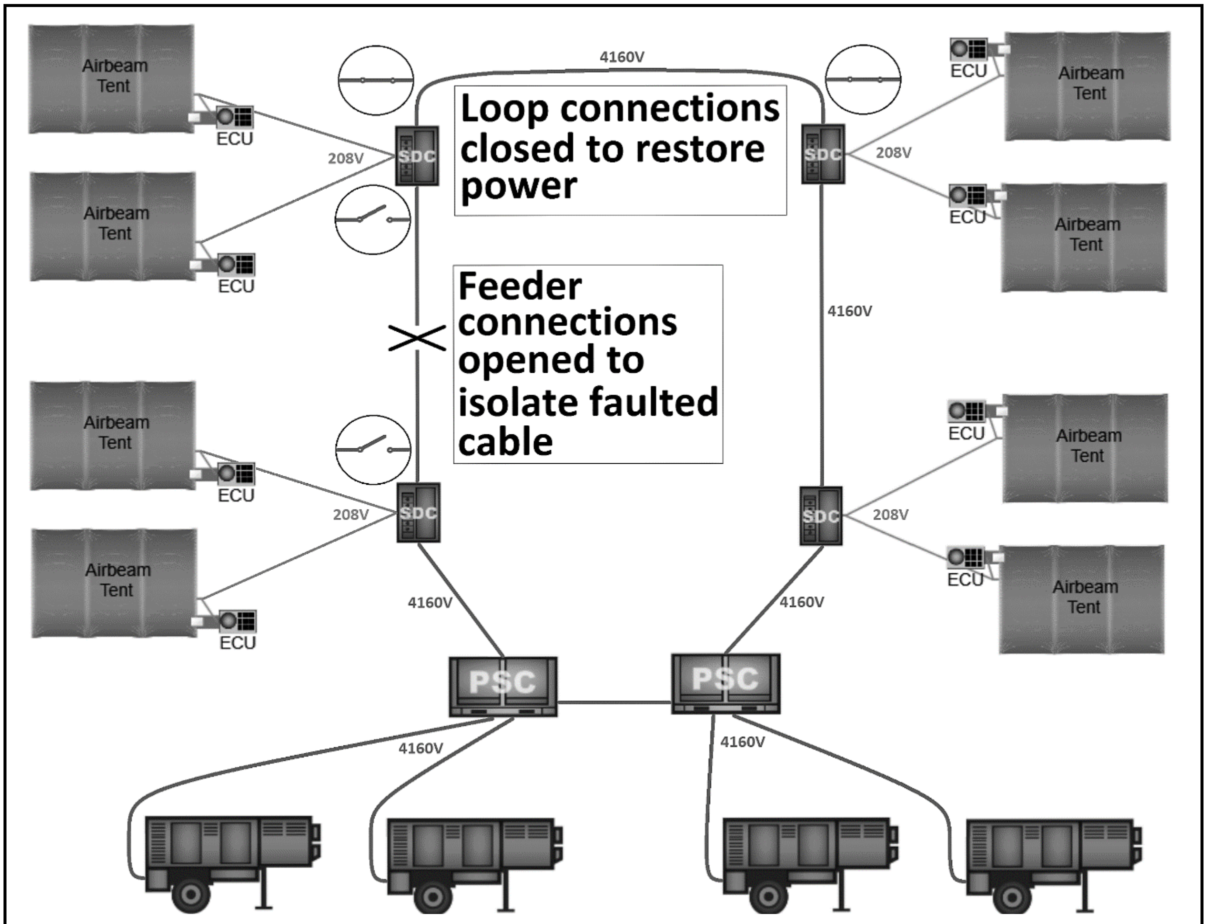


Legend:

PSC	primary switching center
----------	medium-voltage cable
SDC	secondary distribution center

Figure 3-1. Radial layout

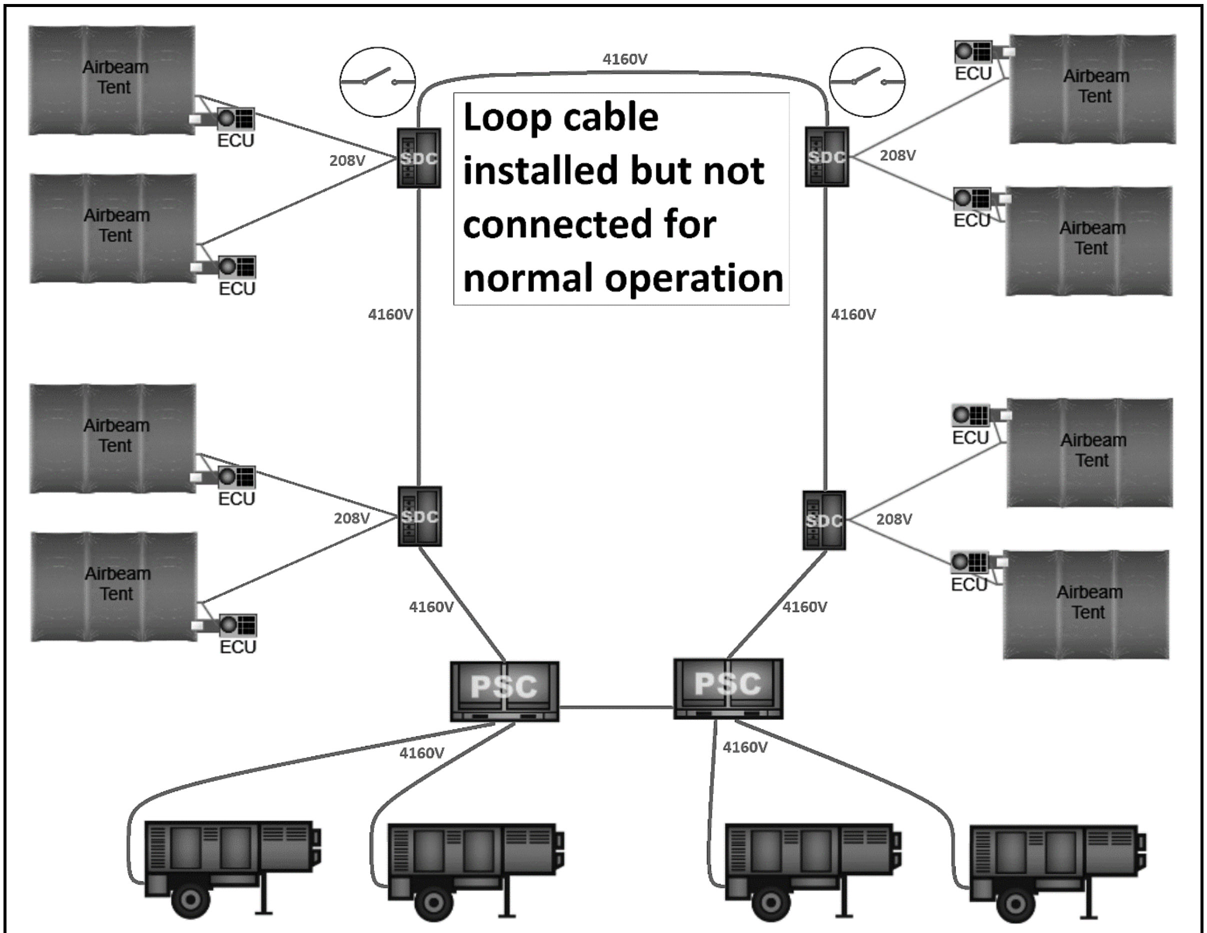
- **Loop.** A loop (also called a ring) power distribution system, as the name implies, loops through the service area and returns to the original point. The looped feeder is usually tied into an alternate power source. By placing switches in strategic locations, the system is configured to supply power to the customer from either direction (or power source). If one source of power fails or a feeder cable is damaged, switches are opened and closed (automatically or manually) and power can be fed to customers from the other source. The loop system provides more reliable service than the radial system, with only short interruptions during switching. The loop system is more complex and expensive than radial systems because more switches and conductors are required, but the resultant improved system is more operationally resilient and reliable. Figure 3-2, page 3-4, illustrates a loop distribution system under faulted condition. Figure 3-3, page 3-5, illustrates a loop distribution system under normal conditions.



Legend:

ECU	environmental control unit
kVA	kilovolt-ampere
PSC	primary switching center
SDC	secondary distribution center
V	volt

Figure 3-2. Loop distribution—faulted

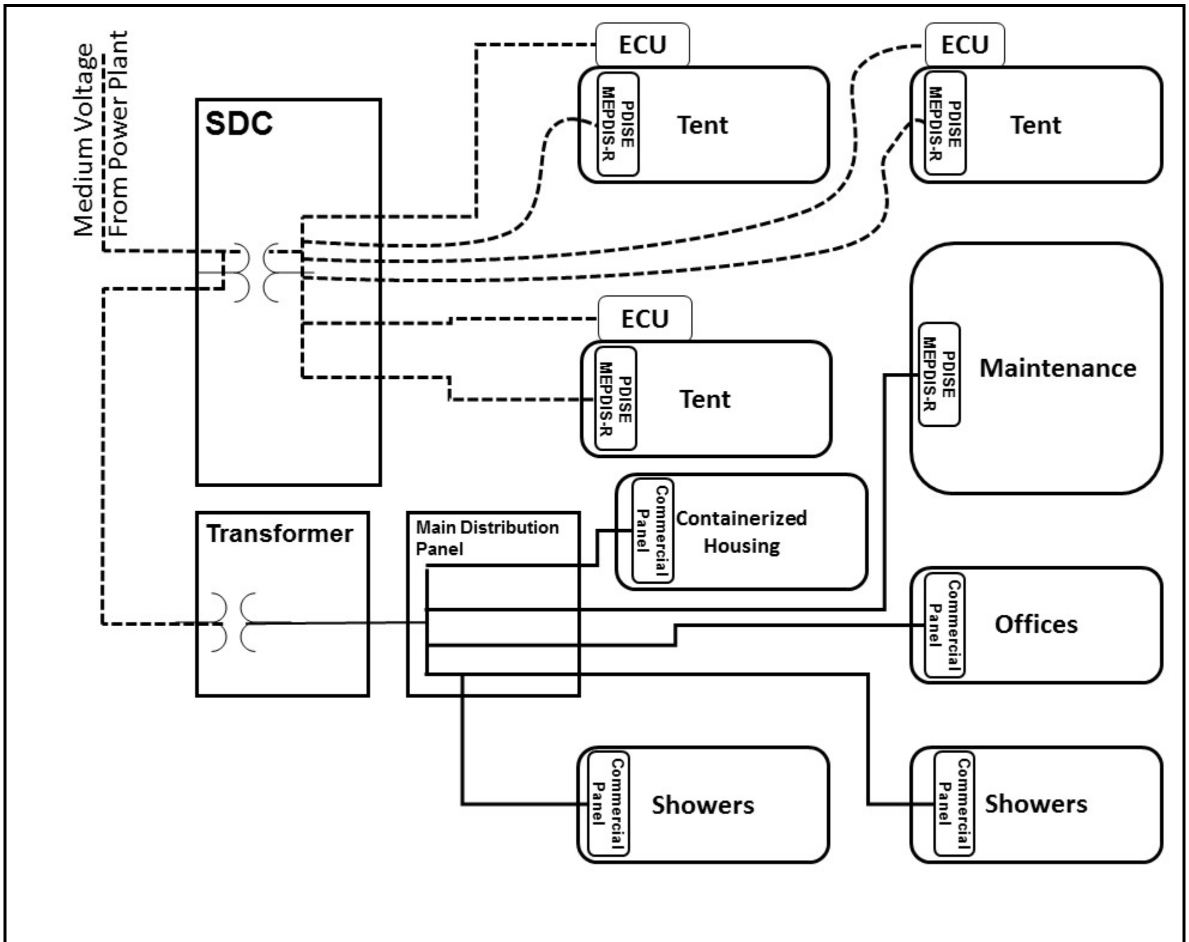


Legend:

ECU	environmental control unit
kVA	kilovolt-ampere
PSC	primary switching center
SDC	secondary distribution center
V	volt

Figure 3-3. Loop distribution—normal

3-13. Primary distribution is at medium voltage to account for the voltage drop (line loss) that occurs over extended distances from the power source. Primary distribution voltage (medium voltage) is stepped-down to secondary distribution (user level voltages) by distribution transformers or SDCs. See figure 3-4, page 3-6.



Legend:

———	commercial user-level voltage cable
– – – –	medium-voltage cable
ECU	environmental control unit
MEPDIS-R	mobile electric power distribution–replacement
SDC	secondary distribution center
PDISE	power distribution illumination system, electrical

Figure 3-4. Typical simple secondary distribution network

SECONDARY DISTRIBUTION

3-14. SDCs are transformers with self-contained switching and protective devices and low-voltage distribution. SDCs are advantageous when providing power to military operations because they are equipped with power distribution illumination systems, electrical (PDISEs), or mobile electric power distribution–replacement (MEPDIS-R) connections. Up to five SDCs can be employed in parallel without medium-voltage switching, which increases capacity and can distribute power over greater distances.

3-15. Distribution transformers are the civilian method of transforming medium voltage to user level voltages. Distribution transformers are used in 50 hertz and 60 hertz systems. See appendix F for geographic locations that utilize the different phases. These transformers are pole- or pad-mounted. There is no connection that interfaces the capability between civilian transformers and PDISE or MEPDIS-R.

3-16. Prime power personnel are capable of providing power distribution to networks, but typically they are not used for performing interior electrical work. This function is performed by vertical-construction platoons, Marine Corps electricians, or contracted electricians. When installing a secondary distribution system, prime power is responsible for the service entrance and for making the connection up to the first circuit panel overcurrent device or the first piece of service equipment. Service equipment installed by interior electricians includes the main distribution panel, switched disconnect, manual transfer switch, automatic transfer switch, or switched fuse box at the structure.

PRIME POWER SUPPORT REQUESTS

3-17. Prime power requests for forces can be generated during deliberate or crisis action planning. These requests originate at the joint force or Service component command. Requests may also originate from other government agencies that require support for domestic or foreign activities.

SERVICE PRIME POWER CAPABILITIES

3-18. Prime power support can be provided by military units, DOD civilians or contracted services. The Army, Navy, and Air Force have prime power capabilities. Contracted prime power generation and distribution are commonly used for enduring bases and when load demand exceeds military prime power capabilities. Appendixes A through D have detailed information for this service capability and capacity of prime power.

ARMY

3-19. The Army engineer prime power units provide the following support to military operations worldwide:

- Analyze electrical-load surveys and design power distribution systems.
- Assist staff in power-related planning.
- Deploy, install, operate, and maintain power generation and distribution.
- Perform damage assessment of distribution systems.
- Provide expertise for electrical power generation, distribution system installation, maintenance, and repair.
- Use COTR for power-related contracts.

NAVY

3-20. The Navy mobile utilities support equipment (MUSE) program provides the following support:

- Direct support of shore installations where in-place utility infrastructure is unable to meet system demands due to temporary overloads, increases in mission tempo, or changes to facility planning and programming until utility requirements can be satisfied through normal programming.
- Direct utility support for Navy vessels and fleet operations when in-place services have insufficient capacity, are nonexistent, or are uneconomical.
- Support of expeditionary military operations.
- Support of shore installations during unforeseen utility emergencies, such as failures resulting from natural disasters and unexpected equipment breakdowns while interim repair or replacement of failed utilities and distribution is performed.
- Support of other short-term requirements of federal and nonfederal activities as directed by the Secretary of the Navy the Office of the Secretary of Defense, or the Joint Chiefs of Staff.

AIR FORCE

3-21. The Air Force provides the following support:

- Direct support of airfield operations where in-place utility infrastructure is unable to meet system demands due to temporary overloads, increases in mission tempo, or changes to facility planning and programming until utility requirements can be satisfied through normal programming.
- Direct support of electrical systems when in-place services have insufficient capacity, are nonexistent, or are uneconomical.

MARINE CORPS

3-22. The Marine Corps provides the following support:

- Combat logistics battalion utility services to the regimental combat team, which includes tactical power generation and distribution, bulk water production, laundry, and field showers for the regimental combat team (RCT).
- Organic power generation capability in support of the internal requirements of the MAGTF.

CONTRACTING

3-23. Contracting is considered when the operational situation requires continuous electrical power and the military prime power capacity is anticipated to be exceeded. Exceptions to contracting are usually for sites that preclude civilian access or require reliable power from military sources.

3-24. Base camp power contracts use various contract vehicles, such as theater support contracts (executed by warranted contracting officials within the operational area) and external support WWP contracts (awarded by a contracting organization outside of the operational area). Electrical power plants can be procured through military construction contracts, leased equipment and services, or leased services of government-furnished equipment

Chapter 4
Utility Electrical Power Systems

This chapter discusses the planning and resourcing for the construction of power assets, which present a number of challenges within the utility electrical power systems. As with any engineering or construction project, there are time and resource constraints, laws and regulations, customer coordination issues, and unclear or evolving missions. Primary challenges associated with power assets are the theater entry conditions, mission duration, access to resources, and competing requirements and visions. Power assets and capabilities must be carefully integrated into the overall general engineering concept and employed to support the objectives of the theater civil engineer support plan. This planning process needs to occur long before it is needed—and not as the need arises.

TRANSITION TO UTILITY POWER

4-1. A contingency power system typically begins when a unit-owned tactical power system transitions to a deployable prime power system and then progresses to a civilian- or contractor-managed system, which provides utility power systems. The goal of electrical power planning is to employ power systems that support and build on one another.

4-2. Deployed units rely on tactical generators for initial power needs. Power produced by low-voltage tactical generators should be replaced by military prime power or commercial prime power. Once removed from daily use, tactical generators can function as back-up power sources for critical mission applications if the need arises. Replacing tactical generators with prime or utility power increases the reliability of the power source and saves wear and tear on tactical generators for temporarily deployed forces. Stand-alone prime power plants should be replaced with utility power as it becomes available. Military prime power plants should be considered as a temporary power solution for situations up to 18 months. Units that are planning to switch to commercial prime power purchase commercial generators, such as the logistics civil-augmentation program, local contractors, and USACE contracts, early in the planning process, or purchase commercial generators must address preventive maintenance and fuel consumption considerations. Prime power equipment and personnel are low-density MOSs.

4-3. During the initial phase of a base camp, the deployed unit uses organic equipment to set up, operate, and maintain the area of operations. In this phase, there is no need for a larger power solution than the deployed unit assets for power generation.

4-4. When multiple base camps are set up within a geographic location, they may be close enough to be electrically joined together. Several smaller base camps that are set up in a close geographic area can eventually become one large base camp. For example, the local tactical generators are removed from service and when the situation allows, the original distribution is used in this new design. Ideally, tactical generators are replaced by SDCs or commercial transformers, which allow voltage transformation and distribution to the user level voltage.

4-5. When base camp power requirements exceed unit organic capabilities, there are several resources that may provide additional power system capacity. The Army Force Provider is a modular and scalable base camp life support system capable of housing 150 to 3,000 personnel; it comes complete with power generation assets. For larger or longer-duration operations, the Force Provider Prime Power Connection Kit enables transition and connection to the prime power system. The Air Force base expeditionary airfield resources (BEAR) system is a deployable airfield support package, complete with low-voltage and medium-voltage power systems. Additional power systems equipment and support requirements may be obtained from external support contracts, such as the USACE WWP contract or the Army Materiel Command Logistics Civil Augmentation program task order. Power system equipment is available through the General Services Administration or local contract sources and requires proper system design to ensure that equipment is utilized safely and efficiently.

4-6. The Army has organic capabilities for the establishment and maintenance of critical infrastructure. USACE is responsible for the Army and DOD military construction, real estate acquisition, and development of U.S. infrastructure through the civil works program. USACE also provides technical assistance and contract support to joint forces deployed worldwide.

4-7. USACE supports engineer planning and operations through reachback and deployable forward engineering support to joint force commanders. Teams conduct engineer reconnaissance (assessments and surveys) in support of the full range of reconstruction operations. USACE provides two types of forward engineering support: forward engineer support team–advanced and forward engineer support team–main.

4-8. The forward engineer support team–advanced provides additional engineer planning capability to combatant command and Army Service component command engineer staff, or it deploys in support of a joint task force. Capabilities include contracting, multiple engineer planning and design, and real estate acquisition and disposal. The forward engineer support team–advanced may provide an initial technical infrastructure assessment or survey, contracting support, real estate acquisition support, and technical engineer assistance.

4-9. The forward engineer support team–main provides C2 of USACE teams in the joint operations area. It also provides sustained USACE engineering execution capability within the joint operations area. This team typically supports a theater-level headquarters or a joint force command. The forward engineer support team–main provides liaison officers and USACE engineering planning modules to supported units, as required. It is a flexible, self-sustaining organization with a mission of providing the following USACE capabilities through forward presence and reachback mission areas:

- Contract construction.
- Environmental engineering.
- Geospatial engineering support.
- Infrastructure engineering planning and design.
- Real estate acquisition, disposal, and protection.
- Technical engineering expertise.

4-10. Plans should allow for sufficient time for base closure activities. Contracted support for a sustained power system may require 90–120 days or more before base closure to terminate service and to dismantle and remove power system equipment. Engineer prime power units can assess the power system and, if necessary, reestablish a deployable prime power system to support an orderly build-down process. As redeployment progresses, the power system eventually reverts back to a tactical power system with unit responsibility. Additional tactical generators may be required for the final closeout. See ATP 3-37.10/MCRP 3-40D.13 for additional base closure information.

4-11. Operation and maintenance for a utility power system may range from a simple service contract for operator-level preventive maintenance checks and services to a more full-service contract, which includes daily operation, fueling services and periodic maintenance and repair, as needed. A utility power system contract may include system construction and facility connections and repairs. The utility power system may utilize power system equipment, which is provided by the contractor or purchased by the government to be used by the contractor, or it may use a tactical power system or deployable power system for which operational responsibility has been transferred to a contractor.

COMMERCIAL AND HOST NATION UTILITY POWER

4-12. In a deployed theater of operations, the host nation electrical power generation and distribution may be considered for usage. The key factors in the decision-making process include—

- Damage to the local electrical power generation and distribution system.
- Operational requirements.
- Reliability of the host nation utility.

4-13. The DOD establishes a contract and a memorandum of agreement with a host nation utility to define charges for consumption, demand, maintenance, and system monitoring in the event that transitioning to the host nation grid system is prudent.

4-14. An acquisition and cross-serving agreement is applicable worldwide to acquire logistics services, supplies, and support directly from, or to provide them to, a foreign government or organization, such as the North Atlantic Treaty Organization or the United Nations. See acquisition and cross-serving agreements, CJCSI 2120.01D, and DOD Directive 2010.9 for complete details, responsibilities, and procedures for acquiring and transferring logistics support, supplies, and services under the authority of 10 USC 2341 and 10 USC 2342.

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Chapter 5
Electrical Power Planning

This chapter discusses power systems construction, planning, and resourcing that presents multiple challenges within electrical power planning. For example, with any engineering or construction project, there are time and resource constraints, laws and regulations, customer coordination issues, and evolving missions. The primary challenges associated with power assets are theater entry conditions, mission duration, access to resources, and competing requirements and visions. Power assets and capabilities must be carefully integrated into the overall general engineering concept and employed to support the objectives of the theater support plan. Due to the logistical burden, electrical power should be approached through the deliberate planning process.

PLANNING CONSIDERATIONS

5-1. Electric power planning involves several factors, such as equipment availability, mission variables, operational variables, and power requirements. This chapter is designed to assist units in developing a safe and reliable power production, distribution, and management plan. Units must integrate electrical power requirements and capabilities in the mission-planning and decision-making processes.

MISSION

5-2. The mission statement includes both task and purpose. The mission statement clearly indicates the action that must be taken by the organization. A thorough understanding of the mission and its anticipated duration helps to focus on the power planning process and desired outcomes. If an operation is of short duration, tactical generation may be the best approach to power systems. If the mission requires occupying or constructing a base camp, the selection of prime or utility power may provide benefits that outweigh resource investments. Similar plans are also appropriate for longer-term (such as 120 days or more) foreign humanitarian assistance or disaster relief missions.

ENEMY

5-3. Power is critical to the success of C2 centers, communication systems, and key weapon systems. Friendly units can expect the enemy to engage power generation and distribution systems with a wide variety of ground and aerial systems to detect and permit engagement by direct and indirect fires. Recognizing vulnerabilities can allow planners to prepare defensive measures to mitigate threats to power systems assets. Several factors affect C2 center survivability, such as dispersion, mobility, redundancy, size, signatures (auditory, electromagnetic, infrared, and visual), and camouflage and concealment. Cover and concealment or shielding by terrain features and urban structures should be used, when available.

TERRAIN AND WEATHER

5-4. Terrain and weather affect the operation of power systems sources and the routing of distribution cables. Power output of generators decreases by 3.5 percent per 1,000 feet above 4,000 feet. Also, equipment operating temperatures increase at higher altitudes; thinner air is less efficient at carrying away waste heat. Likewise, rugged terrain and dense vegetation affect the placement of power systems and distribution cables. Generators need a relatively level surface.

5-5. Weather and climatic conditions also affect power generation equipment. Temperature extremes require additional authorized listed or use unit responsible items. Sometimes it may be necessary to clear and level an area before installing generators. Tropical and coastal regions require additional equipment maintenance to prevent corrosion from humidity and salt spray. Desert regions require frequent maintenance due to the heat and dust. Grounding problems are often encountered in dry climates due to high soil resistance. In addition to the applicable power source technical manuals, the *PS Magazine, The Preventive Maintenance Monthly Magazine* for the Army has multiple articles on operations in climatic conditions. See the references section of this publication for more information.

TROOPS AND SUPPORT AVAILABLE

5-6. The effectiveness and reliability of power systems are dictated by the availability of trained operators, maintainers, and external support. Power systems sustainment support is provided by level of power system employed.

TIME AVAILABLE

5-7. It may not always be feasible to construct the best power system due to time constraints. In these instances, planners should develop a course of action over appropriate timelines to upgrade the unit power supply as resources become available.

CIVIL CONSIDERATIONS (ARMY ONLY)

5-8. Civil considerations influence the conduct of military operations. These factors include organizations, the power infrastructure, the local populace, and activities of civilian leaders. Civil considerations also include actual structures, geographic areas, local utility capabilities, and events. All of these variables can affect the emplacement, operation, and security of power systems.

AUTOMATED DISTRIBUTION ILLUMINATION SYSTEM, ELECTRICAL

5-9. AutoDISE is a software tool for assisting units in planning safe and effective power systems that support the mission. AutoDISE uses an intuitive graphics interface to aid in designing microgrid layouts with a variety of military standard power systems. Using AutoDISE can enable a trained electrician to create a virtual layout consisting of shelters, electrical loads, distribution equipment, and generators based on the unit table of organization and equipment. Once the basic layout is complete, the AutoDISE program produces a wiring diagram that depicts the virtual layout. A key advantage of AutoDISE is its ability to automatically provide an electrical equipment list based on the planner layout. It also estimates generator set fuel consumption.

5-10. AutoDISE is a stand-alone client application. An individual can download or run it directly from a CD. AutoDISE is available from the Project Manager Expeditionary Power and Sustainment Systems. AutoDISE can be installed on DOD computer systems. Army AutoDISE users should refer to TM 9-6150-226-13, which takes precedence over information in the AutoDISE user manual and software. Marine Corps AutoDISE users should refer to TM 6110-OI/1, which takes precedence over information in the AutoDISE user and software.

5-11. Figure 5-1 depicts a notional 3-D internal AutoDISE power distribution layout. An outside layout that includes generators and distribution equipment is available with AutoDISE.

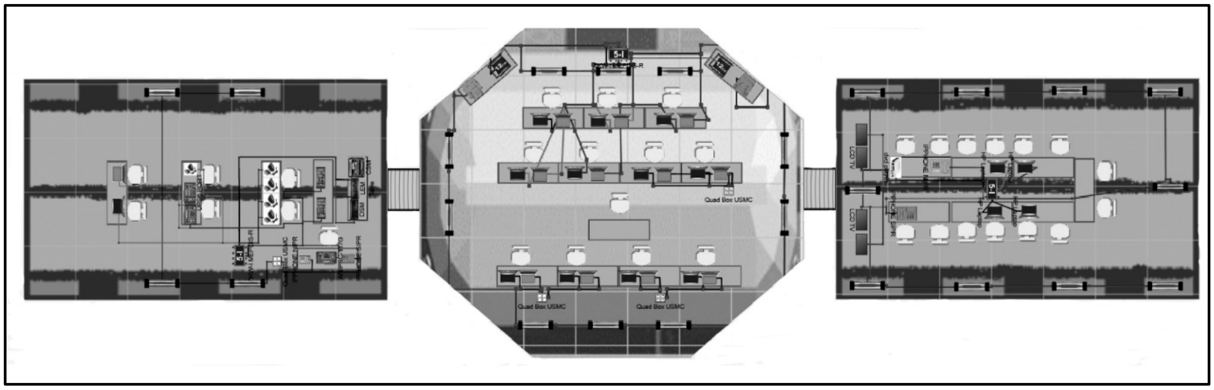

Figure 5-1. Notional AutoDISE power distribution layout

5-STEP POWER-PLANNING PROCESS

5-12. The 5-step power-planning process can be used to design and emplace power production and distribution systems. This cyclical process enables planners to compensate for changes in power requirements as missions change. The graphic training aid is available for downloads, or units can order it through the local training support center. In figure 5-2, the 5-step power-planning process is used to develop a power production and distribution scheme.

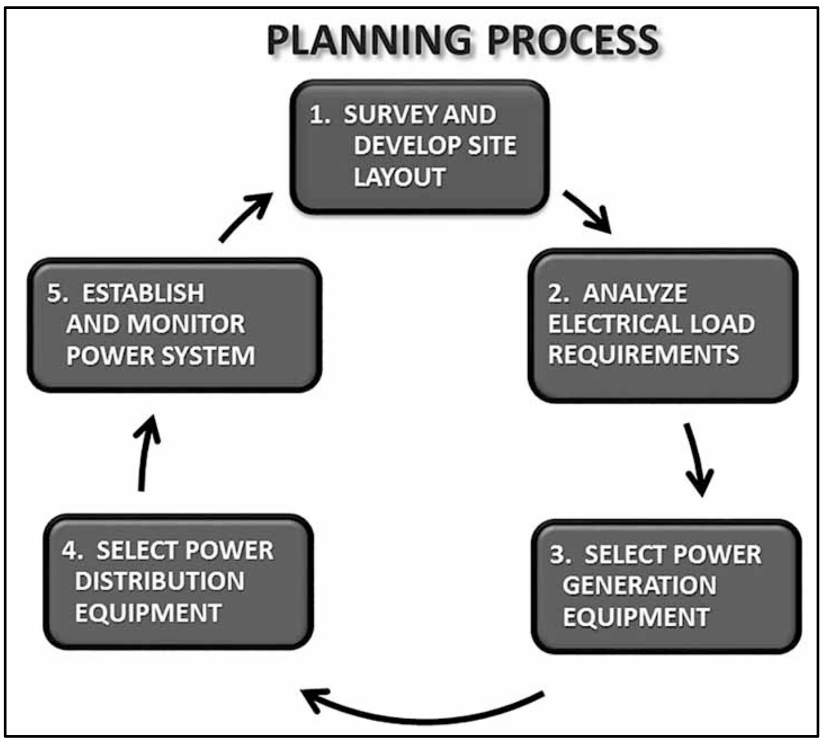

Figure 5-2. The 5-step power-planning process

5-13. The first four steps produce a power system layout based on the unit power needs. These steps result in a diagram that identifies the locations of electrical loads, power sources, and power distribution equipment. The final step is the establishment and monitoring of the power system. Establishment is accomplished by individuals who are trained to perform emplacement tasks according to the applicable technical manuals. During the monitoring process, designated operators ensure that the power system is operating at its peak efficiency to conserve fuel and reduce mechanical failure.

STEP 1–SITE SURVEY AND LAYOUT

5-14. Unit standard operating procedures depict notional layouts for the organization. Power planners review the notional layouts to develop power system site layouts. The tactical situation, location of critical loads, terrain, time, and resources should be considered when determining the placement of power systems and distribution equipment. The tactical situation may preclude ideal layouts; but as time permits and circumstances change, improving the power layout should be considered. Preferred layout techniques can also be affected by host nation-imposed environmental restrictions, such as restricting or prohibiting the burial of power distribution lines. Once the unit is at a deployed location, the power planner should walk the terrain and mark the locations of all items on the layout and assess them using the following criteria:

- **Adequate space around generator sets.** There must be adequate space between generator sets and other items (such as shelters and other systems) for airflow, grounding, maintenance, and refueling operations. Also, the ground is relatively flat and well-drained and it must support the weight of the generator. Sometimes it is necessary to use logs, planks, or other shoring materials to prevent the skids or frame from sinking into soft soil.
- **Distance from the power source to the load.** For tactical generation, source-to-load distance should be 50–150 feet (300 feet maximum). For prime power generation, distribution distances can be up to several miles.
- **Generator exhaust and noise.** The way in which the emplacement of generator sets affect nearby structures, work and sleep areas, and equipment should be considered. It is important to emplace power sources far away from work and sleep areas to minimize noise effects and allow engine exhaust to dissipate.
- **Location of large demands.** The location of the generator set can affect the overall efficiency of the power system. Power production should be placed close to load centers. Sometimes it might be necessary to place more generator sets in parallel to meet the demands.
- **Vulnerability and exposure of the power source and load cables.** This aspect includes the proximity of personnel and vehicle traffic to the cables. If practical (and the tactical situation warrants it), load cables should be buried according to technical manual specifications. Damaged cables present a dangerous electrical shock hazard and degrade power surety. Shelter for a generator set if the unit remains on-site for an extended period of time or if the operational situation allows. Although the equipment resists climatic effects, protection from inclement weather and enemy fire is prudent.

STEP 2–ANALYZE ELECTRICAL LOAD REQUIREMENT

5-15. Preliminary tasks that the power manager should complete before selecting power sources and distribution equipment include computing the load, determining the load cable requirement, and balancing the loads. This ensures that the most efficient system is employed and reduces the logistical burden. This process also determines if the unit needs 100 percent redundancy (emergency power) for critical systems, such as C2, communications, and direct patient care activities. This step also includes future power requirements. The unit power managers reassess the power system requirements when anticipating changes that are to be made to the system. Table 5-1 depicts considerations for electrical power systems.

Table 5-1. Electrical power system considerations

ORGANIC (UP TO 90 DAYS)		
Electrical Power System Attributes	***Load and Situational Attributes***	***Operational Considerations***
• Organic tactical generator, tactical power plant connected to a single load at user voltage. • Power sources remain separated.	• Primarily user loads: C2; communications; weapons and weapon systems; field feeding; and essential maintenance, heating, ventilation, and air conditioning systems.	• Mobility and rapid set-up to support combat operations overrides other considerations. • Organic equipment operated by individual users.
INITIAL (COMPANY/BATTALION/BATTALION LANDING TEAM) (UP TO 6 MONTHS)		
Electrical Power System Attributes	***Load and Situational Attributes***	***Operational Considerations***
• Creation of tactical microgrids using organic power generation equipment and the inclusion of additional generation and distribution resources. • Initial consolidation of power sources.	• Large tactical operations centers, supply and maintenance, laundry facilities, shower facilities, dining facilities (including refrigerated and frozen storage), life support areas (bed down including heating, ventilation, and air conditioning).	• Requires deliberate system planning and coordination. • Tactical power plant(s) and PDISE equipment organic to operations section and operated by assigned personnel. Individual unit organic power equipment operationally controlled by operations section.
INITIAL (BRIGADE COMBAT TEAM/REGIMENTAL COMBAT TEAM) (UP TO 6 MONTHS)		
• Tactical prime power system; medium-voltage power generation and distribution system; SDCs (transformers) replace tactical power plants. • Consolidating tactical microgrids into prime power plant.	• Water purification and distribution; ice production facilities; morale, welfare, and recreation facilities; gymnasiums, fitness centers; Army and Air Force Exchange Services or Navy Exchange.	• Requires base camp master planning. • Prime power platoon continues to augment utility companies to install, operate, and maintain prime power system. Tactical power plants serve as redundant back up or can be reallocated to other sites.
TEMPORARY (UP TO 5 YEARS)		
Electrical Power System Attributes	***Load and Situational Attributes***	***Operational Considerations***
• Tactical prime power system; expand power system as needed; expand or improve distribution system. • Improved facilities can be designed to utilize waste heat from generators to preheat water for shower, laundry, to reduce fuel consumption.	• Initial standard loads plus: expanded morale, welfare, and recreation facilities; Army and Air Force Exchange Services or Navy Exchange vendors; theater level maintenance; and supply activities. • Improved or consolidated dining facilities, improved shower and laundry facilities.	• Requires base camp or installation master planning. • Prime power platoon continues to augment utility companies for power system operation and maintenance. Transition from tent-based facilities to improved facilities.

Table 5-1. Electrical power system considerations (continued)

SEMIPERMANENT (2 to 10 YEARS)		
Electrical Power System Attributes	***Load and Situational Attributes***	***Operational Considerations***
• Transition to utility power system (military construction, LOGCAP, and USACE WWP contract, commercial power). • Tactical prime power equipment retrograded to Army pre-positioned stocks (war reserve) program. Consider renewable energy.	• All facilities connected to consolidated power system. • Expeditionary power systems (isolated generators or microgrids within overall system) should be eliminated.	• Requires base camp or installation master planning. • Long-term civilian contract (LOGCAP or similar) for operations and maintenance. Utility company personnel serve as contract QA oversight.

Legend:

C2	command and control	SDC	secondary distribution center
LOGCAP	logistics civil augmentation program (Army)	QA	quality assurance
PDISE	power distribution illumination system, electrical	USACE	United States Army Corps of Engineers
		WWP	worldwide power

STEP 3–SELECT POWER GENERATION EQUIPMENT

5-16. This step includes the identification of the power source (tactical, prime, utility) that is most suitable to meet the power requirements. After determining the loads and notating them on the site layout, the power manager selects the power source needed to match the load. The DOD standard family of tactical generators can fulfill most organic power requirements. Prime power can be selected when distances and loads exceed those of tactical power sources. Utility power can be selected if it is compatible with mission equipment and reliable enough to suit unit needs. Appendix F contains WWP frequency and voltage data.

STEP 4–SELECT POWER DISTRIBUTION EQUIPMENT

5-17. Units have several options for electrical distribution systems and components. Effective distribution often reduces the number of generator sets needed, can save fuel, and can reduce maintenance. PDISE and MEPDIS-R allow the unit to assemble and operate a safe tactical power grid in all operational environments.

5-18. Prime power selection includes a primary and secondary distribution system to carry medium-voltage power from the power plant to the transformers or SDCs. SDCs are transformers with self-contained switching and protective devices and low-voltage distribution for user loads. SDCs are equipped with PDISE or
MEPDIS-R connections. Utility distribution transformers are the civilian method of transforming medium-voltage to user level voltages. There is no connection interface capability in utility distribution transformers for PDISE or MEPDIS-R.

5-19. Primary distribution systems can be surface-laid, overhead, direct burial, or ducted underground. The following are planning considerations for the types of distribution systems available:

- Surface-laid distribution is typically the initial format used due to the speed of installation. However, it is a temporary solution because of its susceptibility to damage, and it can restrict mobility on the base camp. The cables can be recovered for reuse at another location. Armored and heavily jacketed cables are also available and are more resistant to damage, but they are bulky and heavy and require material-handling equipment for installation.
- Overhead distribution is the easiest type of distribution system to troubleshoot and maintain, but is also more likely to be damaged than underground distribution due to exposure. Overhead distribution systems are the least expensive, quickest to install, and most readily expandable distribution systems for covering large areas over long distances. Traditional overhead systems were built with wooden poles, wooden cross-arms, and ceramic insulators, but newer systems include fiberglass, concrete, or tubular metal poles and composite insulators. Overhead distribution systems require specialized equipment for digging holes, erecting and setting poles, and stringing overhead conductors. Although the conductors are typically about 7 meters above the finished grade surface, special precautions must be taken at road crossings or other areas where tall vehicles (such as cranes and raised forklifts) are used.
- Direct-burial distribution is a semipermanent type of distribution; however, it is more time-consuming to install and repair because of the horizontal resources required. The cables are bedded on sand in the bottom of the trench. Marker tape is installed when the trench is backfilled about halfway. The trenches for a direct-buried system can be dug with readily available engineer equipment (backhoes or excavators), but dedicated trenching machines are generally faster and less disturbing to the soil. Installing a direct-buried distribution system may be challenging in extremely rocky soils.
- Ducted underground distribution systems are generally used in permanent urban locations, where system expansions or modifications are unlikely. Access vaults are emplaced at regular intervals (typically 100 meters) to provide access points for splicing, maintenance, and repair. Additional testing, pumping, and ventilation equipment may be required to allow confined-space access into the vaults. Individual training and safety procedures must be established. Ducted underground distribution systems are the most resource-intensive to install and the least readily adaptable to changes or modifications, but they provide good system reliability because of protection from physical damage.

STEP 5–ESTABLISH AND MONITOR POWER OPERATIONS

5-20. This step includes the installation of the system according to the site layout plans and appropriate technical commander's guidance and publications. The power manager and operators monitor and manage electrical power output. The power manager then directs adjustments as needed to maintain an efficient, safe, and reliable system to support the unit mission.

ELECTRIC POWER MANAGEMENT

5-21. Managing electric power is similar to managing other resources. There are monitoring and controlling responsibilities intended to ensure that the power production is reliable, meets mission needs, and incorporates efficiencies. Managing power operations usually involves the following actions:

- Advising the commander of the overall power system status and efficiency.
- Coordinating power system changes as unit mission needs change.
- Educating personnel on efficient electrical power usage.
- Ensuring that personnel understand their roles and responsibilities.
- Monitoring the fuel consumption and other resources needed for power production.
- Understanding the unit power needs over time and monitoring the demand.

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Appendix A
Army Prime Power

ARMY SUPPORT TO MILITARY OPERATIONS

A-1. Army prime power units provide continuous, reliable, commercial-grade, and medium-voltage power to support military operations. It is typically used when commercial power is unavailable or where tactical generators are impractical. Therefore, prime power can support the range of military operations. Prime power units support general engineering efforts theater-wide by providing advice and technical assistance on all aspects of electrical power. Also, prime power efforts and capabilities must be closely integrated and synchronized with general engineering efforts to achieve the effects intended in a theater engineer support plan.

A-2. Army prime power personnel provide electrical power expertise, technical assistance, and contracting support on all aspects of electrical power and distribution systems. Army engineer prime power units provide support to military operations worldwide. The support tasks include the following responsibilities:

- Conduct electrical-load surveys, analyses, and designs of power distribution systems.
- Deploy, install, operate, and maintain power generation and distribution.
- Perform damage assessments of distribution systems.
- Provide expertise for electrical power generation, distribution system installation, maintenance, and repair.
- Provide power-related planning and staff assistance.
- Serve as the COTR for power-related contracts.

DEPLOY, INSTALL, OPERATE, AND MAINTAIN POWER GENERATION AND DISTRIBUTION

A-3. Army Engineer prime power units produce large quantities of reliable power with organic generators. Also, these units may install, operate, and maintain nonmodified table of organization and equipment power generation equipment and fixed commercial power plants. Prime power units also install, maintain, and operate the associated distribution equipment. Power generation and distribution capability can be used in a variety of base camp configurations and seaports, airfields, C2 nodes, and other critical facilities. The power generation capability of the unit allows them to operate, maintain, and perform damage assessments of fixed commercial diesel engine power plants.

PROVIDE POWER-RELATED PLANNING AND STAFF ASSISTANCE

A-4. The prime power unit provides power-related technical assistance to the appropriate engineer staff. The prime power representative is the theater subject matter expert for electrical power. Prime power engineers provide technical expertise and staff assistance to the base camp and area of operations commanders in the areas of power generation and distribution. This assistance also includes support with electrical generation capacity, distribution, installation, maintenance, and repair of the power systems involved.

A-5. Engineer prime power units are theater level assets. Prime power units are assigned or attached to the senior engineer headquarters in the theater and are normally employed in a general-support role throughout the theater.

Conduct Electrical-Load Surveys, Analysis, and Design of Power Distribution Systems

A-6. An electrical-load survey is an analysis of power requirements. The electrical-load survey is a vital step in providing prime power support. The prime power team conducts the electrical-load survey to determine the supported power and distribution requirements of a unit. The electrical-load survey also determines the required level of reliability and identifies special power demands or problems. The recommended power source is determined based on the electrical-load survey. A thorough electrical-load survey must be completed before installing a power plant or designing a distribution system.

Perform Damage Assessment of Distribution Systems

A-7. The prime power platoons assess damage to existing distribution systems. The prime power team performs inspections and electrical testing to identify damage. Prime power personnel can provide an after action report outlining the damages found and produce a bill of materials for electrical equipment needed to make repairs to the electrical system.

DANGER

Transformers may contain polychlorinated biphenyls, which present hazards to the environment and the Soldier.

Serve as the Contracting Officer Technical Representative for Power-Related Contracts

A-8. The prime power unit provides power-related technical assistance to the representative of the contracting office, USACE, Defense Contracting Management Agency, and others. Prime power engineers help develop specifications for performance contracts and purchase contracts for electrical material and power sustainment operations. This assistance includes scopes-of-work review and bill-of-materials review. In addition to developing specifications for contracts, prime power engineers also help perform the technical evaluation of the bids that are received. When acting as a representative for the contracting office, prime power engineers are able to conduct inspections and accept duties that are in line with maintenance and operation of power plants and distribution equipment. This assistance is available to military engineer units and supporting USACE personnel.

Provide Expertise for Electrical Power Generation, Distribution System Installation, Maintenance, and Repair

A-9. Army prime power personnel can install and maintain temporary, primary, and secondary distribution systems. Distribution systems are designed and constructed with approved materials and methods, to include the appropriate protective devices. Prime power personnel have the ability to repair damaged distribution and limited capability to maintain overhead distribution systems. Prime power conducts critical infrastructure repairs when mission-critical needs arise. By the time the local user is aware of an outage, the personnel working at the power generation plant are already in pursuit of the issue and working toward its repair. Construction and maintenance of extensive overhead distribution systems should be accomplished through the use of contracts or United States Army Reserve power line platoons within the prime power battalion. Prime power personnel can make connections to existing distribution networks.

A-10. Although prime power personnel are capable of performing interior electrical work, they are typically not used for this line of work. Interior electrical work is usually performed by vertical-construction platoons or contracted electricians. When installing a secondary distribution system, prime power personnel are responsible for the service entrance and for making connection up to the first circuit panel overcurrent device or first piece of service equipment. Service equipment, installed by interior electricians, includes the main distribution panel, switched disconnect, manual transfers switch, automatic transfer switch, or switched fuse box at the structure.

ARMY PRIME POWER UNIT

A-11. The Army trains, organizes, and equips the 249th Engineer Battalion (prime power) to provide worldwide prime electrical power generation to support military operations and the National Response Framework. The 249th Engineer Battalion provides prime power support, specialized logistical and technical expertise on power generation, and distribution to commanders and staffs, which includes the design and analysis capability. The battalion manages and coordinates worldwide prime power requirements for the Army. The battalion has three active duty companies and one Reserve company.

PRIME POWER COMPANY

A-12. A prime power company consists of one headquarters platoon and four prime power platoons. The engineer prime power company headquarters provides administrative and limited logistics support to subordinate prime power platoons, which includes specialized Class IV, VII, and IX support.

PRIME POWER ENGINEER PLATOON (POWER STATION)

A-13. The prime power engineer platoon is the basic building block for the company and battalion. The platoon is the smallest deployable element within the battalion. The platoon is composed of two sections with prime power production and interior electrician capability. Each prime power platoon has one organic power plant with four mobile electric power ([MEP]-810B) power units.

A-14. The MEP-810B and its associated distribution equipment must be procured by the requesting organization for installation, employment, and maintenance.

A-15. Prime power platoons have electrical distribution capabilities that are organic to the unit. The distribution system gives the platoon the ability to deploy and provide power in deployed locations. Organic distribution equipment of the prime power platoon serves as an interim solution for power distribution. The prime power platoon is capable of providing a plant operating center, maintenance area, and tool and test equipment storage area. Power distribution systems that are anticipated to operate longer than 18 months should be replaced with permanent systems.

A-16. Prime power units have specialized skills, which include the mechanical, electrical, and instrumentation maintenance of unit power generation equipment. Prime power platoons are also capable of performing overhead power distribution maintenance.

A-17. Prime power personnel assume the role of COTR for USACE prime power contracts. The COTR monitors all technical aspects of the contract and assists in contract administration. The COTR is authorized to perform the following functions:

- Approve monthly invoices before they are certified by the paying office.
- Coordinate the availability of government-furnished property.
- Ensure that the contractor performs the technical requirements of the contract.
- Issue written interpretations of technical requirements, including government drawings, designs, and specifications.
- Maintain written and oral communications with the contractor concerning the technical aspects of the contract.
- Monitor contractor performance, and notify the contracting officer and contractor of any deficiencies.
- Perform inspections necessary in connection with contract performance.

EQUIPMENT AND EQUIPMENT LOGISTICAL CONSIDERATIONS

A-18. Power stations are ready to deploy worldwide on tasking by the USACE Operations Center. All organic equipment, including generators, cable, control vans, and transformers, can be transported on flatbed or lowboy trailers. The MEP-810B has an 840-kilowatt power production capacity, is trailer-mounted, and is Department of Transportation-certified for highway travel speeds up to 55 miles per hour. The power units require a 915-series tractor or commercial equivalent for movement. Organic equipment can also be moved by air.

A-19. Planning factors for deploying a power plant depends on load, time, and available personnel. These manning considerations include management, power plant operation, safety, maintenance, and material handling. Table A-1 describes planning factors for the personnel required to safely and continuously sustain a power plant continuously using 8- to 12-hour shifts. A fully staffed power station can install power production and distribution to a 1,000-man force provider base camp in approximately 14 days.

A-20. A sustainable load is one that equals 60–80 percent of the maximum load of a generation system. In the case of a 3.4- megawatt system, five generators are operating and one is in maintenance or surge load reserve. Five generators create 4.2 megawatts; therefore, 3.4 megawatts is at 80 percent efficient of maximum load.

Table A-1. Load planning factors

Sustainable Load (60–80% max)	*Power Units Required*	*Prime Power Personnel Required to Install Generation and Distribution*	*O&M of Generation*	*O&M of Distribution*
1.7 MW	4	18	14	4
3.4 MW	6	19	14	5
5.1 MW	8	22	17*	6

* An additional maintenance team is required to maintain eight MEP-810s.

Legend:

%	percent
max	maximum
MEP	mobile electric power
MW	megawatt
O&M	operations and maintenance

A-21. Prime power platoons require heavy materials-handling equipment support to mobilize, install, and demobilize equipment subsequent to deployment and redeployment. A 40-ton crane (with appropriate rigging equipment), rough terrain container handler, and a 10,000-pound rough-terrain forklift can support this requirement. Operations involving erecting or repairing and making connections to overhead distribution networks require the use of a line truck, which is organic only to the Reserve Component power line platoons.

A-22. Deployed prime power platoons require support from their attached or operational control higher headquarters for all classes of supply. The operation of a prime power plant requires a daily resupply of diesel fuel 2 or jet propulsion fuel 8. The fuel is delivered to the power plant by the supported unit. The consumption rate depends on the plant size and electrical load.

A-23. The time and cost required to deploy Army prime power assets into a theater of operation varies with location and priority of mission. There are considerations of methods used to deploy an organic power plant abroad. To ensure the rapid deployment of prime power assets, the requesting unit must assign a unit line number that references the force tracking number in the Joint Operation Planning and Execution System.

PRIME POWER SUPPORT TO THE WARFIGHTER

A-24. Prime power supports the combatant commander's capability to have sustainability within the force by adhering to the following principles that are outlined in ADP 4-0 and ADRP 4-0:

- **Anticipation.** Anticipation is the ability to foresee operational requirements and initiate actions that are necessary to meet future requirements without specific directives. It is shaped by professional judgment resulting from education, experience, knowledge, doctrine, regulations, and creativity. When integrated properly, Prime power units assist commanders and staffs by planning and initiating necessary processes to meet anticipated power requirements.
- **Continuity.** Prime power units integrate with supporting and supported unit structures while maintaining support from the prime power battalion and USACE. Continuity is a key issue in sustained operations as units rotate through theater. Prime power personnel provide the continuity for those combatant command power generation and distribution systems.

- **Economy.** Prime power reduces operational energy requirements by consolidating fueling requirements, generator engine hours, and electrical distribution equipment to only what is needed to operate efficiently in a forward theater.
- **Improvisation.** The capability to modify and adapt the power generation and distribution systems and resources to meet current, future, and unexpected operation conditions in any theater exemplifies improvisation. Prime power personnel are highly skilled technicians who understand the power generation and distribution systems and requirements in a manner that enables them to make complex systems work with materials that are on hand or are easily obtainable.
- **Integration.** Prime power combines the assets (equipment, knowledge, personnel) within supported units to facilitate and maximize a more sustainable power generation system. The ideal integration of prime power occurs at multiple levels within an operational area, which includes personnel planning factors from the lowest combatant command to theater engineer support.
- **Responsiveness.** The prime power battalion is regularly available to deploy throughout the world into different operational areas. The prime power battalion has up to three platoons that are in a constant state of preparedness for any power system situation that may arise.
- **Simplicity.** The simplicity of power generation systems is achieved collectively through integrating prime power with theater power operations planning and staffing. Prime power expertise has simplified the power grid by reducing unnecessary spot generation where applicable and integrating more efficient forms of generation and distribution.
- **Survivability.** Survivability is improved by prime power operations. Prime power operations simplify and integrate components of any power grid to minimize exposure to enemy combatants and minimize the exposure of the base by reducing the number of locations that require fuel. Prime power makes existing and future electrical generation and distribution systems safer, preventing unnecessary electrical hazards while in deployed locations.

A-25. Prime power also supports the combatant commander's capability to conduct DSCA within the force by adhering to the following principles that are outlined in the ADP 3-28 and ADRP 3-28:

- **Engaged partnerships.** Prime power is engaged with the Corps of Engineers to work with state and local emergency power managers and governments as they relate to operational and operation requirements and readiness. This partnership allows prime power to respond immediately to disaster situations. This alliance can minimize power interruptions to critical facilities and enable states or local municipalities to provide lifesaving services.
- **Readiness to act.** Prime power has three platoons that are at a constant state of readiness to deploy to a disaster zone when called upon. Prime power personnel have 18 hours from the notification of an event to arrive on site ready to respond.
- **Scalable, flexible, and adaptable operational capabilities.** Prime power is capable of deploying in five different element configurations to support the needs of the Corps of Engineers response and recovery operations under the National Response Framework ESF #3, Public Works and Engineering activities. This scalable response allows prime power personnel to use their power generation and distribution expertise where it is the most needed without delay.
- **Tiered response.** The Corps of Engineers proves a tiered response through operations with several different agencies and prime power support units. This response allows the Corps of Engineers to have the right people in the right place talking to the right agencies for the assistance that is required.
- **Unity of effort through unified command.** Prime power deploys as part of a Corps of Engineers power response team. This allows prime power operations in disaster areas to be synchronized to achieve the maximum synergistic effect. The power response team coordinates with the state emergency operations team to streamline power requirements during disaster operations.

Prime Power Support to Emergency Support Function #3

A-26. The 249th Engineer Battalion prime power unit supports the National Response Framework ESF #3, Public Works and Engineering annex.

A-27. The 249th Engineer Battalion provides Soldiers in required deployment configurations to support relief missions based on ESF #3 requirements. Deployment time for battalion Soldiers and equipment depends on mission requirements and the availability of transportation.

Appendix B

Navy Prime Power Capability

B-1. The Navy executes power generation and distribution as part of the MUSE program. The Navy also has Navy construction engineer (Seabee) construction electricians, who perform tasks similar to Army interior electricians.

B-2. The MUSE program, consisting of 28 enlisted Seabee technicians, provides specialized, easily transportable utility equipment for temporary support of utility and critical power systems and highly skilled technicians to provide technical assistance and training. MUSE includes generation, transformation, and distribution to meet emergency and unforeseen utility shortfalls. The Department of the Navy provides MUSE to meet the requirements of federal and nonfederal activities in the five core areas listed below, in paragraph B-4.

B-3. Command and execution of the MUSE program are provided by the Naval Facilities Engineering Command Expeditionary Warfare Center in support of Naval Facilities Engineering Command public works. MUSE is intended as an interim solution to a long-term requirement; it provides temporary utility support until a permanent solution can be planned and programmed.

B-4. MUSE maintains an inventory of about 150 power generation, transformation, and distribution assets. These assets range from power plants with capacities from 800 kilowatts to 2,500 kilowatts (50 or 60 hertz) at voltages from 480 volts to 4,160 volts. Substations range from 2,500 to 5,000 kilovolt-amperes, 480 volts to 5 kilovolts and 15 kilovolts. Distribution equipment includes 1,200-ampere, 15-kilovolt automatic transfer switches to 5,000 ampere, 480-volt distribution systems. The MUSE units are designed with mobility in mind, and most are packaged into typical international standards organization containers to support the following areas:

- **As directed by higher authority.** Support for other short-term requirements of federal and nonfederal activities as directed by the Secretary of the Navy, Office of the Secretary of Defense, or the Joint Chiefs of Staff.
- **Cold iron.** Direct utility support for Navy vessels and fleet operations when in-place services have insufficient capacity or are nonexistent or uneconomical.
- **Contingency response, humanitarian assistance, and disaster recovery.** Support of shore installations during unforeseen utility emergencies, such as failures resulting from natural disasters and unexpected equipment breakdowns, while interim repair or replacement of failed utilities or distribution is performed.
- **Expeditionary.** Support to expeditionary military operations, as required.
- **Facility.** Direct support of shore installations where in-place utility infrastructure is unable to meet system demands due to temporary overloads, increases in mission tempo, or changes to facility planning and programming until utility requirements can be satisfied through normal programming.

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Appendix C
Air Force Capability

C-1. Air Force shares the same medium-voltage organic-power production equipment as the Army prime power battalion and includes tactical generators. The Air Force employs interior and exterior electrical skills separately, and power generation is separate from power distribution.

C-2. Air Force electrical systems technicians deploy as part of prime base expeditionary engineer force or rapid engineer deployable heavy operational repair squadron engineer (RED HORSE) teams to execute large construction projects. These technicians provide the following tasks in support of electrical systems:

- Install additional power feeds to temporary and permanent facilities and secondary distribution system constraints under field conditions.
- Install and maintains emergency airfield lights.
- Install, maintain, and repair all associated electrical components in secondary distribution systems, expeditionary and in-garrison facilities, 4,160 VAC electrical equipment, and other basic expeditionary airfield resources equipment. Plan and develop primary and secondary electrical distribution layouts for expeditionary locations to support over 12 megawatts.
- Install, maintain, and repair distribution transformers, current regulators, oil circuit breakers, insulators, switching gear, and control circuits.
- Install, maintain, plan, and repair electrical distribution systems, lighting, circuit breakers, and equipment for real property-installed equipment and field-deployed facilities.
- Install, maintain, and repair grounding and lightning protection systems. Modify and substitutes foreign electrical components, such as breakers and receptacles, to suit local installation and field requirements.
- Install, maintain, and repair outside lighting, street lighting, and security lighting. Maintain and repair visual navigational aids (runway lights, visual approach slope indicators) and assemble and install contingency airfield lighting and associated equipment.
- Maintain and repair overhead, underground, and temporary aboveground distribution systems to include cables, potheads, transformers, cable boxes, oil fuse cutouts, load limiters, controls, and instruments.

C-3. Air Force electrical power production technicians deploy as part of prime base expeditionary engineer or RED HORSE teams to conduct large construction projects. These technicians provide the following tasks in support of electrical power production:

- Apply power generation distribution constraints, control system logic, advanced troubleshooting, and field-level calibration on equipment.
- Install, maintain, operate, and certify a variety of aircraft arresting systems and components, to include expedient installation of the mobile aircraft arresting system.
- Install, maintain, and repair a variety of commercial name-brand generators used as emergency back-up and prime power.
- Install, maintain, and repair a variety of unmanned emergency electrical generators (diesel or gasoline) and components that support combat operations and combat support facilities.

- Maintain power generation systems, power-starting units, switchgears, fuel systems, and cooling systems. Install, operate, and maintain automatic and manual power transfer systems.
- Operate and maintain prime power production facilities equipment and standby power plant.
- Perform generator emergency repair and expedient connections of power cables to power distribution systems and transfer switches.
- Plan power plant layouts and load analyses and install, operate, maintain, and repair associated power production components in base expeditionary airfield resource packages, to include prime power generators and tactical generators.

C-4. Field maintenance for generators is performed by electrical systems technicians employed by Prime base engineer emergency force (BEEF) or RED HORSE. Sustainment-level maintenance is performed by specialized civil engineer maintenance inspection repair teams or by depot-level maintenance activity. Civil engineer maintenance inspection repair teams are composed of specially trained heating, ventilation, and air conditioning technicians.

Appendix D

Marine Corps Capability

MARINE CORPS SUPPORT TO MILITARY OPERATIONS

D-1. Marine Corps utility units are manned, trained, and equipped to deliver tactical power generation and distribution to support the accomplishment of missions across the full range of military operations. These utility units are organized under, and are designed to support, the internal requirements of the MAGTF. The MAGTF includes four elements: the logistics combat element, the aviation combat element, the command element, and the ground combat element. Under certain tactical circumstances, the MAGTF may receive an element from the Naval Construction Force or Seabees, such as the Naval Mobile Construction Battalion. When this occurs, the Naval Construction Force are often referred to as the fifth element of the MAGTF or it can be positioned within the logistics combat element. Utilities support organizations within each Marine expeditionary force size MAGTF include the engineer support battalion (ESB), the combat logistics battalions (CLBs) of the Marine logistics group, and the Marine wing support squadron (MWSS) of the Marine aircraft wing. The Marine logistics group CLB and MWSS are typically designated to provide direct support to the RCT or Marine aircraft group (MAG), respectively. The ESB is employed to provide general support across a Marine expeditionary force or Marine expeditionary brigade (MEB) size MAGTF. The Marine expeditionary unit is the smallest permanently organized MAGTF. The Marine expeditionary unit logistics combat element consists of a single CLB. The CLB contains a reinforced engineer platoon, which contains a utilities section. The engineer platoon provides general support general engineering to the entire Marine expeditionary unit. For more details on the MAGTF organization and elements, see MCRP 1-10.1.

D-2. Similar to the MAGTF, Marine Corps power generation and distribution support is scalable to the level of activity, threat condition, and mission. When power requirements necessary to operate base camps exceed the capacity and capability of organic utility units, the MAGTF can request augmentation from external sources. Generally, Seabees are the primary resource used to fill the gaps in the transition between basic, expanded, and enhanced base camp services because they are capable of providing more robust electric power generation and distribution. For more information on Seabee capabilities, see NTTP 3-10.1M/MCWP 4-11.5.

COMBAT LOGISTICS BATTALION

D-3. An RCT typically consists of three infantry battalions that are reinforced with detachments provided by the combat support battalions of the Marine division (combat engineer, light armored reconnaissance, artillery, tank, assault amphibian, reconnaissance). An RCT receives direct logistic support from a designated CLB of the Marine logistics group. A habitual supporting-unit-to-supported-unit relationship exists between the RCT and the CLB in garrison and while deployed. Core competencies of a CLB include executing support operations and providing utilities services (such as tactical power generation and distribution, bulk water production, laundry, and field showers) to the RCT. A utilities section is located in the engineer support platoon of the headquarters and service company.

ENGINEER SUPPORT BATTALION

D-4. The ESB provides general support and general engineering to a Marine expeditionary force or MEB size MAGTF. The ESB contains the requisite personnel, equipment, and C2 mechanisms necessary to provide utilities support to the MAGTF. The ESB possesses a more robust utilities support capability and capacity than CLBs. This is due to the fact that the ESB has a larger quantity of equipment and more personnel than the CLB. The ESB utility capability is located in the utilities platoon of the engineer support company.

MARINE WING SUPPORT SQUADRON

D-5. The MWSS is organized to provide aviation ground support directly to a MAG if the MAG is operating in garrison or if it is operating as a composite MAG or MAGTF aviation combat element while deployed. Aviation ground support includes essential engineer services, such as power generation and distribution. MWSSs are capable of simultaneously operating one forward operating base and two forward arming and refueling points. The primary purpose of the MWSS is to sustain the operational tempo in terms of sortie generation for the supported MAG and attached elements of the Marine air control group. Core competencies of the MWSS encompass power generation and distribution to address personnel, aviation maintenance, expeditionary rescue and firefighting, and C2. The engineer company of MWSS contains a utilities platoon that provides power generation and distribution, refrigeration and air conditioning, field showers, and laundry support to the MAG or aviation combat element. Elements of the Marine air control group possess the organic power generation equipment necessary to directly operate radar, navigation aids, and air traffic control systems. Likewise, the Marine aviation logistics squadron possesses organic power generation equipment that directly supports the performance of maintenance on aviation and avionics systems. The power generation equipment used by the Marine air control group and the Marine aviation logistics squadron is not capable of supporting common power requirements because it provides higher voltages and 400-hertz power.

COMBAT ENGINEER BATTALION

D-6. The Marine division receives organic power generation and distribution support from the combat engineer battalion. The combat engineer battalion possesses a single utilities platoon in the engineer support company. The platoon is capable of providing power generation and distribution support to support C2 of a Marine division.

MARINE AIR-GROUND TASK FORCE ELECTRIC POWER GENERATION AND DISTRIBUTION EQUIPMENT

D-7. MAGTF power generation equipment consists of military standard power generators producing 120, 208, 240, and 416 VAC and outputs ranging from 2 kilowatts to 100 kilowatts. These generators are capable of producing 50, 60, or 400 hertz. Sometimes, power generation is accomplished through the use of commercial, off-the-shelf generators and solar power systems.

D-8. MAGTF power distribution equipment consists of military standard power distribution equipment ranging in size from 30 amperes up to 1,200 amperes. The MEPDIS-R system is the Marine Corps preferred means to safely and effectively distribute power in a field and expeditionary environment. Sometimes power distribution is accomplished through the use of energy storage units, commercial, off-the-shelf distribution panels, and wiring.

D-9. Intelligent power distribution adds the additional capabilities of automatic phase balancing, load prioritization and shedding, remote monitoring, advanced safeties, remote-operated breakers, automatic ground sensing, ground fault monitoring, and isolation.

MARINE AIR-GROUND TASK FORCE POWER GENERATION AND DISTRIBUTION PERSONNEL

D-10. Typically, the table of organization for MAGTF utility units includes officers and enlisted personnel who are trained to plan, install, maintain, and repair power generation and distribution equipment. These Marines receive advanced specialized training in the planning of small- to large-scale tactical power grids, which include heating, air conditioning and refrigeration support; water purification equipment; hygiene equipment; bulk water production; storage and distribution equipment; and general supply equipment through the use of the stubby pencil method and the electronic planning tool AutoDISE. They are also trained in the establishment of field maintenance areas to perform preventive and corrective maintenance at various levels for power generation and distribution equipment. Specific skills, duties, and responsibilities for officers and enlisted MOSs include the following:

- **Electrician (1141).** Electricians plan, design, install, operate, maintain, and repair underground, aboveground, and tactical electrical power distribution systems. These individuals also perform preventive maintenance checks and services and operate electrical power generation and power distribution equipment, load banks, and floodlight sets. Additionally, electricians plan, design, install and repair interior wiring according to the UFC, National Electrical Code, and local code requirements.
- **Utilities chief (MOS 1169).** The utilities chief answer to the commander and assists in the planning, training, deployment, and employment of all utility capabilities. The utilities chief also supervises and coordinates the assignment of personnel and equipment according to the table of organization and equipment. This individual plans, supervises, and coordinates the installation, operation, and maintenance of utilities assets. This MOS is technical in nature and requires years of experience to become proficient. Due to the diversity of commands throughout the Marine Corps, some of the duties and tasks performed by the Utilities Chief may overlap with those of the engineer equipment chief, motor transport maintenance chief, and motor transport operations chief MOSs. The utilities chief may also be assigned to the staff of a Marine air-ground task force command element, ground combat element, aviation combat element, or logistics combat element to provide advice related to planning utilities support. Additional duties may include assignment to the faculty of a formal school, new equipment and systems research and development, or new systems acquisition. This MOS is only assigned to graduates of the Marine Corps Engineer School resident Utilities Chief course.
- **Utilities officer (MOS 1120).** Utilities officers are technical advisers to the commanders at all levels of all elements of the various MAGTFs on the timely and appropriate employment of utilities support. These warrant officers analyze, translate, and execute the commander's operational requirements into a utilities support reality that enhances mission accomplishment. These individuals also plan, manage, delegate, and supervise the operation and maintenance of water purification, storage, and distribution sites; electric power generation sites with the inherent underground, aboveground, overhead, and tactical electric power distribution systems; and shower and laundry services. These individuals coordinate and manage the installation, maintenance, and repair of heating, ventilation, air conditioning (to include automotive), and refrigeration equipment and the maintenance and repair of the electrical systems on engineer and general supply equipment. Water quality assurance, field sanitation, sewage, and waste disposal are also planned, coordinated, and managed. When deployed in support of humanitarian assistance and civil-military operations, these officers plan, direct, and coordinate the installation and repair of plumbing and interior electrical systems. As the utilities specialists for the Marine Corps, these individuals are in liaison with the Project Manager–Expeditionary Energy Sustainment Systems and Joint Water Resources Management Action Group to provide technical input regarding Marine Corps utilities requirements.
- **Engineer equipment electrical systems technicians (1142).** Engineer equipment electrical systems technicians troubleshoot and repair the electrical circuits and systems of all engineer equipment (and some general supply equipment) at the organizational and field levels of maintenance. These technicians are trained on electrical theory; solid-state device, and power supplies; use and care of test, measurement, and diagnostic equipment; troubleshooting techniques; and the reading and analyzing of electrical schematics and wiring diagrams. Their primary duty is to diagnose and repair electrical circuits; their secondary duty is to diagnose, repair, and replace engine ancillary components, such as electrical starters and alternators. Repairs include soldering connections, replacing wires, and exchanging individual components of electrical circuits and circuit boards; repairing or replacing malfunctioning electrical motors, electrical modules, and other electrical components; and repairing or replacing faulty engine mechanical parts on engineer equipment.

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Appendix E
Power Systems Equipment

ELECTRICAL POWER

E-1. Electrical power is an essential element of military operations. Without it, many crucial systems are unable to operate. C2 functions are highly reliant on dependable electrical power. Administrative, health service, and logistical support operations are jeopardized without it. Also, many weapons systems are dependent on electrical power for operation. The proliferation of automated data processing equipment that supports modern warfare further contributes to the deployed force dependency on electricity. This growing dependence on electricity causes an increased requirement for the quantity and quality of power for support operations. The indispensable nature of electrical power compels commanders and planners to recognize their electrical-power needs and to ensure that those needs are met.

TACTICAL ELECTRIC POWER

E-2. Tactical electric power is generated by mobile electrical power sources dedicated to supporting the missions of units engaged in combat operations. To reduce logistics support, DOD created a DOD Standard Family of Mobile Electric Power Sources for use by all Services. The listing of sources and technical characteristics of this family are provided in MIL-STD-633G. These standard military generators are highly mobile, produce user voltages (120 volt, 208 volt, or 240 volt), and do not require the use of transformers. They have an output capacity that ranges from 0.2 to 200 kilowatts. These generators are in the unit table of organization and equipment and are referred to as tactical generators. Distribution systems for tactical power are usually very simple. Also, these generators often consist of standard components, such as field wiring or the Army PDISE. The installation, operation, and maintenance of tactical generators and distribution equipment are the responsibility of the using unit.

SOLDIER POWER SETS

E-3. Soldier power sources are portable and provide power up to 3 kilowatts. The current power sources are the 2-kilowatt tactical generator (see figure E-1). It is portable, skid-mounted, jet propulsion 8-fueled, alternating current (60 hertz), and direct current (28 volts direct current). The 3-kilowatt tactical quiet generator (see figure E-2, page E-2) is skid mounted and diesel-fueled (60 hertz and 400 hertz).

Figure E-1. 2-kilowatt tactical generator

Figure E-2. 3-kilowatt tactical quiet generator

Advanced Medium Mobile Power Source

E-4. The workhorse of the tactical power sources is the advanced medium mobile power source (AMMPS) (see figure E-3). AMMPS represents the third generation of DOD standard family of mobile electric power sources in the 5- to 60-kilowatt power range. AMMPS replaces the mobile electric power tactical quiet generator series. AMMPS provides operational improvements that decrease the logistics footprint. The current family of AMMPS consists of 10 skid-mounted models that are 5 kilowatt, 10 kilowatt, 15 kilowatt, 30 kilowatt, or 60 kilowatt and are in 50- or 60-hertz and 400-hertz frequencies.

Note: Medium refers to the power output capacity and not voltage.

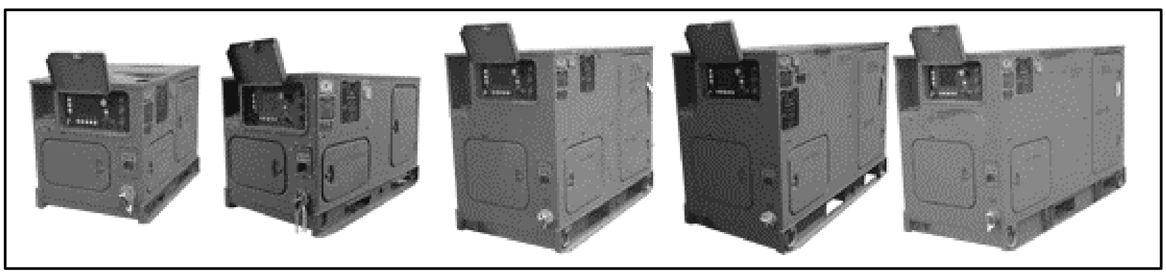


Figure E-3. AMMPS

Power Units and Power Plants LTT and M200

E-5. AMMPS can be configured as trailer-mounted power units and power plants. Power units consist of a single generator set mounted on a trailer. Power plants consist of two generator sets mounted on a single trailer or on two trailers, with a switch box to provide redundant power. The power units and power plants are mounted on military standard trailers matched to their required prime movers. High-mobility, multiple-wheel vehicle configurations use the light tactical trailer, whereas larger vehicles, such as the family of medium tactical vehicles, use the M200, M1061A1, or M353 trailers. The power unit and power plant configurations are described in MIL-STD-633G. Figure E-4 depicts the current AMMPS power systems.

Figure E-4. AMMPS power systems

Large Mobile Power Sources

E-6. Large power sources are 100-kilowatt and 200-kilowatt tactical quiet generators. The 100- to 200-kilowatt generators are modernized, technologically advanced, tactical, diesel-fueled, lightweight, reliable, rugged power-generating systems. The 100- to 200-kilowatt tactical quiet generators are in skid-mounted and power unit configurations. See figure E-5.

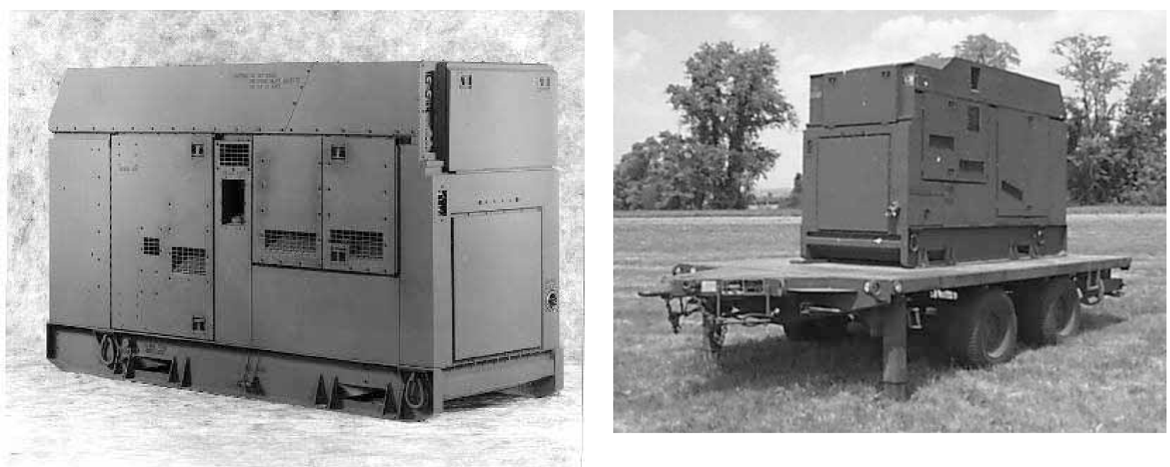


Figure E-5. Large power sources

Tactical Power Distribution

E-7. Tactical power distribution is accomplished through the PDISE system in the Army and the MEPDIS-R system in the Marine Corps. The PDISE and MEPDIS-R provide a portable, reliable, modular, quick- assembly, standardized electrical distribution system. This system allows individuals to connect generators to multiple loads and construct microgrids. The systems are designed to work with any of the DOD standard family of mobile electric power sources that are 5 kilowatts and above. See figure E-6, page E-4, for additional information.

Figure E-6. Tactical power distribution systems

PRIME POWER

E-8. Military prime power is produced by the MEP-810 prime PU. See figure E-7. The prime power plants produce medium-voltage (4,160 volts) and must have a distribution system with transformers to reduce the voltage to user voltages (120 volt, 208, volt or 240 volt). The single sets may be deployed in multiple-unit power plant configurations for increased output capacities. Prime power generators require special site preparation for installation.

Figure E-7. MEP-810

E-9. Prime power MEP-810 generator sets are in the medium-voltage range and require the use of switchgear-transformer- and medium-voltage-rated cabling for operation. Prime power generation systems may be employed as a stand-alone power source (isolated load) or in parallel with a commercial power source (load-sharing or peak-shaving modes). The use of prime power requires the construction of distribution networks to deliver power to the users. The installation, operation, maintenance, and repair of prime power assets are the responsibility of the engineer prime power units.

PRIME POWER DISTRIBUTION

E-10. The primary switch center (see figure E-8) features load-interrupter switches for switching 600-ampere main feeders and microprocessor-controlled, resettable, vacuum fault interrupters for switching and protecting of 600-ampere main feeders. These elbow-connected components are enclosed in a sulfur hexafluoride-insulated, welded steel tank. The three-position (closed-open-grounded) load-interrupter switches are manually operated and provide three-pole live switching of 600-ampere three-phase circuits. These circuits also provide a visible gap when open and internal grounding for all three phases. The 600-ampere fault interrupters feature resettable vacuum interrupters in series with manually operated three-position (closed-open-grounded) disconnects for isolation and internal grounding of each phase.

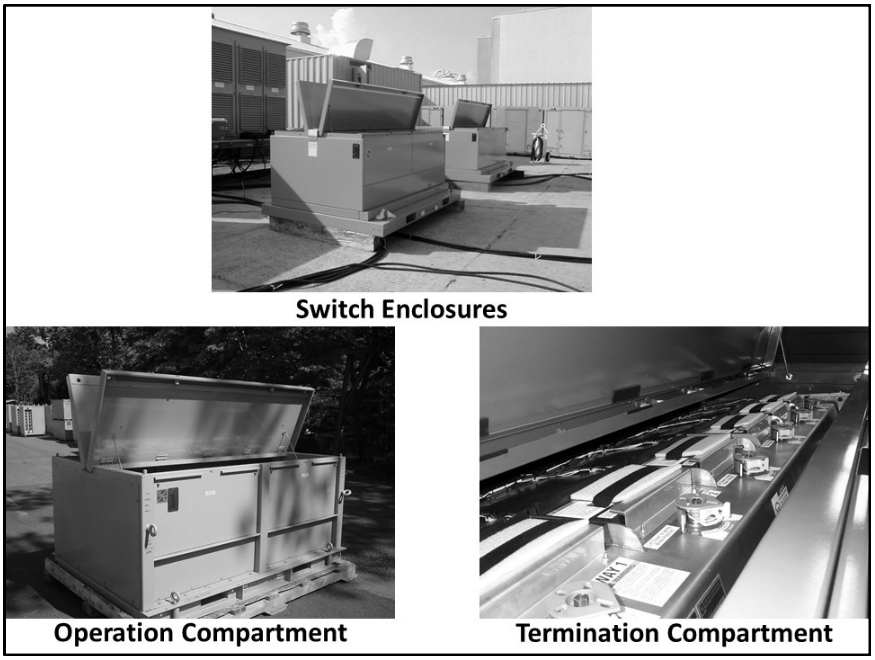


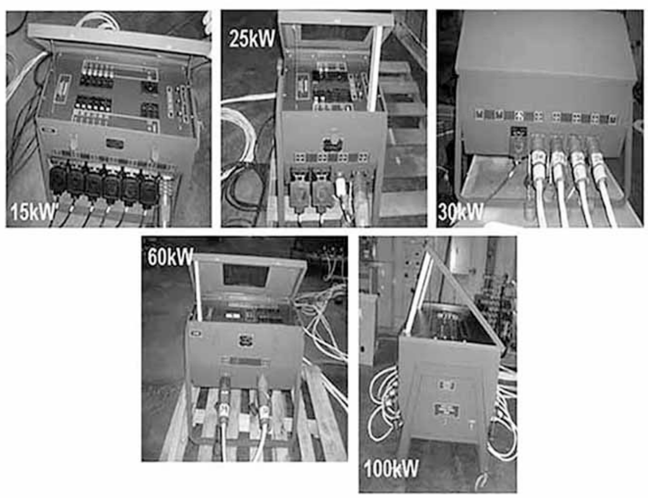
Figure E-8. Primary switch center

E-11. The SDC features a 150 kilovolt-ampere three-phase 2,400/4,160 VAC primary 120/208 VAC secondary utility transformer and a low-voltage secondary distribution panel. The SDC has 16 secondary outputs, 60 amperes each (see figure E-9, page E-6), which are fed by 100-ampere, 208-VAC output circuit breakers (16 each). The primary power terminals are configured for a loop through a double-feed configuration. The high-voltage power is connected using 200-ampere load break quick disconnects to a common high-voltage bus. The high-voltage bus is designed to accept one input and two outputs and is equipped with three sets of high-voltage disconnects. Two sets of disconnects are used to provide flow-through capability. The third set consists of fused disconnects and provides overcurrent protection to the high-voltage side of the transformer. The low-voltage power distribution portion of the SDC provides a 120/208-VAC, 60-hertz, three-phase, wye-connected 5-wire with ground power from a three-phase 800-ampere distribution panel.

Note: The SDCs are available with the commercial connector and the Class L connectors.

Figure E-9. Secondary distribution center

E-12. The power distribution panel receives power from SDCs and distributes it directly to single and three-phase loads. There are five types of power distribution panels: 15 kilowatt, 25 kilowatt, 30 kilowatt, 60 kilowatt, and 100 kilowatt. See figure E-10. Each power distribution panel receives 120/208 volt, 3-phase, 60-hertz, wye-connected 4-wire with ground power through a Class L (MIL-DTL-22992) connector and distributes to three-phase Class L outputs, single-phase military standard outputs, and single-phase National Electrical Manufacturers Association L5–20R outputs. All outputs are circuit-breaker protected.



Legend:

kW kilowatt

Figure E-10. Power distribution panels

E-13. The ruggedized Army transformer (see figure E-11) is a dry type of transformer capable of producing 1 megavolt-amperes at 4,160 VAC Delta primary 480/277 VAC wye secondary and 800 kilovolt-ampere at 3,800 VAC Delta primary 380/219 VAC wye secondary. It has one 200-ampere fused input utilizing load break elbow connectors. It has one output, which utilizes bolt-on connectors. The transformer can be used to supply any point load requiring 480/277 VAC, 60 hertz or 380/219 VAC, 50 hertz. Input connections can be made from one of several sources. It can be connected to a MEB-PU-810A or a MEB-PU-810B or any other generator producing 4,160 VAC, 60 hertz or 3800 VAC, 50 hertz. Also, the ruggedized Army transformer can be connected through one of the fault interrupter switches (Ways 3, 4, 5, and 6) on a primary switching center that is connected to a 4,160 VAC, 60 hertz- or 3800 VAC, 50 hertz-producing generator.

Figure E-11. Ruggedized Army transformer

E-14. The remote area lighting system (RALS) (see figure E-12) provides a flexible solution to support illumination requirements. The RALS features 13 telescoping poles, 12 of which are positional through the use of the left-side and right-side cable loop assemblies emanating from the RALS container. The 13th pole is mounted on the RALS container and is not positional. Each RALS pole uses a single 150-watt, 16,000-lumen, high-pressure sodium lamp. The lamps have a 24,000-hour lamp life that offers high reliability and durability; they can remain in the light fixture during storage and transport, resulting in less handling and faster deployment. A tempered-glass lens in the fixture protects the lamp from debris, and the lamps have a start temperature of -40 degrees Fahrenheit. The poles are aluminum, with manual telescoping and locking collars. All RALS components are stored in the RALS container for storage and transport. Each cable loop assembly is composed of two RALS loop cord sections of 375 feet each, providing a 750-foot lighting string in each direction, for a total of 1,500 feet. The cords connect the poles in parallel. A pole is positioned every 125 feet. The base for the pole is a flat plate with outriggers to provide additional stability.

Figure E-12. RALS

ALTERNATE POWER SOURCES

E-15. Alternate power sources harvest energy from the environment, convert it to an electrical output for immediate use, or store it in a rechargeable battery system for later use. A common example is solar-photovoltaic panels connected to a storage battery system through a controller. Matched with generator sets, an alternative energy source enables users to reduce fuel needs for power generation. Planners should consider leveraging renewable energy-based power sources (such as solar, waste-to-energy, and wind) once circumstances make these options viable for improving sustainability. Proper employment of energy alternatives requires foresight during planning. Plans should consider regional solar insolation, wind patterns, and terrain features (such as mountains, vegetation, and buildings). Creating an allowance for these features during the planning process is important because these features can block, attenuate, or interfere with available solar and wind resources. Also, allocating enough space for renewable energy systems is another essential consideration for employment.

E-16. Hybrid power systems can combine multiple power sources with energy storage and the necessary controls. An example is a generator set combined with a battery system. During periods of low demand, the battery can supply power to the load. The system automatically starts the generator when the load has discharged the battery to a certain threshold. A hybrid source key benefit is reducing the fuel needed for power production compared to continuously operating a generator at low loads. A critical planning factor is the load center mission profile. Constant loads close to the power system capacity do not benefit from a hybrid source. Also, it is necessary to consider maintenance tasks, environmental limitations, and safety factors for the batteries in the energy storage system. Figure E-13 depicts an alternative power source set up.

Figure E-13. Alternative power sources

PREDESIGNED BASE CAMP

E-17. Air Force BEAR unit codes are aggregated into sets or packages that provide environmental control unit capabilities. Sets may be further broken down into subunit codes or involve less than full-set deployments. BEAR base equipment allowance standards are found in Air Force system 157 (BEAR); Air Force system 158 (Harvest Falcon); Air Force system 159 (Harvest Eagle); and Air Force system 429, Part N, for training assets. For a more detailed description of the set contents, refer to AFH 10-222, Volume 2.

COMMERCIAL AND HOST NATION POWER

E-18. Utility and host nation power generation systems are fixed, nonstandard systems. Their output capacity may vary from a few megawatts to several thousand megawatts. Commercial power may be used as an option, but it may not be compatible with user-required characteristics or be reliable enough to support military operations. When outside the continental United States, commercial power may exist, but it may be unreliable or unusable due to mission constraints, damage from conflict, or vulnerabilities of terrorism.

E-19. The USACE works closely with the 249th Engineer Battalion to manage power contracts to deliver centralized power plants and distribution grids. Contracting tools that USACE has at its disposal are—

- Base camp power plants.
  - Used in Afghanistan in place of WWP.
  - Used for 45–60 days without funding issues.
- Bridge contracts.
  - Used as a direct link to a specific contractor.
  - Requires written justification.
  - Used for 5–15 days without funding issues.
  - Typically funded without question.

- Direct contracts.
  - Used for procurement or conducting work outside the scope of the existing indefinite-delivery, indefinite-quantity contracts.
  - Used for 60–120 days without funding issues.
- Electrical support services.
  - Used to support individual electrical task orders.
  - Used for 45–60 days without funding issues.
- WWPs.
  - Used to support power plant services.
  - Used for 45–60 days without funding issues.
- Military construction.
  - Used to purchase items.
  - Requires a long lead time (possibly many years).
  - Used for 10–36 months without funding issues.
  - Typically has funding constraints or requirements that can become invalid.

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Appendix F

Worldwide Voltage and Plug Configuration

F-1. Table F-1 depicts the current voltage, hertz, and outlet plug configurations in deployment areas worldwide. Figure F-1, pages F-8 and F-9, depicts plug configurations and compatibilities.

Table F-1. Worldwide voltages

Country/State/Territory	*Single-Phase Voltage*	*Frequency*	*Plug and Outlet Type (See Figure F-1)*
Abu Dhabi	230 V	50 Hz	G
Afghanistan	220 V	50 Hz	C/F
Albania	230 V	50 Hz	C/F
Algeria	230 V	50 Hz	C/F
American Samoa	120 V	60 Hz	A/B/F/I
Andorra	230 V	50 Hz	C/F
Angola	220 V	50 Hz	C
Anguilla	110 V	60 Hz	A B
Antigua and Barbuda	230 V	60 Hz	A/B
Argentina	220 V	50 Hz	I
Armenia	230 V	50 Hz	C/F
Aruba	120 V	60 Hz	A/B/F
Australia	230 V	50 Hz	I
Austria	230 V	50 Hz	C/F
Azerbaijan	220 V	50 Hz	C/F
Azores	230 V	50 Hz	B/C/F
Bahamas	120 V	60 Hz	A/B
Bahrain	230 V	50 Hz	G
Balearic Islands	230 V	50 Hz	C/F
Bangladesh	220 V	50 Hz	A/C/D/G/K
Barbados	115 V	50 Hz	A/B
Belarus	220 V	50 Hz	C F
Belgium	230 V	50 Hz	C/E
Belize	110 V/220 V	60 Hz	A/B/G
Benin	220 V	50 Hz	C/E
Bermuda	120 V	60 Hz	A/B
Bhutan	230 V	50 Hz	C/D/G
Bolivia	230 V	50 Hz	A/C
Bonaire	127 V	50 Hz	A/C
Bosnia and Herzegovina	230 V	50 Hz	C/F
Botswana	230 V	50 Hz	D/G

Table F-1. Worldwide voltages (continued)

Country/State/Territory	*Single-Phase Voltage*	*Frequency*	*Plug and Outlet Type (See Figure F-1)*
Brazil	127 V/220 V	60 Hz	C N
British Virgin Islands	110 V	60 Hz	A/B
Brunei	240 V	50 Hz	G
Bulgaria	230 V	50 Hz	C/F
Burkina Faso	220 V	50 Hz	C/E
Burma (officially Myanmar)	230 V	50 Hz	A/C/D/G/I
Burundi	220 V	50 Hz	C/E
Cambodia	230 V	50 Hz	A/C/G
Cameroon	220 V	50 Hz	C E
Canada	120 V	60 Hz	A/B
Canary Islands	230 V	50 Hz	C/E/F
Cape Verde	230 V	50 Hz	C/F
Cayman Islands	120 V	60 Hz	A/B
Central African Republic	220 V	50 Hz	C/E
Chad	220 V	50 Hz	C/D/E/F
Channel Islands (Guernsey and Jersey)	230 V	50 Hz	C/G
Chile	220 V	50 Hz	C/L
China, People's Republic of	220 V	50 Hz	A/C/I
Christmas Island	230 V	50 Hz	I
Cocos (Keeling) Islands	230 V	50 Hz	I
Colombia	110 V	60 Hz	A/B
Comoros	220 V	50 Hz	C/E
Congo, Democratic Republic of	220 V	50 Hz	C/D/E
Congo, People's Republic of	230 V	50 Hz	C/E
Cook Islands	240 V	50 Hz	I
Costa Rica	120 V	60 Hz	A/B
Côte d'Ivoire (Ivory Coast)	220 V	50 Hz	C/E
Croatia	230 V	50 Hz	C F
Cuba	110 V/220 V	60 Hz	A/B/C/L
Curacao	127 V	50 Hz	A/B
Cyprus	230 V	50 Hz	G
Cyprus, North (unrecognized, self-declared state)	230 V	50 Hz	G
Czech Republic	230 V	50 Hz	C/E
Denmark	230 V	50 Hz	C/E/F/K
Djibouti	220 V	50 Hz	C/E
Dominica	230 V	50 Hz	D/G
Dominican Republic	120 V	60 Hz	A/B/C
Dubai	230 V	50 Hz	G
East Timor (Timor-Leste)	220 V	50 Hz	C/E/F/I

Table F-1. Worldwide voltages (continued)

Country/State/Territory	*Single-Phase Voltage*	*Frequency*	*Plug and Outlet Type (See Figure F-1)*
Ecuador	120 V	60 Hz	A/B
Egypt	220 V	50 Hz	C/F
El Salvador	120 V	60 Hz	A/B
England	230 V	50 Hz	G
Equatorial Guinea	220 V	50 Hz	C/E
Eritrea	230 V	50 Hz	C/L
Estonia	230 V	50 Hz	C/F
Ethiopia	220 V	50 Hz	C/F
Faeroe Islands	230 V	50 Hz	C/E/F/K
Falkland Islands	240 V	50 Hz	G
Fiji	240 V	50 Hz	I
Finland	230 V	50 Hz	C/F
France	230 V	50 Hz	C/E
French Guiana	220 V	50 Hz	C/D/E
Gabon (Gabonese Republic)	220 V	50 Hz	C
Gambia	230 V	50 Hz	G
Gaza Strip (Gaza)	230 V	50 Hz	C/H
Georgia	220 V	50 Hz	C/F
Germany	230 V	50 Hz	C/F
Ghana	230 V	50 Hz	D/G
Gibraltar	230 V	50 Hz	G
Great Britain	230 V	50 Hz	G
Greece	230 V	50 Hz	C/F
Greenland	230 V	50 Hz	C/E/F/K
Grenada	230 V	50 Hz	G
Guadeloupe	230 V	50 Hz	C/E
Guam	110 V	60 Hz	A/B
Guatemala	120 V	60 Hz	A/B
Guinea	220 V	50 Hz	C/F/K
Guinea-Bissau	220 V	50 Hz	C
Guyana	120 V/240 V	60 Hz	A/B/D/G
Haiti	110 V	60 Hz	A/B
Holland (officially the Netherlands)	230 V	50 Hz	C/F
Honduras	120 V	60 Hz	A/B
Hong Kong	220 V	50 Hz	G
Hungary	230 V	50 Hz	C F
Iceland	230 V	50 Hz	C/F
India	230 V	50 Hz	C/D/M
Indonesia	230 V	50 Hz	C/F
Iran	230 V	50 Hz	C/F
Iraq	230 V	50 Hz	C/D/G
Ireland	230 V	50 Hz	G
Isle of Man	230 V	50 Hz	C/G

Table F-1. Worldwide voltages (continued)

Country/State/Territory	*Single-Phase Voltage*	*Frequency*	*Plug and Outlet Type (See Figure F-1)*
Israel	230 V	50 Hz	C/H
Italy	230 V	50 Hz	C/F/L
Jamaica	110 V	50 Hz	A/B
Japan	100 V	50 Hz/60 Hz	A/B
Jordan	230 V	50 Hz	C/D/F/G/J
Kazakhstan	220 V	50 Hz	C/F
Kenya	240 V	50 Hz	G
Kiribati	240 V	50 Hz	I
Korea, North	220 V	50 Hz	C
Korea, South	220 V	60 Hz	F
Kosovo	230 V	50 Hz	C/F
Kuwait	240 V	50 Hz	G
Kyrgyzstan	220 V	50 Hz	C/F
Laos	230 V	50 Hz	A/B/C/E/F
Latvia	230 V	50 Hz	C/F
Lebanon	230 V	50 Hz	C/D/G
Lesotho	220 V	50 Hz	M
Liberia	120 V	60 Hz	A/B
Libya	230 V	50 Hz	C/L
Liechtenstein	230 V	50 Hz	C/J
Lithuania	230 V	50 Hz	C/F
Luxembourg	230 V	50 Hz	C/F
Macau	220 V	50 Hz	G
Macedonia, Republic of (the former Yugoslav Republic of Macedonia)	230 V	50 Hz	C/F
Madagascar	220 V	50 Hz	C/E
Madeira	230 V	50 Hz	C/F
Malawi	230 V	50 Hz	G
Malaysia	240 V	50 Hz	G
Maldives	230 V	50 Hz	C/D/G/J/K/L
Mali	220 V	50 Hz	C/E
Malta	230 V	50 Hz	G
Marshall Islands	120 V	60 Hz	A/B
Martinique	220 V	50 Hz	C/D/E
Mauritania	220 V	50 Hz	C
Mauritius	230 V	50 Hz	C/G
Mayotte	230 V	50 Hz	C/E
Mexico	120 V	60 Hz	A/B
Micronesia, Federated States of	120 V	60 Hz	A/B
Moldova	230 V	50 Hz	C/F
Monaco	230 V	50 Hz	C/E/F
Mongolia	230 V	50 Hz	C/E
Montenegro	230 V	50 Hz	C/F

Table F-1. Worldwide voltages (continued)

Country/State/Territory	*Single-Phase Voltage*	*Frequency*	*Plug and Outlet Type (See Figure F-1)*
Montserrat	230 V	60 Hz	A/B
Morocco	220 V	50 Hz	C/E
Mozambique	220 V	50 Hz	C/F/M
Myanmar (formerly Burma)	230 V	50 Hz	A/C/D/G/I
Namibia	220 V	50 Hz	D/M
Nauru	240 V	50 Hz	I
Nepal	230 V	50 Hz	C/D/M
Netherlands	230 V	50 Hz	C/F
New Caledonia	220 V	50 Hz	C/F
New Zealand	230 V	50 Hz	I
Nicaragua	120 V	60 Hz	A/B
Niger	220 V	50 Hz	C/D/E/F
Nigeria	230 V	50 Hz	D/G
Niue	230 V	50 Hz	I
Norfolk Island	230 V	50 Hz	I
North Cyprus (unrecognized, self-declared state)	230 V	50 Hz	G
Northern Ireland	230 V	50 Hz	G
Norway	230 V	50 Hz	C/F
Oman	240 V	50 Hz	G
Pakistan	230 V	50 Hz	C/D
Palau	120 V	60 Hz	A/B
Palestine	230 V	50 Hz	C/H
Panama	120 V	60 Hz	A/B
Papua New Guinea	240 V	50 Hz	I
Paraguay	220 V	50 Hz	C
Peru	220 V	60 Hz	A/C
Philippines	220 V	60 Hz	A/B/C
Pitcairn Islands	230 V	50 Hz	I
Poland	230 V	50 Hz	C/E
Portugal	230 V	50 Hz	C/F
Puerto Rico	120 V	60 Hz	A/B
Qatar	240 V	50 Hz	G
Réunion	230 V	50 Hz	C/E
Romania	230 V	50 Hz	C/F
Russia (officially the Russian Federation)	220 V	50 Hz	C/F
Rwanda	230 V	50 Hz	C/J
Saba	110 V	60 Hz	A/B
Saint Barthélemy (informally also referred to as Saint Barth's or Saint Barts)	230 V	60 Hz	C/E

Table F-1. Worldwide voltages (continued)

Country/State/Territory	*Single-Phase Voltage*	*Frequency*	*Plug and Outlet Type (See Figure F-1)*
Saint Kitts and Nevis (officially the Federation of Saint Christopher and Nevis)	230 V	60 Hz	D/G
Saint Lucia	230 V	50 Hz	G
Saint Martin	220 V	60 Hz	C/E
Saint Helena	230 V	50 Hz	G
Saint Vincent and the Grenadines	110 V/230 V	50 Hz	A/B/G
Samoa	230 V	50 Hz	I
San Marino	230 V	50 Hz	C/F/L
São Tomé and Príncipe	230 V	50 Hz	C/F
Saudi Arabia	230 V	60 Hz	G
Scotland	230 V	50 Hz	G
Senegal	230 V	50 Hz	C/D/E/K
Serbia	230 V	50 Hz	C/F
Seychelles	240 V	50 Hz	G
Sierra Leone	230 V	50 Hz	D/G
Singapore	230 V	50 Hz	G
Sint Eustatius	110 V/220 V	60 Hz	A/B/C/F
Sint Maarten	110 V	60 Hz	A/B
Slovakia	230 V	50 Hz	C/E
Slovenia	230 V	50 Hz	C/F
Solomon Islands	230 V	50 Hz	G/I
Somalia	220 V	50 Hz	C
Somaliland	220 V	50 Hz	C
South Africa	230 V	50 Hz	C/M N
South Sudan	230 V	50 Hz	C/D
Spain	230 V	50 Hz	C/F
Sri Lanka	230 V	50 Hz	D/G
Sudan	230 V	50 Hz	C/D
Suriname	127 V/230 V	60 Hz	A/B/C/F
Swaziland	230 V	50 Hz	M
Sweden	230 V	50 Hz	C/F
Switzerland	230 V	50 Hz	C/J
Syria	220 V	50 Hz	C/E/L
Tahiti	220 V	50 Hz/60 Hz	C/E
Taiwan	110 V	60 Hz	A/B
Tajikistan	220 V	50 Hz	C/F
Tanzania	230 V	50 Hz	D/G
Thailand	230 V	50 Hz	A/B/C/O
Togo	220 V	50 Hz	C
Tokelau	230 V	50 Hz	I
Tonga	240 V	50 Hz	I
Trinidad and Tobago	115 V	60 Hz	A/B

Table F-1. Worldwide voltages (continued)

Country/State/Territory	*Single-Phase Voltage*	*Frequency*	*Plug and Outlet Type (See Figure F-1)*
Tunisia	230 V	50 Hz	C/E
Turkey	230 V	50 Hz	C/F
Turkmenistan	220 V	50 Hz	C/F
Turks and Caicos Islands	120 V	60 Hz	A/B
Tuvalu	230 V	50 Hz	I
Uganda	240 V	50 Hz	G
Ukraine	230 V	50 Hz	C/F
United Arab Emirates	230 V	50 Hz	G
United Kingdom	230 V	50 Hz	G
United States of America	120 V	60 Hz	A/B
United States Virgin Islands	110 V	60 Hz	A/B
Uruguay	220 V	50 Hz	C/F/L
Uzbekistan	220 V	50 Hz	C/F
Vanuatu	230 V	50 Hz	I
Vatican City	230 V	50 Hz	C/F/L
Venezuela	120 V	60 Hz	A/B
Vietnam	220 V	50 Hz	A/B/C
Virgin Islands (British)	110 V	60 Hz	A/B
Virgin Islands (United States of America)	110 V	60 Hz	A/B
Wales	230 V	50 Hz	G
Yemen	230 V	50 Hz	A/D/G
Zambia	230 V	50 Hz	C/D/G
Zimbabwe	240 V	50 Hz	D/G

Legend:

Hz hertz

V volt

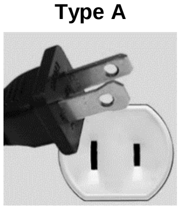
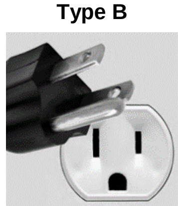
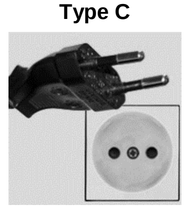
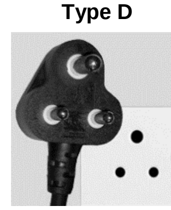
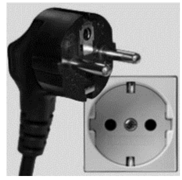
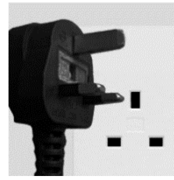
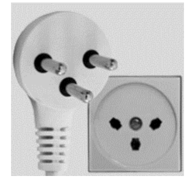
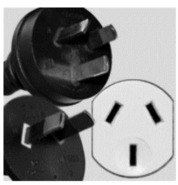
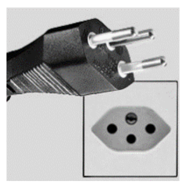
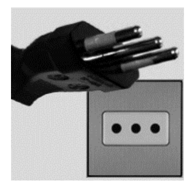
Type A	**Type B**	**Type C**	**Type D**
			
Mainly used in the United States, Canada, Mexico, and Japan 2 pins Not grounded 15 amperes Almost always 100 to 127 volts	Mainly used in the United States, Canada, Mexico, and Japan 3 pins Grounded 15 amperes Almost always 100 to 127 volts Socket also compatible with plug type A	Commonly used in Europe, South America, and Asia 2 pins Not grounded 2.5 amperes Almost always 220 to 240 volts	Mainly used in India 3 pins Grounded 5 amperes 220 to 240 volts Socket also compatible with plug type C Socket unsafe with plug types E and F

Figure F-1. Worldwide outlets and plugs

Type E	Type F	Type G	Type H
 Primarily used in France, Belgium, Poland, Slovakia, and the Czech Republic 2 pins Grounded 16 amperes 220 to 240 volts Socket also compatible with plug types C and F	 Used almost everywhere in Europe and Russia, except for the United Kingdom and Ireland 2 pins Grounded 16 amperes 220 to 240 volts Socket also compatible with plug types C and E	 Mainly used in the United Kingdom, Ireland, Malta, Malaysia, and Singapore 3 pins Grounded 13 amperes 220 to 240 volts	 Used exclusively in Israel, the West Bank, and the Gaza Strip 3 pins Grounded 16 amperes 220 to 240 volts Socket also compatible with plug type C Socket unsafe with plug E and F
Type I	**Type J**	**Type K**	**Type L**
 Mainly used in Australia, New Zealand, China, and Argentina 2 or 3 pins 2 pins: not grounded or 3 pins: grounded 10 amperes 220 to 240 volts	 Used almost exclusively in Switzerland, Liechtenstein, and Rwanda 3 pins Grounded 10 amperes 220 to 240 volts Socket compatible with plug type C	 Used almost exclusively in Denmark and Greenland 3 pins Grounded 16 amperes 220 to 240 volts Socket compatible with plug types C and K Socket unsafe with plug types E and F	 Used almost exclusively in Italy and Chile 3 pins Grounded 10 amperes and 16 amperes 220 to 240 volts 10 A socket compatible with plug types C and L (10 A version) or 16 A socket compatible with plug type L (16 A version)

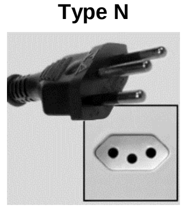
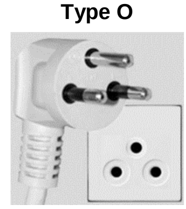
Type M	Type N	Type O
 Mainly used in South Africa 3 pins Grounded 15 amperes 220 to 240 volts	 Used almost exclusively in Brazil 3 pins Grounded 10 amps and 20 amperes 100 to 240 volts Socket compatible with plug type C	 Used exclusively in Thailand 3 pins Grounded 16 amperes 220 to 240 volts Socket also compatible with plug type C Socket unsafe with plug types E and F

Figure F-1. Worldwide outlets and plugs (continued)

Glossary

The glossary lists acronyms and terms with Army or joint definitions. Where Army and joint definitions differ, (Army) precedes the definition. Terms for which ATP 3-37.34/MCTR 3-34C is the proponent are marked with an asterisk (*). The Army proponent publication for other terms is listed in parentheses after the definition. Approved Marine Corps acronyms, terms, and definitions can be found in MCRP 1-10.2, Marine Corps Supplement to the DOD Dictionary of Military and Associated Terms.

SECTION I – ACRONYMS AND ABBREVIATIONS

ADP	Army doctrine publication
ADRP	Army doctrine reference publication
AFH	Air Force handbook
AMMPS	advanced medium mobile power sources
AR	Army regulation
ATP	Army techniques publication
attn	attention
AutoDISE	automated distribution illumination system, electrical
BEAR	base expeditionary airfield resources
BEEF	base engineer emergency force
C2	command and control
CDID	Capabilities Development and Integration Directorate
CJCSI	Chairman of the joint chiefs of staff instruction
CLB	combat logistics battalion
COTR	contracting officer technical representative
DA	Department of the Army
DC	District of Columbia
DOD	Department of Defense
DSCA	defense support of civil authorities
ESB	engineer support battalion
ESF	emergency support function
FM	field manual
GTA	graphic training aid
JP	joint publication
LOGSA	logistics support activity
MAG	Marine aircraft group
MAGTF	Marine air-ground task force
MCO	Marine Corps order

MCRP	Marine Corps reference publication
MCTP	Marine Corps technical publication
MEB	Marine expeditionary brigade
MEP	mobile electric power
MEPDIS-R	mobile electric power distrbution-replacement
MIL-STD	military standard
MO	Missouri
MOS	military occupational specialty
MSCoE	Maneuver Support Center of Excellence
MUSE	mobile utitlties support equipment
MWSS	Marine wing support squadron
PDISE	power distribution illumination systems, electrical
PIN	publication identification number
RALS	remote area lighting system
RCT	regimental combat team
RED HORSE	rapid engineer deployable heavy operational repair squadron engineer
SDC	secondary distribution center
Seabee	Navy construction engineer
TM	technical manual
UFC	Unified Facilities Criteria
U.S.	United States
USA	United States Army
USC	United States Code
USACE	United States Army Corps of Engineers
USAMC	United States Army Materiel Command
USMC	United States Marine Corps
VA	Virginia
VAC	volt alternating current
WWP	worldwide power

SECTION II – TERMS

None.

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ATP 3-34.45
6 July 2018

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