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Jim Ayers, task leader
David Eisler
Jessica Huckabey
Frank Mullen
Scott Schutzmeister

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For More Information

James R. Ayers, Project Leader
jayers@ida.org, 703-845-6721

Dan Y. Chiu, Director, Joint Advanced Warfighting Division
dchiu@ida.org, 703-845-2439

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Executive Summary

Electrical power is an essential component of US Army operations. From forces executing missions on foreign battlefields to units training on domestic installations, assured electrical power is an essential enabler. The Army's ability to efficiently and effectively provide electrical power on the battlefield to brigade-level units and below—where gaps in power supply and demand are most likely—is the focus of this research. Specifically, the US Army Project Manager for Expeditionary Energy and Sustainment Systems (PM E2S2), the Service proponent for electrical power generation and distribution materiel solutions, is concerned that the Army will be unable to reap the benefits of technological advancements in power generation and distribution systems without commensurate changes in the Army's approach to power management. The sponsor asked IDA to review the Army's current approach to power management, with an emphasis on doctrine, organizational structure, and training, to assess how well the non-materiel elements will support the integration of advanced power systems into Army formations at the brigade level and below.

To understand the Army's current approach to power management, we reviewed published Army doctrine and interviewed stakeholders in the power management community, specifically the Combined Arms Support Command (CASCOM), the functional proponent for operational energy, sustainment doctrine, and tactical electric power, and the Maneuver Support Center of Excellence (MSCoE), the functional proponent for general engineering, operational energy, water, and waste efficiencies, prime power distribution, and semi-permanent mobile electric power. We then reviewed official joint requirements documents to determine if any capability gaps had already been identified. We also reviewed current initiatives for improving power management at the brigade level and below, which included draft documents awaiting final approval. Finally, we aligned our research approach with the Army Capabilities Integration Center (ARCIC) Capability Needs Analysis (CNA) framework in order to compare the Army's current approach to power management with the capabilities needed to operate in the future strategic environment.

Our scope was limited to Brigade Combat Teams conducting expeditionary operations in austere environments, where local infrastructure is either non-existent or unreliable. We confined our analysis to electrical systems found within the Brigade Combat Team (BCT) Table of Organization and Equipment, known as *tactical electric power* systems. Measured in kilowatts (kW), tactical electric power falls above *soldier power* (less than 0.5 kW) and below *prime power* (more than 200 kW). Although the majority of our analysis focused on static locations, we also considered the implications for power management of mobile command posts.

Findings

Our review of the Army's current approach to power management found that **power management tasks and responsibilities are split between the engineer, sustainment, and operational communities, with no single organization empowered to orchestrate changes to doctrine, organization, training, and other non-materiel elements**. While MSCoE is the functional proponent for mobile electric power, CASCOM is responsible for operational energy training and sustainment doctrine. CASCOM is also the proponent for the military occupational specialty (MOS) 91D Tactical Power Generation Specialist, the career field responsible for operations and maintenance of tactical generators. The military MOS with more extensive training in power generation and distribution, the 12P Prime Power Production Specialist, falls under MSCoE.

The same split exists at the operational level—during expeditionary operations, engineers are responsible for power management functions at echelons above brigade, including base camp construction and prime power integration. However, at the tactical level, once units move beyond the base camp into the realm of command posts and other fixed sites with smaller footprints, the responsibility for performing power management functions shifts to the sustainment community as well as the units' designated generator operators. At this level, the focus is on configuring tactical power grids, system repair, and materiel sustainment.

After reviewing documents published through the Joint Capabilities Integration and Development System (JCIDS) and the database of capability gaps maintained by ARCIC, we determined that **the Army has captured aspects of power management capability gaps, but opportunities remain to more fully define these gaps at the brigade-level and below through the DOTmLPF-P (Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, Facilities, Policy) change request (DCR) process.** Although the JCIDS documents for operational energy and contingency basing did identify 22 capability gaps, they are focused on institutional awareness, operational energy best practices, base camp sustainment, energy storage, and minimizing logistics challenges by reducing fuel demand. The ARCIC database contains three relevant capability gaps, but they describe the physical and materiel requirements of BCT vehicle platforms and do not address the non-materiel elements of power management.

Despite the absence of formal power management DCRs, the Army's functional proponents for Operational Energy (OE), CASCOM and MSCoE, have taken action to address shortfalls in the Army's current approach. Each organization is leading efforts to improve Army power management capability, focused on updating doctrine, improving training support packages, and revising roles and responsibilities at the BCT-level and below. A major component of these efforts is the concept of a battalion Unit Power Manager and a brigade OE Advisor. These roles, conceived as additional duties rather than independent positions, are designed to bridge the gap between power management planning and execution.

However, these efforts have left several critical issues unresolved. First, which MOS should serve as the Unit Power Manager? Should the function be assigned only to 91Ds—the MOS with the most knowledge and training in tactical power systems organic to the BCT—or can any MOS perform the tasks effectively? Second, what are the Unit Power Manager's roles and responsibilities? Specifically, is the Unit Power Manager responsible for power planning, execution, or both? Third, how do the Unit Power Manager and OE Advisor fit into the battalion and brigade staff structure?

Finally, our assessment of the Army's approach to power management using ARCIC's CNA framework revealed that **the need for power management is greatest beyond the base camp at brigade- and battalion-sized command posts**—the proliferation of networked systems and increased command post size are driving the need to employ fewer generators more efficiently or risk an unnecessarily heavy footprint and inflated demand for liquid fuel.

Recommendations

After comparing the results of our literature review, stakeholder interviews, and the future implications for power management based on the CNA framework, we determined that the Army could take several steps in order to address changes in doctrine, training, and organizational structure. These steps are:

- **Step A:** Designate either CASCOM or MSCoE as the proponent for power management at the brigade/battalion level
- **Step B:** Clarify the roles and responsibilities of the battalion Unit Power Manager and Brigade OE Advisor
- **Step C:** Determine whether only 91D-qualified soldiers can serve as battalion Unit Power Managers, or if the duties are MOS-immaterial

For Steps A and B, we recommend that the Army Training and Doctrine Command (TRADOC), as the lead for capability development, determine if power management is best assigned as a sustainment function or an engineer function and designate either MSCoE or CASCOM as the proponent for power management at the BCT-level and below. This designated proponent should then:

- Update the Army Universal Task List with power management doctrine and promote additional non-materiel capability integration and synchronization through ARCIC
- Define the Unit Power Manager's role within the battalion staff
- Determine and codify which elements of power management (planning versus execution) fall under the Unit Power Manager's responsibility

- Define the OE Advisor's responsibilities and organizational relationship to the battalion Unit Power Managers

For Step C, we offer pros and cons for both options (shown in Table ES-1), and that either choice would require DOTmLPF-P actions to address the drawbacks. Further, this choice hinges on how the proponent designated in Step A defines the Unit Power Manager's roles and responsibilities in Step B. Table ES-2 maps our recommended DOTmLPF-P actions to this choice.

Table ES-1. Summary of Pros and Cons for Unit Power Manager Source Options

	91D as Battalion UPM	MOS-Immaterial as Battalion UPM
Pros	• Already has baseline knowledge of power generation and distribution systems • Ordnance School initiatives are currently incorporating power management tasks into the 91D roles and responsibilities	• More flexibility for commander to choose UPM; not reliant on low density 91D MOS to fill position • Easier to align staff power management efforts; e.g., if assigned UPM works in the S3 section, he/she would automatically become part of the planning team for command post operations according to current doctrine
Cons	• Capacity constraint; typical BCT has only ~23 91Ds • Prohibitive task organization; 91Ds are spread across multiple battalions in small teams of two or three • Highest rank is Staff Sergeant/E-6, with only 2 per BCT; E-5 would be the de facto battalion staff representative for power management • UPM duties may take away from 91D principal responsibility as generator mechanics and trainers of generator operators	• No institutional training available beyond self-development (online) • Variance in backgrounds and skills; assigned Soldier not necessarily familiar with power generation and distribution theory, equipment, operations, and so on.

Table ES-2. DOTmLPF-P Actions for Unit Power Manager Source based on Roles and Responsibilities

Designated UPM Roles and Responsibilities	Preferable MOS?	Recommended Actions
Planning Only	Any	• Develop standardized institutional training for UPMs • Define organizational relationships with battalion staff
Execution Only	91D	• Add more power management training to schoolhouse curriculum • Define organizational relationships with battalion staff
Both Planning and Execution	Unclear	**If Any MOS, then proponent should:** • Develop standardized institutional training for UPMs • Define organizational relationships with battalion staff • Leverage 91Ds for tactical power execution **If 91Ds Only, then proponent should:** • Add power management to 91D Critical Task List; add more power management training to schoolhouse curriculum • Consider moving 91Ds into battalion staff sections, or organizing them into single platoon • Conduct Manpower Requirements Criteria (MARC) analysis to account for power management duties • Define organizational relationships with battalion staff

Our research also found that improving the ability to manage power will yield the greatest benefits at command posts. However, we found that command post modernization initiatives are not coordinated with operational energy stakeholders working to improve power management. To address this, **we recommend that the TRADOC Capability Manager for Mission Command/Command Posts attend the Tactical Power Forum and other Operational Energy stakeholder synchronization sessions, and coordinate their Command Post/Contingency Basing strategies with the ongoing power management improvement initiatives.**

Today, power management challenges primarily affect efficiency, not mission effectiveness, and therefore may not reach a high priority for action given competing capabilities and requirements. While doing nothing is rarely an appetizing alternative, resource constraints and other priorities may crowd out the desire for improved power management capability. As the strategic environment changes, though, shortcomings in power management may impact mission effectiveness, particularly at expeditionary command posts which require uninterrupted power to enable maneuver units to conduct mission command. Analyzing power management through the Army Requirements Oversight Council (AROC), as we have recommended, will quantify the magnitude and scope of the power management gap and expand on many of the findings highlighted in our research. And, even without near-term TRADOC intervention to designate a proponent, better synchronization of current non-materiel efforts could help bridge the gap between the planning and execution elements of power management.

As DoD continues to develop and field more advanced tactical electric power generation and distribution systems, the Army has an opportunity to adapt its non-materiel approach to power management, ensuring the effective and efficient supply of electrical power to tactical consumers.

Contents

1. Introduction

A. Background

From World War I to the present day, the US Army has confronted the challenge of delivering energy in the form of fossil fuel to expeditionary outposts and mobile forces across the battlespace. With each passing decade and each leap in technology, the Army's appetite for fuel increased. Most recently, in Afghanistan and Iraq, the Army dedicated substantial resources to deliver fuel to the tactical edge, often at a cost in lives and equipment. The digitally-connected, geographically dispersed forces on today's battlefields convert fuel into the electricity essential to power their command, control, and communications equipment as well as lights, sensors, and environmental control units.

To reduce the burden of supplying liquid fuel to contingency bases and command posts, the Department of Defense (DoD) has incorporated advancements in renewable energy sources into its strategic guidance and policy for operational energy, and the Army has done the same with its 2014 Army Operating Concept.[1] Advancements in electrical power generation and distribution technology present one area of opportunity for ground forces to minimize their fuel-based sustainment burden and reduce the operational risk of supplying isolated outposts. New technologies promise to improve the resiliency of networked grids, intelligently balance load signals and power distribution, and to reduce the demand for liquid fuel during expeditionary operations.

The developers of these new technologies have expressed concerns that the Army's approach to managing its electric power may limit its ability to reap the benefits of these technologies and to fully integrate them into organic units at the Brigade Combat Team (BCT) level and below. While the Navy, Marine Corps, and Air Force use uniformed electricians to operate, maintain, and employ their power systems, the Army typically relies on generator mechanics and incidental operators to set up, operate, maintain, and repair unit-level electrical power generation and distribution systems.

As DoD develops and fields more modernized power generation and distribution systems, the Army could face mounting risks to efficiency if units are unable to manage their power needs. Although the Army can mitigate these risks today—whether through spot gener-

[1] Training and Doctrine Command (TRADOC) Pamphlet 525-3-1, *The US Army Operating Concept: Win in a Complex World, 2020-2040*. 31 October 2014.

ation, contracted logistics support, or redundant legacy systems still on units' tables of equipment—it is unclear whether these non-materiel factors will lead to greater risks to mission effectiveness in the future.

This paper examines the non-materiel implications of integrating advanced power systems into future Army operations and recommends possible changes in doctrine, organization, training, leadership, personnel, and policy to improve the Army's approach to power management within the context of a BCT. The Institute for Defense Analyses (IDA) conducted this research at the request of the Project Manager for Expeditionary Energy and Sustainment Systems (E2S2) in conjunction with the Deputy Assistant Secretary of Defense for Operational Energy (DASD(OE)).

B. Scope

Tactical electric power may be visualized as a triad composed of power consuming customers, power generating equipment, and power management approaches. Figure 1 shows this triad and how the three pieces fit together within the strategic environment described in the Army Operating Concept (AOC). Our research focused on the non-materiel aspects of power generation and distribution capabilities with an assumption that improved power management leads to increased efficiency. Explicitly included in our scope was an assessment of how power management nests within the maneuver phase of expeditionary operations as well as the transition to operations from fixed sites and static locations.

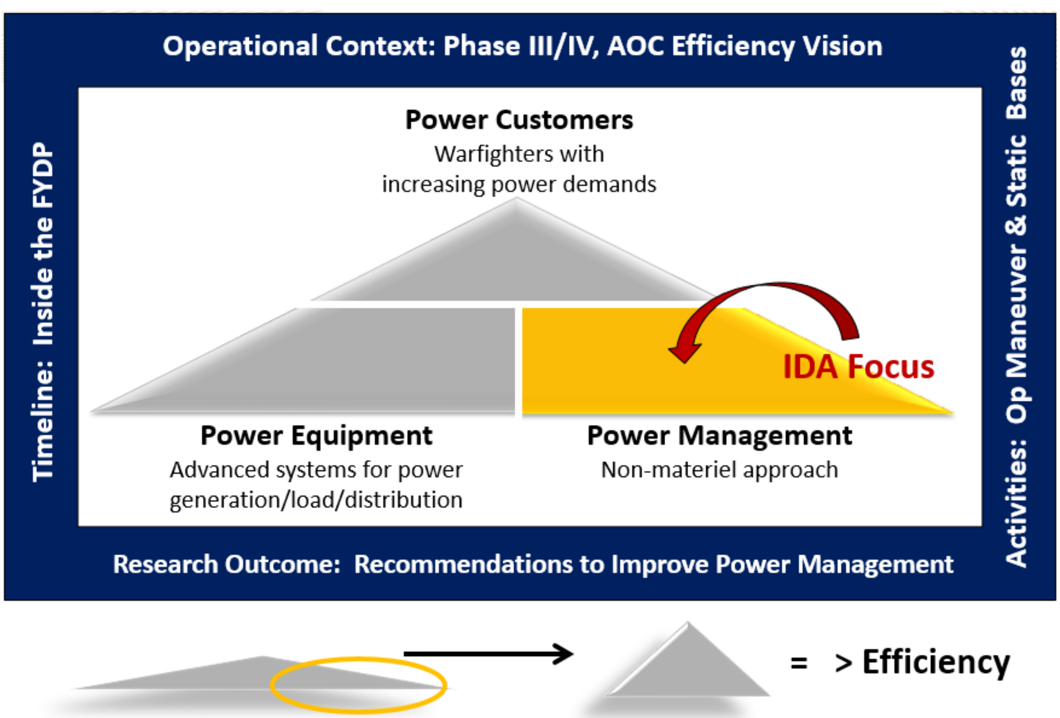

Figure 1. IDA Research Focus on Power Management

We then focused on power management as applied to *tactical electric power* systems. Measured in kilowatts (kW), tactical electric power falls between *soldier power* (less than 0.5 kW) and *prime power* (more than 200 kW).[2] Figure 2 shows how these categories of electric power form a continuum, allowing the potential for overlap (in dashed lines) to show that, for power systems during contingency operations, there are often transitions from tactical power to prime and commercial power systems that do not require complete teardowns.

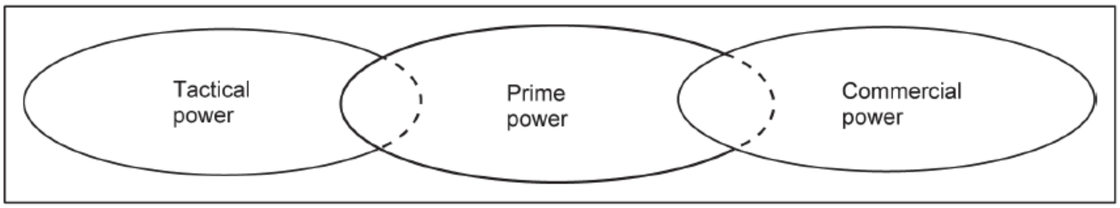

Figure 2. Graphical Representation of the Electrical Power Continuum[3]

As a subcomponent of operational energy, tactical electric power refers to power generation and distribution with a unit's organic equipment and systems. For this research, we focused on tactical electric power systems organic to a BCT's Modified Table of Organization and Equipment (MTOE).

C. Research Approach and Methodology

To address the non-materiel implications of power management for a BCT, we combined an in-depth literature review with stakeholder interviews across the Army's operational energy and tactical electric power proponents. The literature review included products validated through the Joint Capabilities Integration and Development System (JCIDS) process, Army strategic guidance on required capabilities and warfighting concepts, published Army sustainment and engineering doctrine, Army operational energy strategy and policy, lessons-learned reports, draft training support packages and materials, and previous operational energy studies. We also reviewed the Marine Corps' (USMC) approach to utilities and power management from a training and organizational perspective, including the Marine Corps' *Expeditionary Energy Strategy and Implementation Plan* and the Engineer and Utilities Training and Readiness Manuals.[4]

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2 ATP 3-34.40. *General Engineering*. 25 February 2015, 11-5.

3 TM 3-34.45, *Engineer Prime Power Operations*. August 2013, 1-2.

4 USMC Expeditionary Energy Office. *Bases-to-Battlefield: United States Marine Corps Expeditionary Energy Strategy and Implementation Plan* (Washington: Headquarters, USMC, 23 February 2011)

For the sustainment perspective, we spoke with the Combined Arms Support Command (CASCOM) Training Directorate, the Sustainment Center of Excellence (Future Systems and Operational Energy Integration), and the Army Ordnance School. For the engineer perspective, we spoke with the Maneuver Support Center of Excellence (MSCoE) Capability Development and Integration Directorate (CDID), the Army Engineer School, and the 249th Engineer Battalion (Prime Power). We also spoke with the Deployment and Sustainment Branch of the Army Capabilities Integration Center (ARCIC) as well as the Training and Doctrine Command (TRADOC) Capability Manager (TCM) for Mission Command and Command Posts.

Throughout the interview process, we were provided with a range of draft documents in support of operational energy initiatives run by CASCOM and MSCoE. These documents revealed additional context and details regarding current thinking about tactical electric power issues in the near term; however, we caution that these documents are not yet published and any citations are intended to illustrate the document's intent rather than indicate the final version of the text.

Our discussion with the ARCIC Sustainment Division led us to view the Army's power management issues through the Capability Needs Analysis (CNA) framework, described in TRADOC Regulation 71-20 as well as Chapter 5 of this report. Once we aligned our research approach with the TRADOC CNA framework, we reviewed the capability gaps documented in official Joint Requirements Oversight Council (JROC)-approved requirements documents and the ARCIC-approved capability gaps. We then assessed the Army's approach to power management, including ongoing initiatives, in light of the strategic environment and mission requirements characterized by the CNA framework and informed by our interviews.

D. Organization of the Report

Chapter 2 provides the operational context for power management, including a discussion of the Army's approach and the recent challenges documented through studies and after-action reviews. Chapter 3 presents the results of our review of the Joint requirements documents and capability gaps. Chapter 4 summarizes the Army's current initiatives to improve power management capabilities. Chapter 5 examines the Army's approach to power management through TRADOC's CNA framework, highlighting what the Army Operating Concept and other supporting documents say about the future strategic environment and the implied requirements for power management. Chapter 6 then provides IDA's assessment of steps the Army could take to modify its doctrine, training, and organizational structure, focusing on the shortfalls we identified in the Army's current initiatives as well as providing recommendations to improve them. Chapter 7 summarizes our findings and recommendations and includes a brief discussion on opportunities for future research.

2. Operational Context

This chapter provides the operational context for power management and includes definitions, a description of power management roles and responsibilities, and a review of the Army's approach to power management. The final section discusses the Army's documented power management challenges in recent years.

A. What is Power Management?

1. Definitions

Although referenced in Army doctrine, power management does not have an approved, standard definition.[5] The Distribution Working Group (DWG), a joint working group under the direction of the Joint Standardization Board for Mobile Electric Power Systems, derived its own definition in a 2015 report on the Army's non-materiel approach to power generation and distribution.[6]

> [T]he planning, organization, coordination, monitoring, and control of the tactical electric power grid where the properly distributed source output over time at least equals the cumulative unit power demand in order to achieve greater fuel efficiency, higher reliability, and reduced maintenance while maintaining required force operational effectiveness.[7]

CASCOM later simplified these elements in a briefing as part of a training support package for the Tactical Power Management Concept (TPMC), defining tactical electric power

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5 Joint Standardization Board for Mobile Electric Power Generating Sources, *Distribution Working Group FY2015 Army Report* (Fort Belvoir, VA: Program Office for Expeditionary Energy and Sustainment Systems, 16 September 2015), 2.

6 Joint Standardization Boards (JSBs) "provide a DoD-wide forum for achieving common, mutually satisfactory standardization solutions that (1) Cut across multiple Federal Supply Classes, Federal Supply Groups, or standardization areas and cannot be handled by a single Lead Standardization Activity (LSA); (2) cover an evolving technology or commodity that does not have an assigned LSA; or (3) address standardization issues identified by the Defense Standardization Executive that may not result in a standardization document." The JSB for Mobile Electric Power Generating Systems, established in 2006 and renewed in 2010, is focused on standardization and interoperability of electric generators across the Services, all four of which are represented on the board. Although the JSB for Mobile Electric Power Systems is chaired by PM E2S2, the sponsor of this research project, we used their documents for reference only in conducting our analysis. www.dsp.dla.mil/Programs/Joint-Standardization-Boards/

7 *Distribution Working Group FY2015 Army Report*, 2.

management as “the coordination and control for planning, employment, and operation of electric power generation and distribution systems that support military tactical operations.”[8]

2. Echelons

The power management tasks defined in the previous section are performed at multiple echelons under varying conditions. Figure 3 depicts a proposed power management architecture developed by PM E2S2. It shows in a single graphic some of the key variables—such as mobility, duration, and size—that affect power management requirements and capabilities at each echelon.[9] While many of the general tasks at each echelon may be similar, the specified equipment and other mission, enemy, troops, terrain, time and civilian factors tend to drive the complexity of the power management function.[10]

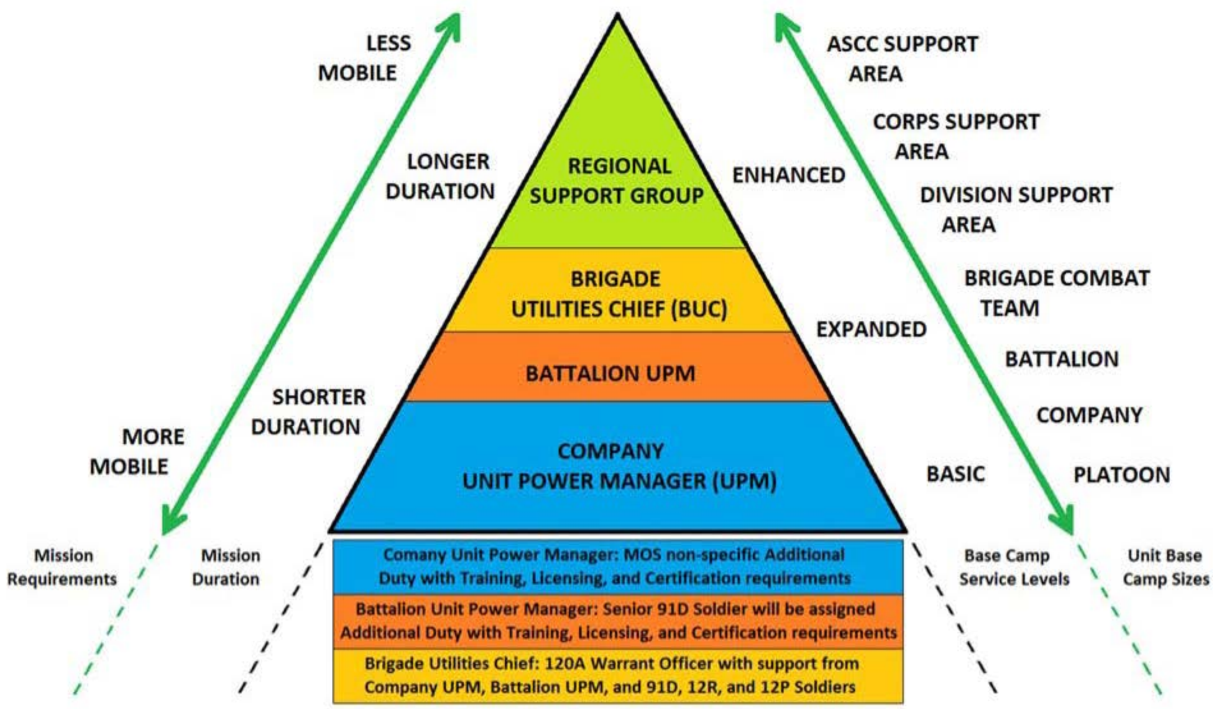

Figure 3. Proposed Power Management Architecture, PM E2S2

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8 Combined Arms Support Command, Tactical Power Management Leadership Training, “Operational Energy Planning,” unpublished briefing, September 2016.

9 Mike Richards, “Who Owns the Grid?” unpublished paper, February 2016.

10 Mission, Enemy, Terrain/Weather, Troops Available, Time, Civilian Considerations

B. Power Management Operational View

The context under which we analyzed the Army's approach to power management was a BCT conducting operations in an austere environment. Figure 4, taken from a CASCOM Materiel Systems Directorate briefing on tactical electric power requirements and emerging needs, depicts an Operational View-1 (OV-1) for tactical electric power sources and distribution. One key addition for our research was to look below the BCT headquarters and incorporate command posts from the BCT's subordinate battalions. We also considered a case where a company-sized element is operating from a fixed location (i.e., combat outpost) in an isolated position removed from higher echelons of sustainment and support.

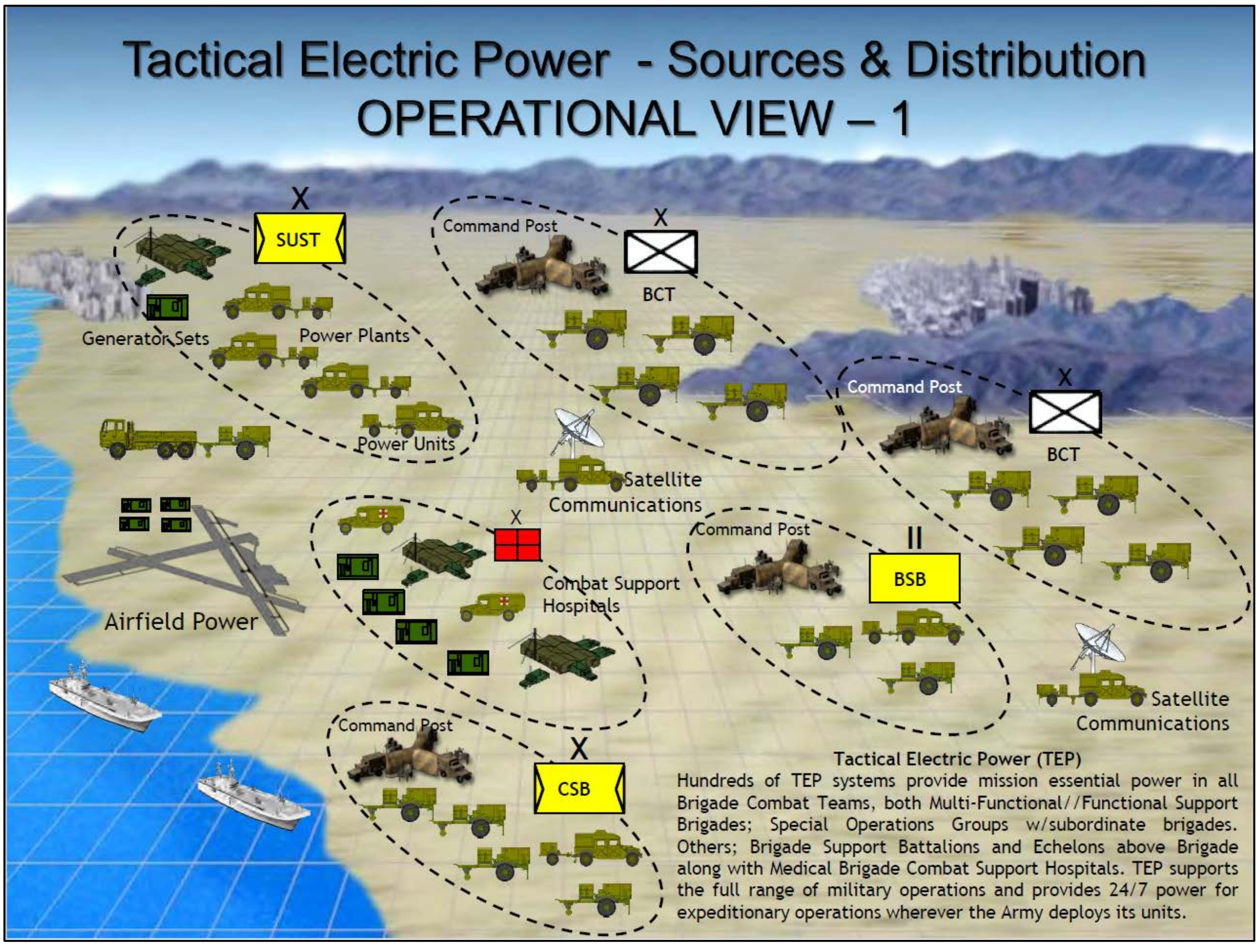

Figure 4. Operational View-1 for Tactical Electric Power[11]

[11] Timothy Raney, CASCOM Materiel Systems Directorate, "Tactical Electric Power and Distribution: Requirements and Emerging Needs," Briefing, (6 Aug 2015.)

C. The Army's Approach to Power Management

Building on the definitions of power management and the power management architecture outlined in the previous two sections, we now turn to a general description of the Army's current approach to power management with a focus on published Army doctrine as well as the roles and responsibilities for power management within Army formations.

1. Army Power Management Doctrine

Army Doctrine Reference Publication (ADRP) 1-03, *The Army Universal Task List* (AUTL), provides the most comprehensive list of Army tasks and missions as well as recommended measures of performance for each.[12] At the highest level, the AUTL groups Army Tactical Tasks (ARTs) into six warfighting functions (Movement and Maneuver, Intelligence, Fires, Sustainment, Mission Command, Protection) and one supplemental set of Tactical Mission Tasks and Military Operations.

Within this organizing framework, power management is mentioned under the tactical task, "Supply Mobile Electric Power," nested within the sustainment warfighting function. The hierarchy is

- The Sustainment Warfighting Function (ART 4.0)
    - Provide Logistics Support (4.1)
        - Provide General Engineering Support (4.1.7)
            - Supply Mobile Electric Power (4.1.7.4)

The AUTL provides the following description of the subtask:

> This ART covers how units supply electric power generation and distribution to military units through mobile generation and a tactical distribution grid system. ART 4.1.7.4 includes power production, power distribution, and power management. (TM 3-34.45)[13]

The 29 performance measures for this task (see Appendix B for the complete list) are primarily construction engineer-oriented and do not generally relate to the power management tasks described in Section A of this chapter. The reference at the end of the subtask description, TM 3-34.45, is *Engineer Prime Power Operations*. Although this technical manual describes many of the basic concepts of electrical power generation and distribution, its focus is neither

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[12] ADRP 1-03, *The Army Universal Task List*, October 2015.

[13] ADRP 1-03, 4-67. The text in parentheses is part of the original reference.

tactical power systems nor power management. So, while ART 4.1.7.4 references both tactical electric power and power management, there is no specific doctrinal reference for either.[14]

While power management does not currently have a stand-alone doctrinal reference, power management concepts can be found throughout other engineer publications. Army Techniques Publication (ATP) 3-34.40, *General Engineering*, includes a chapter on power systems and describes the engineer branch's responsibilities and capabilities for power generation and distribution.[15] The chapter summary notes that

> General engineers play a key role in synchronizing the construction, operation, and maintenance of power systems to achieve the desired [general engineering] effort in unison with [combatant commander] priorities.[16]

Another publication, ATP 3-34.22 *Engineer Operations-Brigade Combat Team and Below*, describes the engineering role for electrical power systems specifically in the context of a base camp:

> The augmentation of power generation support may be necessary, especially if the BCT is responsible for the construction or maintenance of a base camp or forward operating base. Prime power teams are uniquely designed to provide this support, particularly if the nature of the base camp or forward operating base includes multiple, co-located sustainment units. General engineering is required to facilitate and assist in the creation of a power distribution system.[17]

One common theme in the engineer doctrine for mobile electric power is the reference to prime power support in expeditionary environments. The prime power doctrine, however, explains the reality of prime power availability in a section on frequently asked questions:

> Although it is comforting to have a couple of technicians conveniently on hand to serve as a security blanket for power issues, the reality is that there are only about 200 prime power Soldiers in the Army force structure. Because they are such a scarce resource, it is extremely unlikely that you will be able to get a prime power team to support you for anything other than a well-defined mission with a clear end state.[18]

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[14] In October 2016, the TRADOC Combined Arms Center released a Doctrine Smart Book that lists current and forthcoming Army doctrinal publications by proponent. Under the Maneuver Support Center of Excellence, a not-yet-published ATP 3-34.45 is listed with the title *Power Generation and Distribution*, nested within the larger set of engineer operations doctrine. Because this document was unpublished at the time of this writing, we were unable to determine if there would be additional definitions of tactical electric power and power management.

[15] ATP 3-34.40, *General Engineering*. 25 February 2015.

[16] ATP 3-34.40, *General Engineering*, 11-1.

[17] ATP 3-34.22, *Engineer Operations and the Brigade Combat Team and Below*. December 2014, 3-19.

[18] ATM 3-34.45, *Engineer Prime Power Operations*, August 2013, Item B-21, B-5.

Two key points emerge from reviewing the existing Army doctrine for power management. First, although these publications fall within the scope of the sustainment warfighting function, they are all owned by the engineers; there is no separate sustainment doctrine that includes tactical electric power or power management. Second, the true engineer hook within power management doctrine appears to be ownership of the prime power occupational specialty as well as the construction engineering warrant officer. As will be seen in the next sections, the engineers do not have Soldiers who specialize in lower voltage tactical power systems—those Soldiers belong to the sustainment career field. The overlap between the engineer and sustainment functions with respect to power management will be a recurring theme throughout this paper.

2. Power Generation and Distribution Techniques

The cornerstone of power management is connecting systems that consume electricity—typically referred to as *loads*—to sources that produce electric power. There are several ways to do this, and determining which method is best-suited to the unit's requirements is one of the more common topics in the Army's approach to power management. The simplest technique, known as *spot generation*, is defined in an Army Audit Agency report on the use of electric grids as

> [A] contingency power system with a single electric power source. The system may be a small power source providing electrical power to a single load, or it can be a large power source providing electrical power to multiple loads.

The report also notes that "Generally, spot generators are inefficient because of the demand factor and increased maintenance requirements" compared with electric grids.[19] Figure 6, taken from a Maneuver Support Center of Excellence (MSCoE) white paper on operational energy management, shows an example spot generation schematic for multiple loads attached to a single generator through a distribution panel called a Power Distribution Illumination Systems, Electrical (PDISE). The MSCoE paper also expands the notion of inefficiency beyond fuel to include wasted manpower and man-hours if units rely too heavily on spot generation:

> Multiple spot generation sites require an increase in manpower/man-hours associated with maintenance and fueling operations. For example, two 10kW generators require twice as much maintenance and fueling man-hours as one 20kW generator. Moreover, generators running under less-than-optimal conditions require additional maintenance that adds additional man-hours.[20]

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[19] Army Audit Agency, "Operational Energy: Use of Electrical Grids." Audit Report A-2016-0018-IEE, 15 December 2015, 5.

[20] MSCoE CDID, "Army Operational Energy Management: Electric Power Production and Distribution White Paper," 1 April 2015, 14–15.

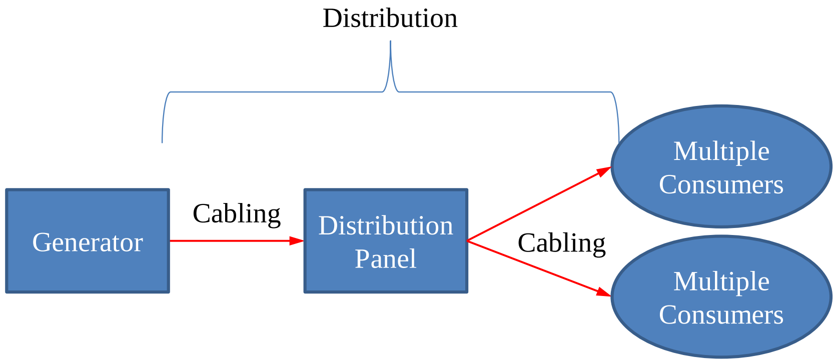

Figure 5. Spot Generation Schematic[21]

A microgrid configuration (Figure 7), in contrast to spot generation, distributes electricity through a linked network of power generation sources to multiple electric loads. This configuration, though more complex to implement and operate, provides additional resiliency (no single point of failure) and efficiency compared with spot generation. The intended effect, when combined with intelligent power distribution systems that automatically match electrical supply and demand, is to optimize the electrical power generated based on the electrical load demanded by the network of systems. In general, though, the benefits are frequently discussed in terms of reducing the demand for liquid fuel.

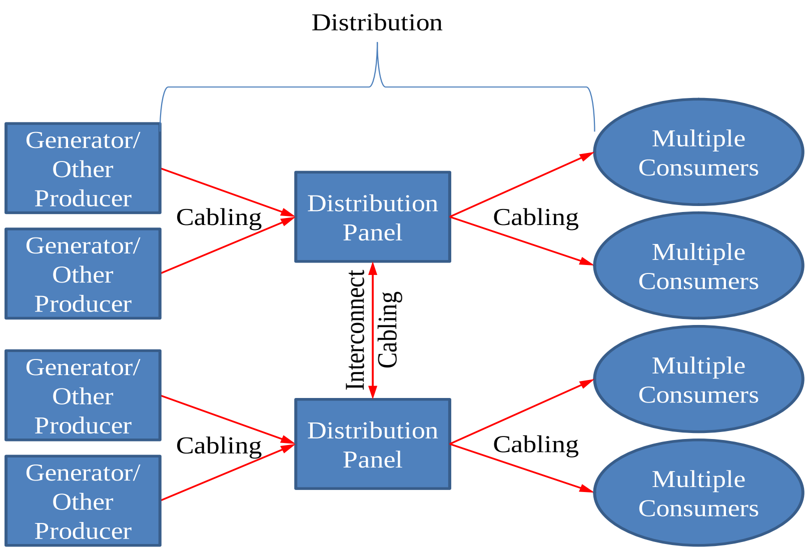

Figure 6. Microgrid Configuration Schematic[22]

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21 MSCoE CDID, "Army Operational Energy Management," 14.

To help power planners develop and analyze the layouts of these more complicated grids, PM E2S2 created a software tool called Automated Distribution Illumination System Electrical (or AutoDISE). The software allows users to create a "virtual layout consisting of shelters, electrical loads, distribution equipment, and generators based on the unit's TOE" and to analyze various configurations for connecting the loads to the sources of electrical power.[23] It also allows users to estimate generator-based fuel consumption. This software comes up frequently in discussions about power management training.

3. Roles and Responsibilities

Roles and responsibilities for power management are assigned to several branches and military occupational specialties (MOS) across the Army. At the tactical level, within a BCT, the following duty positions are needed for operational energy planning, from highest to lowest echelon:

- Operational Energy Advisor
- Tactical Power Generation Specialist
- Unit Power Manager (UPM)
- Tactical Electric Power Operator

Because there is no official publication that fully defines the roles and responsibilities for power management, the following definitions for each position are adapted and modified from the Tactical Power Management Concept.[24]

Operational Energy Advisor: The Operational Energy (OE) Advisor will assist UPMs with creating Tactics, Techniques & Procedures (TTPs) and checklists to help identify inefficiencies and possible resolutions, incorporate energy changes into training, operations, and training. The OE Advisor has the expertise to plan and use energy smartly and efficiently. The OE Advisor provides strategic energy advice to the unit leadership and coordinates the transfer of technical expertise to the operators and maintainers.

Tactical Power Generation Specialist: The 91D MOS[25] performs field level maintenance on tactical power generation sets, power distribution equipment, internal combustion

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[22] MSCoE CDID, "Army Operational Energy Management," 20.

[23] TC 4-37.10, *Tactical Electric Power Production and Distribution*. Draft version, January 2017, 5-3.

[24] Adapted from CASCOM Tactical Power Forum, unpublished briefing, 18 May 2016, and lesson plan report for Tactical Electric Power Energy Planning (151-AWA-03/1), 19 February 2016 Leader training support package. The TPMC is a CASCOM draft pilot program to improve power management at the brigade level and below, primarily through additional training. CASCOM intends to evaluate the training's effectiveness during Army Warfighting Assessment 17.1.

engines, and associated items of equipment. 91D10 level Soldiers assist operators in proper employment of tactical power generation equipment. 91D20/30 level Soldiers train operators and perform duties as unit power planner, completing power assessments and tactical power grid design plans. They also advise unit staff personnel on how best to employ tactical power generation systems, including distribution equipment to meet power requirements.

Unit Power Manager: Commander-designated Soldiers responsible for employing existing tactical power solutions and integrating advanced solutions. The unit power manager uses the Tactical Electric Power planning process and, once employed, continuously monitors the unit's energy needs and operations inside and outside the wire.

Tactical Electric Power Operator: Designated Soldiers who are properly trained and licensed to operate and maintain tactical power systems and distribution equipment.

Of these positions, only the Tactical Electric Power Operator (a designated duty for any soldier) and the Tactical Power Generation Specialist (the 91D MOS) are part of the BCT organizational structures; the UPM and the Operational Energy Advisors are both initiatives in the concept development and assessment phase.

In addition to the above operational and sustainment roles within a BCT, the engineers have another MOS responsible for prime power systems.

Prime Power Production Specialist: The 12P MOS prime power production specialist performs electrical assessments, facilities maintenance and quality assurance/quality control operations. He or she supervises, operates, installs and performs direct support/general support-level maintenance on electric power plants, consisting of prime power generator sets of 500 kW and higher along with associated auxiliary systems and equipment.[26]

One major difference between the prime power career field and the 91D tactical power generation specialist is the amount of training involved; prime power soldiers, who must have already achieved the rank of Specialist or Sergeant in another MOS before applying for a voluntary reclassification, spend 48 weeks in their Advanced Individual Training qualification course, compared with 10 weeks for the 91D straight out of basic combat training.

The engineers also have a warrant officer career field relevant to power management.

Construction Engineering Technician: The 120A warrant officer MOS is available to prime power soldiers who have at least four years in service and reached the rank of E-5/ Ser-

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[25] The current nomenclature for the 91D MOS is "Power Generation Equipment Repairer." Effective October 2017, this title will be revised to "Tactical Power Generation Specialist." For more, see Chapter 4, Section A.4, and Appendix C of this report.

[26] US Army official website for careers and jobs, www.goarmy.com/careers-and-jobs/browse-career-and-job-categories/construction-engineering/prime-power-production-specialist.html.

geant. These warrant officers serve in a multifunctional capacity across the broad and diverse spectrum of engineer operations. Duties include supervising and coordinating base camp and facility construction; providing advice and technical assistance on all aspects of electrical power and distribution in support of military operations; supervising and managing theater prime power teams; and supervising the construction, repair, and maintenance of horizontal and vertical infrastructure.[27]

4. Reviewing the Current Approach

Reviewing the Army's approach to power management led us to the following finding:

Finding #1 – Power management tasks and responsibilities span the engineer, sustainment, and operational communities.

The Army's construct of separating tactical electric power from prime power and assigning the responsibility for each to a different proponent has led to a split between the maneuver support and sustainment branches at the operational as well as institutional levels. According to TRADOC Pamphlet 350-70-16, *Army Training and Education Proponents*, the Army Engineer School (under MSCoE) is the functional proponent for

- General Engineering—Operational Energy, Water, and Waste Efficiencies
- General Engineering—Prime Power Distribution
- General Engineering—Semi-Permanent Mobile Electric Power
- Base Camp Infrastructure, Development, Construction, Transfer, and Closure[28]

These correspond to power management functions that typically occur at echelons above brigade. On the brigade staff, the MSCoE intends to use the 120A Construction Engineering Technician warrant officers in the Brigade Engineer Battalion and train them as operational energy advisors, with responsibility to advise the commander as well as oversee the power management training program across the battalions.

But once units move beyond the base camp and into the realm of command posts and less permanent fixed sites with smaller footprints, the responsibility for power management shifts to the sustainment branches as well as to the units' designated MOS-incidental generator operators. TRADOC has designated CASCOM as the proponent for

- Operational Energy

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[27] Adapted from www.usarec.army.mil/hq/warrant/prerequ/WO120A.shtml.

[28] TRADOC Pamphlet 350-70-16, *Army Training and Education Proponents*. 2 August 2016, 14.

- Sustainment Doctrine
- Base Camp Sustainment (through the Quartermaster School)
- Tactical Electric Power and Distribution (through the Ordnance School)

At this level, the focus is on tactical power grid configuration, power generation and distribution operations, system repair, and materiel sustainment. The sustainers, specifically the 91D tactical power generation specialists (formerly generator repair personnel), provide repair services via attached Forward Support Companies of the Brigade Support Battalion.

The split in tactical formations is mirrored at the Army's institutional level. As we will show in Chapter 4, current DOTmLPF-P initiatives to improve the Army's non-materiel approach to power management originate through both CASCOM (sustainment) and MSCoE (engineers). And, despite some level of coordination, each proponent's efforts are focused on issues that directly affect their own communities rather than the power management function as a whole. According to an Army Audit Report on the use of electrical grids, the Army "didn't have one activity or organization responsible for centralized management and oversight of power management and distribution efforts or the broader area of operational energy."[29]

Venues like the Tactical Power Forum, led by CASCOM's Future Systems and Operational Energy Integration Division with a mission to "establish a synchronization effort of tactical power management roles and responsibilities to strengthen the operation energy security of the force," help bridge the different levels of responsibility, but none of the communities participating is empowered to manage and integrate the multiple lines of effort, nor is one the designated advocate for these capabilities to DoD and the Office of the Secretary of Defense (OSD).[30]

We can summarize how power management is split between these communities as follows.

Engineers "own" power management functions at Echelons above Brigade and for Base Camps/Contingency Basing.

- Focus on prime power integration and base camp management
- Proponent for mobile electric power
- Proponent for 12P (Prime Power Production Specialist) and 120A (Construction Engineering Technician Warrant Officer)

Logisticians and incidental operators "own" power management functions at the Brigade Staff/Battalion/Company levels.

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[29] Army Audit Agency, "Operational Energy: Report on Use of Electrical Grids," 16.
[30] CASCOM Tactical Power Forum, unpublished briefing slides, 18 May 2016.

- Focus on generator operations, repair, and materiel sustainment
- TRADOC-designated proponent for operational energy training and sustainment doctrine
- Proponent for 91D (Tactical Power Generation Specialist)

Resolving this split as a way toward a more holistic approach to power management will require TRADOC to designate either CASCOM or MSCoE as the proponent for power management at the brigade-level and below. Chapter 6 will discuss this issue and provide more detailed recommendations.

D. Documented Army Power Management Challenges

A number of studies and publications have highlighted problems with the Army's management of tactical electric power. A Defense Science Board report in 2008, *More Fight-Less Fuel*, noted the OE challenge for US land forces: "during peacetime, fuel consumption by Army aircraft makes up almost 50% of its total. But during wartime, generators become the largest single fuel consumers on the battlefield."[31] With this in mind, as long as the Army uses generators during combat operations and follow-on phases, there will be significant DOT-mLPF-P issues related to how to sustain and to manage them.

In 2013, then-Deputy Chief of Staff of the Army for Logistics (G-4), Lieutenant General Raymond V. Mason, wrote of the need to address "the problem" at remote and austere sites in Afghanistan that had been around since the beginning of the war:

> Unit rotations and the lack of focus on tactical electric power systems exacerbated problems during the course of those 11 years. Many remote bases had boneyards of broken power generation equipment that often exceeded the density of operational power equipment….Contingency contracting officers purchased commercial generators but received little or no follow-on maintenance support…Furthermore, soldiers were not trained to operate or maintain commercial generators. Typically, there is little ownership associated with leased equipment; the well-populated generator boneyards were a visible reminder.[32]

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[31] The study's authors also noted that, "[w]hile the Army consumes less fuel than the Air Force, that fuel is generally difficult to move and protect." *Report of the Defense Science Board Task Force on DoD Energy Strategy: "More Fight, Less Fuel,"* (Washington, DC: Office of the Under Secretary of Defense For Acquisition, Technology, and Logistics, 2008), 44.

[32] LTG Raymond V. Mason and CW4 Michael G. Richards, "Operational Energy in Afghanistan: Culture Change in Action," *Army Magazine*, September 2013, 30. Mason's co-author, CW4 Mike Richards, served as the Army's first uniformed OE Advisor during Operation DYNAMO and was attached to the 173d Airborne Brigade Combat Team from July 2012 until March 2013.

OE solutions arrived at these locations on the "tactical edge"—combat outposts, forward operating bases, and village stability platforms—during Operation DYNAMO (2012–13).[33] The deployment of advanced medium mobile power sources (AMMPS) generators and PDISE by the project manager for mobile electric power (PM MEP) were part of the Army's concerted efforts to reduce the need for fuel and the risks associated with its resupply. The goal was to "…help reduce fuel deliveries and improve operational capability by returning combat power to commanders. Soldiers who do not have to recover air-dropped fuel can focus on higher priority combat missions."[34] Thus, energy efficiencies—through more fuel-efficient AMMPS generators (as replacements for older Tactical Quiet Generators), proper loading, and power distribution using PDISE—should improve military effectiveness. Operational benefits during Operation DYNAMO, LTG Mason wrote, included "significant operational capability through increased power reliability, improved quality of life, safer conditions and decreased requirements for fuel."[35]

Materiel solutions in the form of new equipment were only part of the OE upgrades in Afghanistan; on-site expertise was also needed. A key non-materiel solution was the concept of an OE advisor who would be the commander's OE subject matter expert, empowered to correct inefficiencies and to educate Soldiers.[36] OE advisors knew how to match electricity supply to actual demand and not underload the diesel generators (usually 30 kW or 60 kW) in spot generation, which led to unburned fuel passing into the exhaust system and clogging the generator, a process known as "wet stacking." They also knew how to incorporate other OE solutions, such as hybrid energy sources (e.g., solar-based solutions to power remote equipment at isolated, hard-to-supply locations).

Operation DYNAMO demonstrated that energy-informed plans and decisions that impact forward operations need both materiel and non-materiel components. Part of the initiative was an expectation that the addition of AMMPS to unit MTOEs throughout the Army would need to be accompanied by the resident tactical power management knowledge (i.e., organic within

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[33] Operation DYNAMO was a PM E2S2 initiative to bring advanced power generation and distribution systems to remote outposts in Afghanistan, and to assess the effects on fuel demand and efficiency. AMSAA performed an independent analysis of the initiative in 2013, focusing on the OE Advisor concept and the OE Solutions Teams who employed the new equipment. "AMSAA Analysis of Project Manager Mobile Electric Power Operational Energy Solutions in Afghanistan: Operation Dynamo I," Technical Report No. TR-2013-35, July 2013.

[34] Mason and Richards, "Operational Energy in Afghanistan," 30.

[35] Mason and Richards, 31.

[36] The concept centered on the use of uniformed advisors, warrant officers and senior non-commissioned officers. As demonstrated in Afghanistan, this included one uniformed advisor at the brigade/forward operating base level, and approximately six other advisors (contractors) who circulated among the more remote outposts to conduct surveys, address safety issues, and make recommendations (how to fix distribution issues, what new equipment was needed).

the unit) of how to configure, operate, and maintain them. As TRADOC's *Energy to the Edge In Theater Assessment Report* for Operation DYNAMO stated, "BCTs currently lack the expertise to properly emplace and employ military power generation and distribution equipment to meet their power needs, much less the wide range of commercial generators and power distribution hardware they find in theater."[37]

Power management challenges have continued since the Army's drawdown from Afghanistan, as reflected by several noteworthy publications. In 2013, the US Army Corps of Engineers (USACE) produced a lessons-learned report on energy management at contingency bases, combining subject matter expert interviews with after action reviews from Afghanistan.[38] The survey revealed that overreliance on spot generation was a "major inefficiency and contributor to excessive fuel consumption at contingency bases," and described the employment process that leads to this approach:

> During initial phases of operations, units that initiate and develop base camps bring with them tactical generators, their single reliable source of power during this phase. Unless the command can identify a sufficient number of SMEs with the knowledge, skills, abilities, tools, and equipment to manage power, spot generation remains and even expands as the base camp grows.[39]

The report also noted that "the Army does not have the training required to support use of low voltage micro-grids," and that proper training of existing equipment could increase energy efficiency by 30–40 percent.[40] Other relevant insights, taken verbatim from the report were

- Additional power training for 91D30 [Staff Sergeant] comes too late in their careers; 91Ds are generator maintainers that progress to another career field at the skill level 40 (E-7), so it is too late in their career to provide energy management training.
- Interest at high levels of DoD in increasing the availability and use of prime power has not yet appeared to result in higher interest for unit commanders at lower levels. Unit commanders seem to lose interest once the "power is on" and focus back on their specific mission.

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37 As quoted in *Distribution Working Group FY2015 Army Report*, (Fort Belvoir, VA: Program Office Expeditionary Energy and Sustainment Systems (DWG chair), September 2015), 10. IDA also performed an independent and classified assessment of the operational effectiveness and savings (realized and potential) of materiel and non-materiel OE initiatives for the Energy to the Edge in-theater assessment for sponsors ASD/OEPP and TRADOC's ARCIC for IDA Task Order AQ-8-3483.

38 John Vavrin, W. Brown, and W. Stein. *USACE Support to Contingency Base Energy Management: Lessons Learned*. (Washington, DC: Headquarters, US Army Corps of Engineers, August 2013).

39 Contingency Base Energy Management: Lessons Learned, vii.

40 Contingency Base Energy Management: Lessons Learned, 15.

- Inefficient use of spot generation is still rampant throughout [theaters in Iraq and Afghanistan].
- In two separate assignments in theater, there did not seem to be a rationalizing of energy/power needs. (There were far too many redundant generators and no micro-grid implementation.)
- The misuse of (apparently) similarly technically qualified personnel, e.g., a "power plant engineer" is not the same as an "electrical engineer"; not all electrical engineers understand power.

In 2014, the Massachusetts Institute of Technology's Lincoln Laboratory prepared the *Tactical Power Systems Study* for the Assistant Secretary of Defense for Operational Energy Plans and Programs that considered whether advanced tactical power systems (such as hybrid or microgrids) would address the spot generation problems experienced in Afghanistan through more intelligent loading via networks of multiple sources. The report offered recommendations that assessed when spot generation or other configurations such as two generators, hybrid, or microgrid made more sense, concluding that the driving factor was mission duration: spot generation for short duration (a few months) and microgrids for missions lasting more than six months.[41] The report also showed that in the case of some demand profiles, such as for a tactical operations center (TOC) with an average load factor of 51%, they were already efficient using spot generation and would not appreciably gain more efficiency by using two generators or hybrid.[42]

The report's authors also identified non-materiel concerns, including safety, associated with advanced tactical power systems—what they called the "next-generation power sources and distribution networks of increased complexity."[43] The issue was whether Service personnel were sufficiently trained (or even existed) to handle these more complex systems and technologies. The Lincoln Lab team surveyed experts across the four Services about the occupational specialties that dealt with generators and power management. They divided the roles into the categories shown in Figure 9 and rated each Service's roles in terms of training and personnel. The survey found that the Army's tactical power management challenges were

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41 S.B. Van Broekhoven, E. Shields, S.V.T. Nguyen, E.R. Limpaecher, and C.M. Lamb, *Tactical Power Systems Study* (Technical Report 1181), (Lexington, MA: Lincoln Laboratory, 19 May 2014), 54.

42 Broekhoven, *et al.*, *Tactical Power Systems Study,* 39. We use the term *TOC* to refer to the command and control node of a command post. A command post refers to a "unit headquarters where the commander and staff perform their activities." See also Army Techniques Publication (ATP) 6-0.5, *Command Post Organization and Operations.* March 2017, 1-1.

43 Broekhoven, *et al.*, *Tactical Power Systems Study,* 79. Examples of new hazards that required safety training included high voltage DC exposure, lockout-tagout (LOTO) procedures for generator auto-start systems, setup/teardown of live microgrids, lithium battery safety, and proper electrical grounding and fault protection. Broekhoven, *et al.*, 84.

of a greater severity compared to those of the other military services, and that the Army was not well-positioned to take on more advanced power systems.

Few/No Problems Exist | Some Problems Exist | Serious Problems Exist

Role	Army	Navy	USMC	Air Force
Operator	Incidental Operator	Incidental Operator	Incidental Operator	Incidental Operator
	91D Generator Maintainer	CM – Construction Mechanic (Seabees)	1142 Electrical Systems Technician	3E032 Basic Electrical Power Production
Generator Maintenance	91D Generator Maintainer	CM – Construction Mechanic (Seabees)	1142 Electrical Systems Technician	3E032 Basic Electrical Power Production
Electrical Layout/Design	91D Generator Maintainer	CE – Construction Electrician (Seabees)	1141 Electrician	3E052 Operation/Maintenance of Generators
			1120 Utilities Officer	
Leadership/ Responsibility	*OE Advisor	CE – Construction Electrician (Seabees)	1120 Utilities Officer	3E092 Electrical Superintendent
			1169 Utilities Chief	
Prime Power	12P	CE – 5633 (MUSE Techs)	n/a	3E072 Supervisor of Generator Operator/Maintainers
Supporting/ Other	91B Wheeled Vehicle Mechanic	n/a	n/a	n/a
	12R Interior Electrician			

*OE Advisor was a trial position

Figure 7. DoD Training Challenges by Role[44]

The report labeled as a "serious problem" (cells in red in Figure 9) the Army's lack of uniformed electricians at the tactical power level and its sole reliance upon generator maintainers to perform electrical layout and design. As the authors noted, the 91D MOS "is severely understaffed and undertrained to meet the requirements placed on them in the field. This is a critical deficiency. Despite having no training in electrical layout and distribution, they are tasked with setting up and right-sizing electrical grids."[45] The Army's power management problem was compounded by the lack of more senior technical expertise. The Army had no equivalent to the Marines' Utilities Officers and Utilities Chief, and the OE Advisor was still just a concept field-tested in Afghanistan during Operation Dynamo, as previously described.

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44 Figure by Lincoln Laboratory "Tactical Power Systems Study," as in Broekhoven, *et al.*, 81.

45 Broekhoven et al, 83. The report describes that the grid designer as "responsible for identifying loads and generator assets at a given location and designing an appropriate distribution of loads onto assets to ensure generators experience neither wet stacking nor overload/fault conditions during typical use conditions. This person is likely trained in power-planning software such as AutoDISE, and has sufficient experience in the field to understand how different loads are typically utilized. The grid designer is also responsible for reconfiguring power grids when they diverge from initial layouts. This role is often utilized in locations lacking appropriately trained personnel for ensuring stable and efficient grid designs." Broekhoven et al, 80.

Another example came from Network Integration Exercise (NIE) 14.2 in 2014 at Fort Bliss, Texas, where a microgrid configured with the newer AMMPS generators powered a brigade command post. While the system performed as expected, personnel and training issues proved a limiting factor in its implementation. In one case, the command post lost power due to the improper connection of the PDISE, which caused a power spike and a shutdown of the power system. One assessment described operational benefits of microgrids (load balancing, better performance, improved fuel efficiency) while also noting the negative impacts:

> The microgrid power system is complicated. Initially, the unit experienced power interruptions because they did not understand how to plan and deploy the equipment properly. The unit requires a power manager trained to properly employ the AutoDISE software to prepare a detailed plan to prevent overloading circuits to [command post] power users.[46]

A September 2015 report by the DWG for the Joint Standardization Board for Mobile Electric Power Generating Systems went even further in labeling the Army's entire approach to power management as "inadequate" to keep pace with the growing complexity of power systems, particularly related to personnel, doctrine, and training. According to the group's report, the Army lacks a definition of power management and other related questions, such as why power management is necessary, who are the power managers, and how to train/employ them.[47] The DWG also agreed with the Lincoln Laboratory authors that 91D personnel (maintainers) are not the best choice to handle new power management responsibilities, like planning, and that these new functions would take them away from their core competencies.[48] Building on that idea, the DWG report noted that while the Army intended to "develop distribution equipment with intelligent power management features that they believe will eliminate the need for highly trained power managers," they cautioned that

> The only way to achieve this [capability] is by adding electronic components (communication, decision making and sensing) and moving parts (switching devices) to the distribution equipment. These additions add weight and cost, and decrease reliability and flexibility. The other Services, leveraging the advanced skills, knowledge, and attributes of their organic electrical specialists, use or are in a position to use flexible distribution equipment that offers the largest range of options for power management to their commanders. *In essence, the Army wants distribu-*

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[46] David Scalsky, Larry Martin, and David Gray, "DOTMLPF-P and Technology Assessment Capability (DTAC) Individual Assessment and Analytic Charts to Support System Under Evaluation (SUE) Final Report Annexes," (Kettering, OH: SURVIAC, 30 May 2014), 7. The report further described the personnel impact: "The complexity of power management using the micro grid requires a full-time power manager. This Soldier must have sufficient rank (E6-E8) to manage the system, to supervise its correct setup, and to reset or adjust the power distribution when command post design changes occur" (13).

[47] *Distribution Working Group FY2015 Army Report*. ii–iii.

[48] *Distribution Working Group FY2015 Army Report*, 5.

> *tion equipment with simple user interface and sophisticated system components. The other Services want distribution equipment designed with basic components that will be managed by a sophisticated operators.* It is the DWG's opinion that until the Services develop a similar approach to power management, they will not be able to adopt common equipment.[49] (Emphasis added)

The DWG report pointed to other examples of an Army unit's organic power management capabilities experiencing difficulties with more complex systems. A microgrid installed at a company-sized camp in the United Arab Emirates in 2013 became inoperable when unit personnel attempted to reconfigure it. As the DWG report noted, "the unit's power managers were not properly trained, and therefore could not articulate or identify the issue, and as a result Force Provider had to redeploy the team to diagnose the failure."[50]

Most recently, the Naval Surface Warfare Center published its *Behavioral Energy Operations Demonstration (BEyOnD) Phase I* report, analyzing the potential for the Army and Marine Corps to reduce their operational fuel consumption through behavioral changes as applied to diesel generators and environmental control units.[51] The researchers found a number of challenges specifically for the Army:

- The task of operating power grids is most critical at the BCT-level and below, but the only MOS trained to do so (12P) has insufficient numbers to provide support at these levels
- The 91D career path progresses from power generation specialists to motor pool supervisor at E-7, which "creates a void of Senior NCOs in this specialty to advise the command" in addition to the lack of a warrant officer career field dedicated to utilities
- Compared to their Marine counterparts, 91Ds do not receive enough electrical training

As with the USACE lessons-learned report, the BEyOnD authors noted that the Army does not have a specific MOS for operating low-voltage power generation equipment, assigning the task to any available Soldier, "the same Soldiers who have come back from long patrols and are given the added role of fueling onsite generators and doing their best to keep those systems running." And:

> Unlike the USMC, Navy, and Air Force, the Army does not train low-voltage electricians to provide support in forward deployed areas. The result is that the owners and operators of tactical power generation equipment and those responsible for

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49 *Distribution Working Group FY2015 Army Report*, 2.

50 *Distribution Working Group FY2015 Army Report*, 12.

51 Eric Shields and Dr. Amy Wolfe, *Behavioral Energy Operations Demonstration (BEyOnD) Phase I*. Naval Surface Warfare Center, Carderock Division, NSWCCD-63-TR-2016/21, August 2016.

maintaining “right sized” grids are those with no electrical training, and only a cursory training in generator operation.[52]

Table 1 summarizes the Army’s documented power management challenges in recent years: the lack of baseline power management training, complex systems that require specialized training to operate them, misaligned power management roles and responsibilities, and a prohibitive organizational structure that does not match lower ranks with more experienced leadership to provide training and oversight.

Taken together, these recommendations and observations indicate that the Army still faces considerable power management challenges. Specifically, the concern is that the “smart” power systems the Army is fielding (or plans to field in the future) still require skilled personnel at brigade and below levels and are not the “plug-and-play,” worry-free systems as suggested.

Table 1. Summary of Documented Army Power Management Challenges

Challenge	Op Dynamo	USACE	Lincoln Labs	NIE 14.2	DWG	BEyOnD
Lack of baseline training in power management	X	X	X	X	X	X
Systems too complex without specialized training			X	X	X	
Misaligned roles and responsibilities		X	X		X	X
Prohibitive organizational structure			X			X

52 Shields and Wolfe, *Behavioral Energy Operations Demonstration (BEyOnD) Phase I*, 29.

3. Literature Review of Joint Requirements and Capability Gaps

As the Army and Marine Corps took stock of their lessons learned during sustained deployments to Iraq and Afghanistan, a parade of requirements documents, white papers, and external studies started to appear in 2009 that sought to address the operational energy issues that had plagued the tactical edge during the previous several years. Figure 10 shows the chronology of these documents.

In this chapter, we review the Army and Joint Staff-approved requirements documents for power management gaps as well as the capability gaps identified through TRADOC Capability Needs Analysis process.

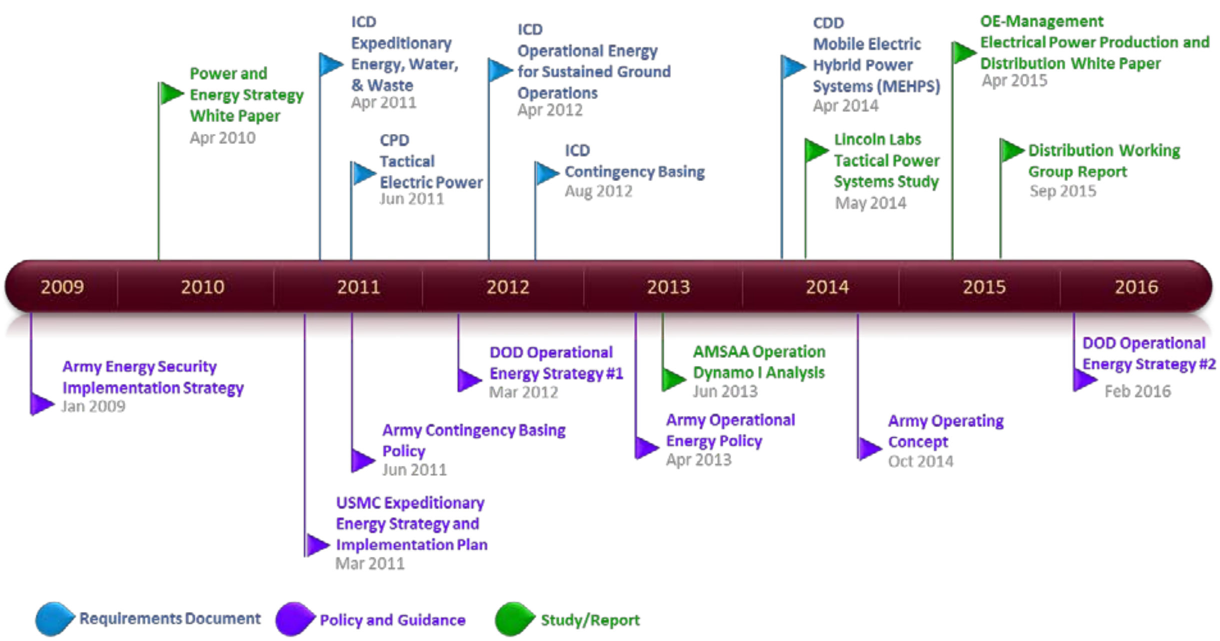

Figure 8. Timeline of Relevant Power Management Documents

A. Joint Requirements Documents

Four key documents—one white paper, two initial capabilities documents (ICDs), and one capabilities production document—form the foundation of the Army's official requirements for tactical electric power systems as part of the larger operational energy portfolio. Between the two ICDs, there are 22 identified capability gaps that focus primarily on institutional awareness and operational energy best practices, base camp sustainment, energy storage, and minimizing logistics challenges by reducing fuel demand. The ICDs also contain an additional 34 “ideas for non-material approaches” to augment any proposed materiel solutions, 26 of which we assess as related to power management. The original descriptions of these gaps and non-materiel recommendations are listed in Appendix A. The following sections describe the key points of each document in more detail.

1. Power and Energy Strategy White Paper

The capability development process for tactical electric power began with a 2010 white paper published by ARCIC. Although not part of JCIDS process, the *Power and Energy Strategy White Paper* substituted for a capabilities based analysis, laying the analytical groundwork for what the Army would later incorporate into its operational energy for sustained ground operations initial capabilities document.[53]

The white paper covered five overarching categories for operational energy: enduring infrastructure power, expeditionary base camps, ground vehicle power, aerial vehicle power, and soldier power. Of these, only the section on expeditionary base camps touches on tactical electric power capabilities and requirements as currently conceived for this research, namely from company-level combat outposts to forward operating bases supporting a BCT. Within the context of these expeditionary base camps, the ARCIC paper noted that

> Both forcible and early entry operations are characterized by multiple sites operating over wide areas in a distributed fashion, complicating electrical power generation and energy resupply in general. Solutions to this situation are complex, and energy demand and supply must be balanced to facilitate effective warfighting. Reducing power demand is a significant part of the equation, as is developing the means to provide supply.[54]

The white paper suggested a number of suggested requirements for improving existing power management systems for expeditionary operations and base camps. Underlying these requirements is the sense that assured access to a continuous supply of electrical power involves balancing the expense and risk of importing bulk fuel with the unreliability of indigenous infrastructure to support deployed US forces. Base camp electrical grids must therefore “incorporate ‘smart-grid’ control technology to enable commanders/staffs to effectively manage their electrical generation, distribution and use. Grids will facilitate energy storage, and prioritization of loads.”[55]

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53 Army Capabilities Integration Center, Research, Development, and Engineering Command; and Deputy Chief of Staff, Army G-4, *Power and Energy Strategy White Paper*, 1 April 2010.

54 ARCIC, *Power and Energy Strategy White Paper*, 9.

55 ARCIC, *Power and Energy Strategy White Paper*, 9.

Incorporating advanced technology is another key component of the white paper's suggested requirements, which include establishing "power management processes and tools to determine, monitor, and adjust load and demand," as well as seeking out innovative alternative energy sources in order to "eliminate generators by 2030."[56] As modern systems move away from liquid fuel as the driving source of electrical power generation, the Army must

> continue to work to develop its electrical power integration approach, including component design (e.g., controls, switching and storage) and integration approaches such as modularization and smart grids. The multi-energy solution will provide a significant contribution toward increased ground force flexibility and adaptability.[57]

The white paper also showed the origins of the Army's philosophy of energy-informed operations. "The greatest and most important challenge," the authors write, "is to empower each member of the team as an energy manager."[58]

In the paper's overall conclusions, the authors noted that "the most significant, crosscutting challenge is to build capabilities and processes to monitor and manage power and energy…Awareness and control are fundamental enablers for performance improvement, regardless of the DOTmLPF solutions we choose to apply."[59]

2. Capabilities Production Document for Tactical Electric Power

Just over a year after ARCIC published their white paper, CASCOM released the capability production document for tactical electric power (TEP), describing the official requirements for modernized tactical electric power systems. Approved by the Department of the Army Headquarters in June 2011, the capability production document was an updated version of a 2004 operational requirements document for tactical electric power that predated the JCIDS process and consequently had no ties to any originating capabilities based analysis, ICD, or capability development document.

The document focused on the materiel requirements for a modernized tactical electric power system to replace the Army's set of tactical quiet generators from the 1970s and 1980s. The capability production document described the key performance parameters and key system attributes of a new tactical electric power system in great detail, but also discusses other DOTmLPF-P considerations beyond the materiel solution (which would later become advanced medium mobile power sources or AMMPS). The bulk of the non-materiel discussion

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[56] ARCIC, *Power and Energy Strategy White Paper*, 9–10

[57] ARCIC, *Power and Energy Strategy White Paper*, 10.

[58] ARCIC, *Power and Energy Strategy White Paper*, 12.

[59] ARCIC, *Power and Energy Strategy White Paper* 24.

covers organization, training, and personnel, making the case that fielding a new generator system would lead to only minimal changes in the organic units that field them. In fact, the capability production document stated that:

> There are no changes to the unit's TOE, and Tactical Electric Power (TEP) will not affect its organizational tasks. Sustainment units in the Army and other Services will provide logistic support. Given that the new TEP systems will possess greater reliability, augmenting sustainment units and/or Contractor Logistics Support (CLS) is not required. This capability will not require a new Military Occupation Specialty or Special Skill Identifier. The MOS-incidental Soldier-operator has the competencies needed to employ this capability. MOS 91D, Power Generation Equipment Repairer, is the maintainer.[60]

After the initial, contractor-provided new equipment training, unit commanders with the modernized systems would be responsible for sustainment and proficiency training. According to the capability production document, "TEP sustainment training in operational units is the commander's responsibility," and "TEP operators will serve as unit trainers and advisors to commanders on TEP employment, sustainment, and training." It is unclear who is meant by TEP operators, or what training they were to have received in order to train other operators and advise commanders on these systems, particularly since the Army's traditional approach to generator employment relies on lower enlisted or junior non-commissioned officers without regard to their primary occupational specialty. Later, the capability production document states that

> Once soldiers complete their operator/maintainer [new equipment training], they will have the necessary skills to operate the equipment (and support equipment). The primary users in all the services are MOS-incidental Soldiers, Sailors, Airmen, and Marines.[61]

The capability production document was revised and republished in 2014, but without notable changes to the non-materiel section.

3. ICD for Operational Energy for Sustained Ground Operations

Building on the broad ideas of the 2010 Power and Energy Strategy white paper, Army analysts at ARCIC drafted an ICD in 2012 that addressed materiel and non-materiel gaps in operational energy for sustained ground operations (hereafter referred to as OESGO) from the perspective of an expeditionary BCT.

While emphasizing the importance of efficient, effective power and energy to joint operations, the ICD identified the required capabilities and current capability gaps for four opera-

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60 CASCOM Materiel Systems Directorate, *Capability Production Document (CPD) for Tactical Electric Power (TEP)*, 10 June 2011, 30.

61 CASCOM Materiel Systems Directorate, *Capability Production Document for Tactical Electric Power*, 34.

tional energy focus areas: (1) Soldier Power and Energy; (2) Aviation Systems; (3) Surface Systems; and (4) Expeditionary Base Camps. Most of the required capabilities reference improving efficiency/reducing fuel demand, flexibility, and knowledge management of power and energy systems.

The analytical underpinnings of the ICD came from Operational Needs Statements, drawn from forces deployed to Iraq and Afghanistan, which indicated a "lack of sufficient power generation, energy storage, energy conversion, and power distribution systems to meet the demands of distributed operations in harsh environments."[62] In total, the ICD identified 16 capability gaps across the 4 focus areas, many of which focused on the inability of forces to monitor and manage the supply and demand of their power systems.

In general, the ICD emphasized developing materiel solutions that will require the least amount of human intervention, and that "energy and power systems should be automated to the maximum extent possible to reduce the need for additional manpower."[63] The ICD also briefly listed a handful of DOTmLPF-P ideas and approaches that could mitigate some of the capability gaps, though the authors are careful to note that non-materiel solutions alone cannot sufficiently address the problem. Importantly, the final recommendations section of the non-materiel approach section says that

> The Army can immediately undertake a number of non-material solutions to address operational energy gaps. For example, expanding upon the systems architecture developed in conjunction with this ICD, and integrating energy into operational analyses each will provide insights needed to refine TTPs, decision criteria, and performance measures that are necessary to enable step improvements in operational energy outcomes. In addition, the Army can initiate the DOTmLPF-P Change Recommendation (DCR) process to address additional potential non-materiel solutions.[64]

To date, there have not been any official DCRs that followed this recommendation.

4. ICD for Contingency Basing

Around the same time as the publication of the OESGO ICD, the Joint Requirements Oversight Council approved an ICD for Contingency Basing.[65] Primarily written by engineers working in the Joint Staff J4, the document sought to identify and prioritize the gaps and necessary capabilities for operating at contingency locations for the 2015-2024 timeframe. The ICD noted that most of the capability gaps for contingency basing tend to be "non-materiel in

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62 ARCIC, Initial Capabilities Document for Operational Energy for Sustained Ground Operations, 27 March, 2012, 7.

63 ARCIC, ICD for OESGO, 14.

64 ARCIC, ICD for OESGO, 14.

65 Joint Requirements Oversight Council, "Initial Capabilities Document for Contingency Basing," 6 August 2012.

nature" and grouped these gaps intro three categories: (1) time and location; (2) size and type; and (3) integration.[66]

Within the gaps for integration, the ICD focused on the master planning requirements for contingency bases, including the generation, distribution, and management of power as well as water, waste, and construction materials. An important component of this was the question of how to plan, manage, and synchronize the electrical power requirements across the Joint Force, and, more specifically, how to ensure that the Services had an adequate number of trained personnel to support commanders at all echelons of contingency locations.

Altogether, the Contingency Basing ICD identified six capability gaps, three of which implicitly include elements of power management:

- The Joint Force lacks sufficient capability for contingency location master planning and facilities design;
- The Joint Force lacks sufficient and proficient functional area capabilities to operate contingency locations;
- The Joint Force lacks sufficient and proficient capabilities to manage and integrate contingency location operations.

None of these gaps specifically refers to power management or directly references any of the gaps in the OESGO ICD. Unlike the OESGO ICD, though, the Contingency Basing ICD did lead to a number of Army DOTmLPF-P Integrated Capabilities Recommendations (DICRs) to generate non-materiel solutions to the capability gaps, most of which belong to the engineer community and focus on improving base camp management capabilities. These DICRs, while complementary, do not directly address power management at the brigade level and below.

B. Capability Needs Analysis Gaps

In addition to the capability gaps and requirements identified through JCIDS, TRADOC leads a parallel process—the CNA—designed to reveal capability gaps independent of materiel acquisition efforts. While we describe this process in more detail in Chapter 5, ARCIC's Sustainment Division supplied us with the descriptions of the gaps they are tracking within the scope of tactical electric power:

> **Gap 460081**: The Infantry Brigade Combat Team (IBCT) lacks the ability to provide and sustain power during persistent operations in all environments under unified land operations at all echelons brigade and below, and an inability to recharge batteries to support organic systems.

[66] Joint Requirements Oversight Council, ICD for Contingency Basing, i.

> **Gap 462206**: The Armored Brigade Combat Team (ABCT) lacks the ability to execute critical tasks during unified land operations due to the physical limitations of the systems that have exceeded the original required size, weight and power margin specifications
>
> **Gap 500742**: The Stryker Brigade Combat Team (SBCT) lacks sufficient tactical mobility to execute mission-essential tasks during unified land operations due to demands of the systems that have exceeded the original required size, space, weight, and electrical power growth margin specifications.

The second and third gaps address the electrical power requirements of the vehicle platforms (armored vehicle and Stryker, respectively) associated with two of the Army's BCT-variants. The first gap, closer in spirit to the issues of power management, nonetheless contains nothing specific about managing tactical electric supply and demand. Depending on how one interprets the language of the first gap (ignoring the clause about rechargeable batteries), the emphasis could be on several different elements of the paragraph—which element is more critical, the ability to provide and sustain power during "persistent operations," or "in all environments"? Combining these elements with the second part about rechargeable batteries only exacerbates the ambiguity, though there may be an opportunity to use this ambiguity to justify future power management DCRs.

There is no significant evidence in the CNA database of acknowledged gaps, nor any suggestion that power management deficiencies are leading to mission failure at any echelon. In all likelihood, this circumstance reflects reality—power management has not yet risen to a level of urgency to the extent that it threatens risk of mission failure.

C. Observations on Capability Gaps and Requirements Review

Although the capability gaps documented through the Army's requirements development processes identified a number of important issues relevant to tactical electric power and power management, the non-materiel aspects of power management are neither defined in detail nor treated as a capability gap. This literature review led to our second finding:

Finding #2: The Army has captured key aspects of power management capabilities gaps in various requirements documents, but opportunities remain to define these gaps more fully at the brigade- and battalion levels through the DCR process.

In one sense, this is unsurprising—due to their inherent focus on system acquisition, the JROC-approved capability gaps tend to favor materiel solutions while minimizing the need for the Services to adapt their non-materiel approaches. In many cases, the authoritative requirements documents describe the some of the tasks associated with power management, but could be expanded to identify who should perform them. This includes both operational and institutional levels.

Future initiatives to adapt and improve the Army's approach to power management should align with official DoD and Army analytical processes in order to reveal, characterize, document, and prioritize power management capability gaps and present non-materiel solutions to close them. Operating outside these processes creates bureaucratic obstacles that could hinder changes to doctrine, organization, training, and policy.

4. Initiatives to Improve Army Power Management

Despite the lack of official DOTmLPF-P change requests to completely address non-materiel issues of power management, the functional area proponents of operational energy have addressed shortfalls in the Army's approach to power management. Consequently, the two primary stakeholders—CASCOM and MSCoE—are leading efforts to improve Army power management capability, focused primarily on updating doctrine, improving training support packages, and revising roles and responsibilities at the BCT level and below. A third organization, MCCoE, while not directly focused on improving power management capabilities, nonetheless relies on improved power management as part of its solutions for modernizing and enhancing command post operations. The following sections summarize each organization's current initiatives and their relevance to power management.

A. Combined Arms Support Command

CASCOM's efforts to improve the Army's power management capabilities are concentrated in two areas: publishing an Operational Energy Training Strategy, and implementing the Tactical Power Management Training Concept. CASCOM has also drafted a training circular for tactical electric power production and distribution, and revised the official duty descriptions of the 91D MOS to include elements of power management.

1. Operational Energy Training Strategy

CASCOM's Operational Energy Training Strategy is designed to implement the Army Operational Energy Policy, published in 2013. The OE Policy emphasized creating an "energy-informed culture through education, training and awareness programs that values energy as a resource that enables enhanced capabilities (agility, endurance, flexibility, resilience) and lowers operational risk."[67] CASCOM's Training Strategy focuses on three domains: institutional, operational, and self-developmental. Figure 11 depicts the supporting efforts within each domain.

[67] CASCOM, *Army Operational Energy Policy*, 30 April 2013, 2.

Operational Energy Training Strategy

Institutional Domain Training

- Operational Energy (OE) Awareness (IMT – BCT – BOLC(A))
  - General OE awareness - best energy practices, energy conservation and practical tactical energy demand reduction techniques.
- OE Management (PME NCO/BOLC(B)/WOBOLC(A)/CGSC/GO/SES).
  - Management and planning of unit energy requirements in tactical operations.

Operational Domain Training

- Technical Training (Home Station)
  - Planning, supervision and employment of tactical electric power production, distribution and storage equipment during expeditionary base operations
- Leaders Training (Home Station)
  - Strategic planning and endorsement of OE best practices in support of military operations.
- Contingency Training (Combat Training Centers)
  - Inclusion of OE in the MDMP process and reaction to energy interdiction scenarios.

Self-Development Domain

- Expand individual knowledge and skills. Includes general information on OE initiatives and energy awareness, leader planning skills, technical skills, familiarization with lessons learned and best energy practices.

Figure 9. CASCOM Operational Energy Training Strategy

The OE Training Strategy acknowledged that the benefits of technological solutions are limited without a commensurate focus on improving soldiers' knowledge and skills. "Without an effective training and education regimen," the authors write, "the most efficient and capable technologies available are practically worthless if employed by untrained Soldiers and led by those who do not understand their capabilities and limitations."[68] A companion article for *Army Sustainment Magazine* titled "What is the Army Doing with Operational Energy?" also discusses the importance of developing a training strategy:

> The goals of the strategy are to give Soldiers and leaders the knowledge and skills needed to manage and use operational energy effectively and to make energy a consideration in all they do…Soldiers should receive tiered technical training and leader education in power production, distribution, storage, planning, and management.[69]

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[68] CASCOM, *Army Operational Energy Training Strategy*, 2015, 2.

[69] Ryan Hulse, "What is the Army Doing With Operational Energy?" *Army Sustainment Magazine* (March-April 2016): 52.

In an attempt to clarify operational energy roles and responsibilities, the training strategy includes a section on home station technical training as part of the operational domain, noting that the "target audience for the tactical electric power technical training is defined by roles and responsibilities and not confined to specific MOSs."[70] Further, the strategy seeks to define more clearly the interactions between operator, power manager, 91D repairer, and advisor:

> The **operator** is the Soldier designated by the unit leadership to employ, operate, and maintain tactical electric power generation and distribution equipment. The **power manager** is the designated supervisor (NCO, Warrant Officer, or Officer) assigned to plan and manage tactical electric power systems, analyze and develop site layout plans, and supervise overall operation of the tactical electric power process. The 91D30 Power Generation Equipment Repairer can serve as the tactical electric power advisor, and conduct training for the operators and managers as can the 12P Prime Power Production Specialist and 120A Construction Engineering Technician when available. A member of the company leadership team is responsible for ensuring the power management staff receives sufficient training to meet and maintain qualification standards.[71]

As a complement to the technical training, CASCOM is also developing handouts on operational energy topics for leaders attending the Company Commander and First Sergeant Pre-Command Course. These topics include training and licensing requirements for generator operators as well as the need to identify a unit power manager to "analyze, plan, and supervise the use of power, both in garrison and during tactical operations."[72] CASCOM is also developing a Training Support Package (TSP) on power management designed to

> [Provide] the supervisor with enough technical knowledge to direct the work of the operator, review plans, and recognize properly established and utilized tactical electric power generation and distribution equipment. The training is appropriate for NCO's, Warrant Officers, and Officers performing planning and supervising functions. The TSP will include interactive multimedia instruction and lists of references suitable for use in unit training.[73]

This power management training would include the following topics, taken verbatim from the training strategy:

- Manage tactical electric power operator training and licensing.
- Ensure training and planning resources are accessible, i.e., AutoDISE program.
- Review tactical electric power equipment required/on hand.

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[70] CASCOM, *Army Operational Energy Training Strategy*, 10.
[71] CASCOM, *Army Operational Energy Training Strategy*, 10.
[72] CASCOM, *Army Operational Energy Training Strategy*, 11.
[73] CASCOM, *Army Operational Energy Training Strategy*, 12.

- Develop, update or approve site layout plan.
- Supervise installation/employment/maintenance and monitoring of tactical electric power equipment.

2. Tactical Power Management Concept

In addition to the Operational Energy Training Strategy, CASCOM has developed a TPMC designed to

> Influence attitudes and shape sustaining behaviors, creating an environment where every Soldier views energy as a critical enabler and has the skills to plan for and use energy wisely in the execution of current and future missions. Assigned Soldiers will develop necessary skills to efficiently employ and manage unit tactical electric power systems.[74]

Figure 12, taken from an August 2016 overview brief, shows the TPMC concept of employment—the goal is two trained generator operators and one unit power manager per battalion as well as for the brigade main headquarters. The concept is explicitly aligned with Army Warfighting Challenge 16 (Set the Theater, Sustain Operations, and Maintain Freedom of Movement) as well as the three Capability Needs Analysis gaps described in Chapter 3.B.

In a way, the TPMC serves as a component of the implementation plan for the OE training strategy. CASCOM developed Training Support Packages for testing and evaluation during Army Warfighting Assessment (AWA) 17.1 in August and October 2016, focused on training operators and unit power managers to plan, establish, and operate electrical power grids for command posts. The stated objective for the TPMC is "Given assigned TEP equipment systems, technical, planning and management training, units meet their power production requirements and reduce energy-related logistics requirements."[75]

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74 CASCOM Tactical Power Management Concept, unpublished briefing, 26 August 2016.
75 CASCOM Tactical Power Management Concept, unpublished briefing, 26 August 2016.

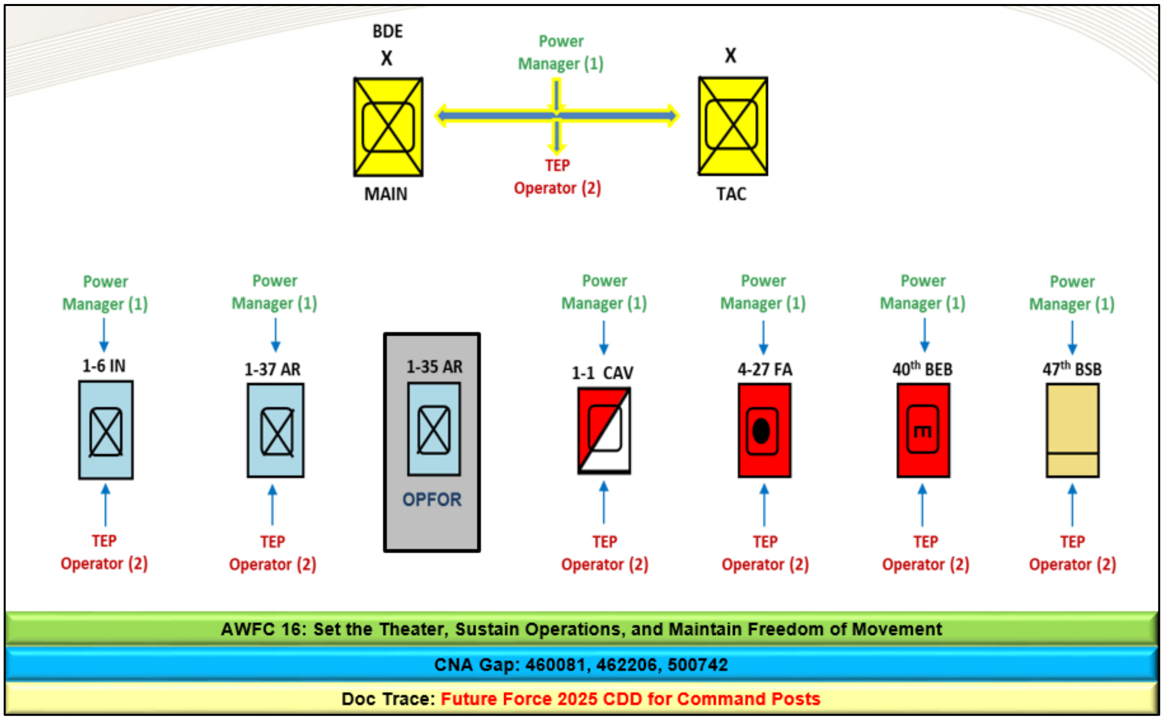

Figure 10. Tactical Power Management Concept – Concept of Employment

The training materials for the pilot program focus on three groups at the battalion level: Unit Leaders, UPMs, and Generator Operators. The program called for the Unit Leaders to receive two hours of instruction on the basics of operational energy and tactical power planning, base camp principles, power generation and distribution equipment, analyzing electrical load requirements, and certification programs for generator operators and unit power managers.

The bulk of the training materials were aimed at the UPMs and TEP Operators—both groups were to receive ten hours of instruction. According to the TPMC overview brief, the units designated to participate in the pilot training program were expected to do the following prior to AWA 17.1:[76]

- Identify 2–3 individuals (SSG and below) as assigned generator operators; Tactical Electric Power Operators, with required operator licenses prior to New Equipment Training.
- Each battalion and brigade will be required to identify 91D30s or a senior staff individual (SFC, MSG, WO, CPT, MAJ) as the UPM.
- Brigade designates lead Soldier as Brigade Operational Energy Advisor (120A preferred) providing liaison noncommissioned officer assistance in planning and coordi-

76 Adapted from CASCOM Tactical Power Management Concept, unpublished briefing, 26 August 2016.

nating with unit power managers in preparing for new equipment training and AWA execution.

- Training must be completed early enough for training to be incorporated into unit planning for AWA 17.1—recommend early within the new equipment training window. Units will identify power distribution requirements and TEP assets to ensure training is developed properly.

The intent of the pilot program was to assess the effectiveness of the training and determine whether the training led to more efficient and effective management of the unit's tactical electric power. One crucial detail is the ambiguity of who should be the unit power manager—both the TPMC and the OE Training Strategy waver on this point, with the TPMC stating that the pilot units could select either a 91D30 (Staff Sergeant) or a more senior staff individual (E-7 and above) regardless of MOS. The OE Training Strategy, in the paragraph on roles and responsibilities quoted in the previous section, uses similar language for its description of the power manager—the power manager is simply a "designated supervisor" (NCO, Warrant Officer, or Officer), though the document explains that the 91D30 can "serve as the tactical power advisor" as can the 12P prime power specialist or the 120A Construction Engineer warrant officer "when available." We address this further in Chapter 6.

3. Tactical Electric Power Production and Distribution Training Circular

As a way to formalize the content in the OE Training Strategy, CASCOM has also drafted a Training Circular (TC), TC 4-37.10, for *Tactical Electric Power Production and Distribution*, which serves as a

> compilation of Tactics, Techniques, and Procedures (TTP) found in doctrine, lessons learned, and other reference material. It provides a systematic approach for planning, managing, producing, distributing and storing tactical electric power. This TC also incorporates current best practices, technologies and considerations into a "how-to" guide for TEP operations.[77]

The training circular covers the basics of operational energy, a description of the electrical power domains, power management roles and responsibilities, tactical electric power planning and production, a sample tactical electric power standard operating procedure, and a series of appendices with relevant data, calculations, equipment, and more.

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[77] TC 4-37.10, *Tactical Electric Power Production and Distribution*. January 2017 (draft). Just before publication of this paper, this training circular was renumbered as TC 4-30.02. For consistency, this paper will retain references to the original number rather than the latest version.

4. 91D MOS Roles and Responsibilities

The Army Ordnance School, which falls under CASCOM, has updated the official duty descriptions for the 91D Power Generation Equipment Repairer, now called the Tactical Power Generation Specialist. Figure 13, provided by the Army Ordnance School, shows the updated tasks of the 91D MOS for each skill level. CASCOM has also updated the duty descriptions for each 91D skill level in Department of the Army Pamphlet (DA PAM) 611-21, *Military Occupational Classification and Structure*, which were approved in October 2015 and will go into effect in October 2017. Appendix C shows a detailed comparison of the original 91D duty descriptions with the revisions.

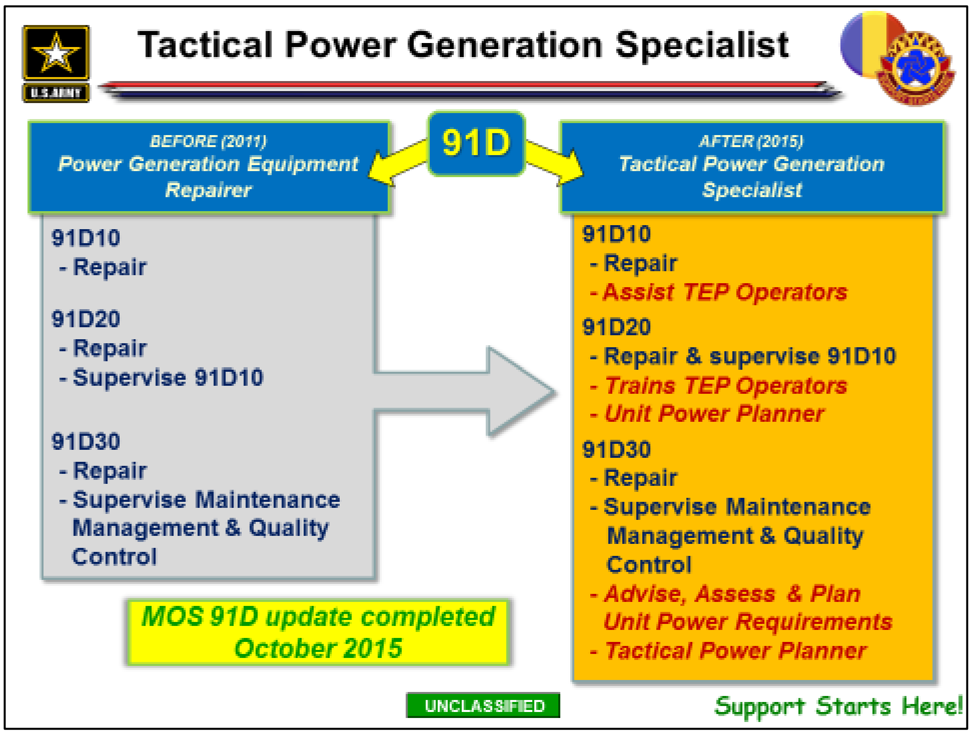

Figure 11. Updates to 91D Roles and Responsibilities

B. Maneuver Support Center of Excellence

According to the hierarchy of the Army Universal Task List (Section 2.C.1), MSCoE is the owner of power management doctrine. As such, they have also undertaken efforts to improve the non-materiel aspects of power management, specifically through a white paper designed to "shape and inform the products created through the JCIDS process"[78] as well as an

[78] MSCoE CDID, "Army Operational Energy Management," 1 April 2015, 6.

initiative to train MOS 120A (Construction Engineering Technician) warrant officers as operational energy advisors.

1. Army Operational Energy Management: Electrical Power Production and Distribution White Paper

In April 2015, MSCoE published a white paper titled *Army Operational Energy Management: Electrical Power Production and Distribution*. The paper was designed to

> serve as the conceptual basis for acknowledging the need for integrated Army OE-[Management] across the recognized areas of OE and will provide a coordinated path forward and a framework to guide future developments. Specifically it will focus on developing solutions for the future force relating to Electrical Power Production and Distribution for the Army across the doctrine, organization, training, materiel, leadership and education, personnel, facilities, and policy (DOTmLPF-P) domains.[79]

As with CASCOM's efforts, the MSCoE paper recognizes that the Army's current approach to power and energy management has been faced with challenges. Specifically, they note that

> the Army lacks the necessary personnel, training, and materiel solutions to optimize energy use at both the production and end-user stages. This inability to optimize energy use significantly contributes to a larger logistics footprint/burden than might otherwise be needed. The Army can improve efficiency through personnel and materiel developments, and reduce waste through disciplined energy use. This requires formalized policy, doctrine, training, and standards.[80]

The rest of the white paper examines Operational Energy Management (OE-M) operations with a focus on why the current approach leads to inefficiencies, particularly with respect to power production and distribution.[81] The paper also devotes considerable attention to the challenges facing base camps. One of the primary challenges is the ability of those responsible for base camp management to improvise and adapt to the many variables that drive energy requirements, from operational phases and mission profiles to the differences of each physical location. "This complex nature of base camps," the authors write, "and consequen-

[79] MSCoE CDID, "Army Operational Energy Management," 2.

[80] MSCoE CDID, "Army Operational Energy Management," 3.

[81] The white paper consistently refers to Operational Energy Management defined as "the purposeful planning and oversight of energy resources from raw fuel (of any form) to usable consumer energy." Although this concept is distinct from power management as defined in Chapter 2, the document nonetheless captures many of the elements of power management.

tially power systems that support them, requires personnel to think and function in nonlinear ways and rapidly update energy delivery and consumption plans."[82]

The inherent difficulties of managing base camp operational energy are exacerbated by the confluence of non-materiel factors that complicate decision making—leaders often do not know what they don't know, and have few references to teach them. According to the white paper,

> Leadership often lack the appropriate knowledge, experience, resources, and/or personnel to make energy informed operations. Outdated doctrine, policies, and TTPs, combined with conflicting missions, do not give leadership the knowledge base required for OE-M…Personnel on-ground often lack the requisite training and experience necessary to manage power systems to obtain maximum efficiency. Commands delegate responsibility to the "best qualified" person, which may result in unqualified personnel managing a system they know nothing about.[83]

This lack of specialized knowledge is not limited to unit leaders, though. The Army's recent tendency to rely on "tactical power systems designs [that] are simple, intuitive, and intended for operation by any person within the unit" obscures the complexity of performing the specified tasks. On one hand, the white paper notes, "this arrangement reduces the number of personnel needed during expeditionary operations." This comes at a cost, though, as

> the lack of specialized personnel, combined with the overly simplistic power system design, creates a perfect-storm of learned helplessness; we do not know what we do not know, and we do not know how to fix what we do not know is wrong.[84]

After describing the challenges facing OE-M today, the MSCoE white paper then looks at the future and suggests ways it could be improved, noting that the "success of future operations is dependent on the Army's ability to implement solid OE-M practices, reduce waste, and increase efficiency where possible."[85] Again, the authors highlight the importance of training Soldiers with the right tools to succeed in quick-reaction environments:

> Power systems and OE-M solutions must empower the force to adapt quickly to on-ground changes and integrate seamlessly into the configuration. The ability to adapt rapidly to change requires foresight and planning by highly skilled personnel… These subject matter experts must be capable of assessing, designing, and constructing new and existing power systems to obtain maximum efficiency. These personnel must possess both working experience and theoretical knowledge of power production and distribution.[86]

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82 MSCoE CDID, "Army Operational Energy Management," 13.
83 MSCoE CDID, "Army Operational Energy Management," 13.
84 MSCoE CDID, "Army Operational Energy Management," 15.
85 MSCoE CDID, "Army Operational Energy Management," 16.
86 MSCoE CDID, "Army Operational Energy Management," 18-19.

The final section of the white paper assesses the DOTmLPF-P elements of OE-M. Although the document covers each element, we focus on doctrine, organization, training, and personnel based on the scope of our research.

Doctrine. "The Army must build OE-M considerations into doctrine so it is present during planning and execution phases, and understood at all levels."[87] The paper also lists a number of current engineering publications that should be updated to reflect elements of OE-Management, including "power system considerations, construction, operations, and maintenance; construction and insulation of buildings and facilities; overall base camp planning and construction."[88]

The authors also argue that the Army should "reassess the doctrinal responsibilities and division of labor between the personnel responsible for electrical power and distribution tasks to fill gaps and create proper overlap."[89] This is a crucial point that we will discuss in more detail in Chapter 6.

Organization. Units require functional, flexible equipment as well as the right mixture of personnel to employ it—"Unit equipment must be inherently efficient, scalable, simple to setup and use, and properly trained personnel available to operate it."[90] Knowing how to request higher echelon assistance is another critical organizational component. The white paper also notes that the Army "must diversify its personnel and create a balance between operators, maintainers, and advisors."[91] In a best case scenario, the paper suggests that

> it may be necessary to create, or make more accessible, specialized utilities units, similar to the 249th Engineer Battalion (Prime Power), which can assist forward operations by designing and constructing infrastructure (power, water, and waste). This organization will maximize capability and efficiency, and conserve resources.[92]

Training. Beyond instilling a culture of conservation and energy reduction into entry-level training courses, the white paper recognizes that more complex systems and equipment will require additional training. The paper argues that "training must be asymmetrical and focus on theory rather than a specific system," and lists a number of areas where additional training will be needed.[93]

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87 MSCoE CDID, "Army Operational Energy Management," 20.
88 MSCoE CDID, "Army Operational Energy Management," 20.
89 MSCoE CDID, "Army Operational Energy Management," 21.
90 MSCoE CDID, "Army Operational Energy Management," 21.
91 MSCoE CDID, "Army Operational Energy Management," 22.
92 MSCoE CDID, "Army Operational Energy Management," 22.
93 MSCoE CDID, "Army Operational Energy Management," 22.

- Officer Corps and Senior Enlisted trained in Base Camp operations and management
- Unit personnel properly trained on the basic setup and operations of single source power systems
- Increase of theory-based resident training for all MOSs that are involved in power systems operations and maintenance
- MOS 12R (Interior Electrician) trained in low voltage power systems, regardless of size or location, to include microgrid and alternative energy systems
- Safety considerations for microgrid and alternative energy systems
- MOS 12P increased training in low voltage microgrid and alternative energy systems

Personnel. The most critical personnel issue is the "mix of the power related MOSs within the different hierarchy of unit organizations."[94] The white paper describes this in detail:

> Throughout the years, a disconnection has grown between the MOSs directly responsible for power-related activities (12R, 12P, 12Q, 91D, and end-user responsibilities) and battlefield operations. The end-user is responsible for the setup and operations of a basic power system consisting of equipment on the Table of Organizational Equipment (TOE). The 91D, containing the most power-related personnel, is responsible for maintaining that TOE equipment to ensure system reliability and offer initial levels of expertise in system application. The 12R, 12P, and 12Q provide increasing levels of support and expertise as the system becomes more complex with the addition of theater provided equipment.[95]

Ultimately, this challenge boils down to "[having] the proper personnel within the formation to plan and then execute the expected missions, and the ability to request reach-back assistance from units with SMEs when the needed capability exceeds the organic qualification."[96]

2. Operational Energy Education and Operational Energy Advisor

After publishing the OE-M white paper, MSCoE, in conjunction with the Army Engineer School and in coordination with CASCOM, began looking at expanding operational energy education materials as well as the concept of an operational energy advisor at the BCT level.[97]

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[94] MSCoE CDID, "Army Operational Energy Management," 25.
[95] MSCoE CDID, "Army Operational Energy Management," 25.
[96] MSCoE CDID, "Army Operational Energy Management," 25.
[97] The content in this section is derived from an August 2016 pre-decisional Army Engineer School briefing to OSD, provided to IDA by the Army Engineer School.

Based on the assumption that there is a need for a "comprehensive Operational Energy Education program," MSCoE outlined a plan to develop and institutionalize a program of instruction that would blend distance-learning and classroom instruction through the Army Engineer School. Their efforts focused on training service members on energy best practices and developing individual capability to serve as unit energy advisors.

A critical component of the OE Education plan is to develop a Program of Instruction for the 120A Construction Engineering Technician Warrant Officer Basic Course. MSCoE's intent is to train these warrant officers to serve as Operational Energy Advisors within BCTs. Proposed training topics include:

- Operational Energy Strategy
- Planning and Management
  - Microgrid
  - TPMC
  - Medium Voltage
- Design of Energy Distribution
- Logistics
- OE Consumption Measuring Tools by Equipment
- Capabilities Based Assessment Tools for Combat Units

CASCOM, also consulted with respect to curriculum development, suggested that the following topics also be included:

- Battlefield Statistics
- Operational Impact (overview)
- Strategic Considerations
- COP/FOB operations (examples of poor set-ups followed by best practices)
- Electrical Theory (Effective generator/grid establishment, wet stacking, etc.)
- Alternative/Renewable energy solutions, considerations, pros/cons
- Current and near-term solutions at the individual, squad, platoon, company, COP/FOB (tailored to specific course)
- Operational Impacts (Detailed)
- Leadership challenges (tailored to specific course)
- Energy Advisor roles and responsibilities; additional unit/Soldier
- Training (training/education)

- Practical Exercises

Once the curriculum is developed and trained at the schoolhouse, newly-minted 120A warrant officers are then expected to serve as the OE Advisor at the Brigade staff level. In a way, this is simply a formal designation of a concept originally developed during Operation DYNAMO in Afghanistan (see Chapter 2.D) except that instead of creating a new position to be trained and filled independently, the MSCoE approach leverages the single 120A warrant officer billet already included in the BCT MTOE within the Brigade Engineer Battalion. These warrant officers would then be dual-hatted as the senior construction engineer technician (the original MOS designation) as well as the Brigade OE Advisor. CASCOM's TPMC, described in 4.A.2 of this chapter, already includes the OE Advisor position as part of its concept of employment.

C. Mission Command Center of Excellence

Although not part of the sustainment or engineering communities, the MCCoE also has a number of current initiatives that include elements of power management, particularly as they relate to command post modernization efforts. These initiatives include the Army Command Post Strategy, a capability development document for Command Post Integrated Infrastructure, and new doctrine for Command Post Organization and Operations.

1. Army Command Post Strategy

The main intent of the Army Command Post Strategy (in draft and not yet published) is to design an approach that allows for agile future command posts as the centerpiece of expeditionary mission command. The Army's vision for these future command posts includes synchronized people and processes linked through information systems and facilities that enable commanders to act decisively and independently in ambiguous environments. A critical distinction from recent experiences in Iraq and Afghanistan is that future command posts are intended to be flexible rather than static, a requirement that may increase the complexity of balancing the supply and demand of operational energy and electric power.

Annex B of the draft Command Post Strategy describes the materiel needs for future command post infrastructure. The document notes that

> [T]he command post (CP) is the place where personnel, networks, procedures and processes, and information systems come together and interoperate to support agile, adaptive, and innovative commanders as they execute mission command. Expeditionary, adaptable, and agile CPs are vital to orchestrate the successful accomplishment of the mission across the range of military operations. CP *infrastructure* includes integrated platforms, displays, shelters and workspace, local area networks

> (wired/wireless), environmental control units, and power generation, distribution, and management associated with the CP.[98]

The key materiel element of the command post strategy is the Command Post Integrated Infrastructure (CPI2) program, which will "leverage improvements in technology to reduce the current command post footprint and foster agility," specifically for the BCT-main as well as command posts for subordinate battalions.[99] With all of the requirements for information systems, network connectivity, and environmental control units, the CPI2 family of systems expects to integrate solutions for intelligent power distribution—including microgrids—as a standard component of command post operations, including in the near term (FY18-22). Mid-term solutions (FY23-33) assume that Corps, Division, and Brigade-level command posts will have intelligent power management systems that will efficiently balance the electrical power supply to meet the variable demands.

2. Capability Development Document for Command Post Integrated Infrastructure

In addition to the draft Army Command Post Strategy, the TRADOC Capability Manager (TCM) for Mission Command and Command Posts is also writing a capability development document that defines the materiel requirements for the CPI2 mentioned in the previous section. As a system of systems, the CPI2 intends to integrate existing technologies into a single command post framework. In addition to the physical components of the command post—shelters, lighting, cables, wireless networking, and so on—the CPI2 will also include "a standardized Army intelligent power system that minimizes fuel consumption by dynamically matching power output to changing load demands, increases system reliability, and reduces logistics burden."[100]

Intelligent power management is included in many of the document's key system attributes and key performance parameters. Command post power is also called out as an additional performance attribute:

> The command post power system shall integrate the standardized Army intelligent power system that minimizes fuel consumption by dynamically matching power output to changing load demands, and be fully compatible with existing Tactical Electrical Power equipment (e.g., AMMPS), the Power Distribution Illumination System Electric (PDISE), etc.).[101]

The authors rationalize this requirement as follows:

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[98] TRADOC Capability Manager – Mission Command, CDID, *US Army Command Post Strategy* (draft version), 29 August 2016, Annex B, 1.

[99] TRADOC Capability Manager–Mission Command, *US Army Command Post Strategy* (draft version), 1.

[100] TCM-MC, Capability Development Document for CPI2, draft version as of September 2016, ii.

[101] TCM-MC, Capability Development Document for CPI2, draft, 17.

> An intelligent power management system combined with centralized power for the CP will not only reduce fuel consumption through its ability to match generated power to load demand changes throughout the day, but will also lead to increased mobility/survivability and decreased footprint as individual system generators can be removed from the formation.[102]

3. Command Post Organization and Operations (ATP 6-0.5)

Beyond the materiel developments described in the last section, the Mission Command Center of Excellence has also developed an Army Techniques Publication (ATP) on command post organization and operations designed to complement the tactics found in Field Manual 6-0, *Command and Staff Organization and Operations.*

The document's introduction gives a brief overview of Army command post doctrine and operations over the last thirty years, from the AirLand Battle concept of linear battlefields to the large, static, and complex command posts of Iraq and Afghanistan. Today, though, the changing security environment means that

> Army forces must be prepared to operate across the range of military operations to include fast-paced and large-scale combat operations over great distances. As such, headquarters must be capable of deploying, constructing, camouflaging and concealing, operating, echeloning, positioning, and displacing CPs rapidly in austere environments.[103]

The document includes a section on power management within the chapter on command post operations. The authors note that "power is critical to the success of command post operations since units rely on it extensively to run much of their equipment and support systems."[104] They also list the key components to effective power management as:

- Selection of a power source
- Setting up the power generators (use of phases, wiring, loading, physical location, sun shade)
- Grounding of power sources and electrical components
- Distributing the power

Although power management is not the primary focus of command post organization and operations, the doctrine nonetheless reveals how important power management capability

[102] TCM-MC, Capability Development Document for CPI2, draft, 17.
[103] ATP 6-0.5, Command Post Organization and Operations. March 2017, iv.
[104] ATP 6-0.5, Command Post Organization and Operations, 3-16.

is to their success. The need for effective power management at the command post will come up again in Chapter 5.

D. Summary of Current Initiatives

Each of the previous sections described the current engineer, sustainment, and mission command initiatives and how they relate to power management. We can summarize the key objectives of each:

Combined Arms Support Command

- Expand the knowledge and understanding of Operational Energy concepts, ideas, and techniques through institutional, operational, and self-development training
- Train operators, technicians, and unit leaders on operational energy and power management best practices
- Define power management roles and responsibilities
- Use the Army Warfighting Assessment to evaluate the pilot training support packages to determine suitability for migration to Army at large

Maneuver Support Center of Excellence

- Identify Operational Energy management capability gaps and develop non-materiel solutions for power production and distribution, focused on base camps
- Address the Army's lack of necessary personnel, training, and materiel solutions to optimize energy use at both the production and end-user stages
- Diversify personnel and create a balance between operators, maintainers, and advisors

Mission Command Center of Excellence

- Incorporate advanced intelligent power management capabilities into expeditionary, adaptable, and agile command posts
- Integrate power generation, distribution, and management technology into a unified, physical command post platform at brigade/battalion-level

These lead to our third finding:

Finding #3 – Despite the lack of official DCRs for power management, Army Operational Energy stakeholders are taking steps to improve the Army's power management capability.

On a cautionary note, many of these initiatives, and the proponent centers and schools in general, tend to use the terms *operational energy* and *tactical electric power* interchangeably.

Even the working group hosted by CASCOM’s Future Systems and Operational Energy Integration Division intended to synchronize the cross-community improvement efforts calls itself both the “Tactical Power Forum” and the “Operational Energy Forum” in the same document. While this may seem like nitpicking, the implication can be confusion about which proponent is responsible for the power management functions described in Chapter 2.A—while TRADOC has designated CASCOM as the proponent for operational energy, MSCoE is still the doctrinal proponent for mobile electric power generation and distribution. We will return to this issue again in Chapter 6.

5. Viewing Power Management through the Capability Needs Analysis Framework

While the JCIDS process is primarily designed to assess materiel gaps and provide the parameters for materiel solutions, TRADOC's CNA process prioritizes DOTmLPF-P solutions by assessing the Army's ability to accomplish its required tasks in light of the warfighting challenges described in the Army's strategic documents. This chapter provides a brief overview of the CNA process and uses the CNA framework to derive insights about the Army's approach to power management based on the implications of the future operating environment.

A. Description of the CNA Process and Framework

The CNA process is defined as an "assessment of the Army's ability to perform future organizational and functional missions as defined by joint and Army concepts, taking into account existing and programmed DOTmLPF solutions."[105] According to TRADOC Regulation 71-20, *Concept Development, Capabilities Determination, and Capabilities Integration*, the CNA "identifies, assesses, integrates, and orders the Army's required capabilities, DOTmLPF solutions, capability gaps, and gap solution approaches based on risk assessments," and "can be used to fulfill analysis requirements in lieu of a normal JCIDS CBA."[106] We summarize the general steps of a CNA in Figure 14.

105 TRADOC Regulation 71-20, "Concept Development, Capabilities Determination, and Capabilities Integration," 28 June 2013, 66.

106 TRADOC Regulation 71-20, Concept Development, Capabilities Determination, and Capabilities Integration, 66.

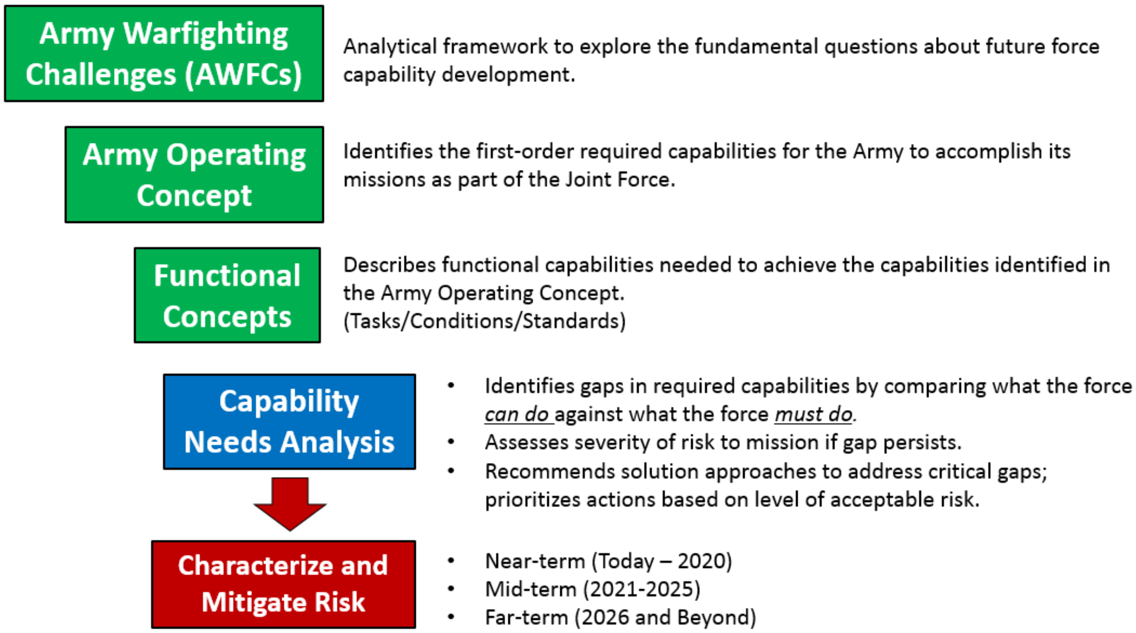

Figure 12. General Depiction of the CNA Framework

The goal of the CNA framework is to compare the Army's current approach to accomplishing its mission against the required capabilities laid out in the Army Operating Concept and supported by the Army Warfighting Challenges. Comparing what the force *can do* today with what the force *must do* in the near-, mid-, and far-term allows us to characterize the risks to efficiency and mission effectiveness that come with stagnation, i.e., if the Army does not modify its current approach.

Aligning our research with the CNA framework allowed us to reveal previously undocumented gaps in the Army's power management capability by assessing ongoing and planned initiatives to improve power management against the demands of the current and future strategic environment. The following sections show how the power management function nests within this strategic environment, and lead toward a characterization of the risks to mission accomplishment in the near-, mid-, and far-term.

Key research questions we wanted to address with this framework were:

- Do power management challenges become more difficult to mitigate over time?
- Is there a point where risks to efficiency become risks to mission effectiveness?
- How does the risk change from the near-term to far-term?
- Which echelons will be hit hardest by the shifting risks? (Brigades? Battalions? Companies?)

To do this, we reviewed the Army Warfighting Challenges, the Army Operating Concept, and the Functional Concept for Sustainment. We also reviewed broader Army and DoD strategic guidance documents, including the Army's 2013 Operational Energy Policy, the Army's 2015 Energy Security and Sustainability Strategy, and the 2016 DoD Operational Energy Strategy.

B. Implications of the Operating Environment

Within the CNA framework, the Army Warfighting Challenges and the Army Operating Concept provide a window into how the future operating environment may change. These changes, from evolving adversary threats to advances in technology, will drive the Army's required capabilities in the coming years. Together, the AWFCs and the AOC provide the general characterization of the strategic environment facing the Army into the near-, mid-, and far-term.

1. Army Warfighting Challenges

ARCIC describes the Army Warfighting Challenges (AWFCs) as "enduring first-order problems, the solutions to which improve the combat effectiveness of the current and future force."[107] The AWFCs are commonly presented as sets of questions, or *Learning Demands*, that fall under the broad umbrella of each challenge. For example, Warfighting Challenge #2 is "Shape the Security Environment," and the first learning demand asks, "How does the Army determine, develop, and sustain the cognitive competencies required to Shape the Security Environment?" The AWFCs are routinely updated with new learning demands based on iterative feedback driven by the Capability Needs Analysis process. Currently, there are 20 AWFCs, and each is assigned to a lead organization responsible for continued analysis and refinement of the problem statement, learning demands, and solution strategies. Power management is related most closely to two of the current Army Warfighting Challenges—AWFC #16 (Set the Theater, Sustain Operations, Maintain Freedom of Movement), and AWFC #19 (Exercise Mission Command).

For AWFC #16, the most pressing challenges related to power management, captured in the learning demands are:

- What are the attributes/characteristics of a resilient and reliable sustainment and distribution network in support of combatant command high tempo operations? (AWFC 16.4)

[107] US Army, "Army Warfighting Challenges," as of 31 January 2017, www.arcic.army.mil/App_Documents/AWFC-Current.pdf.

- How does the Army drive demand reduction to decrease sustainment requirements? (AWFC 16.9)[108]

In addition to the learning demands, AWFC #16 describes two additional areas that will drive sustainment developments. The first area is, "Increase Endurance and Reduce Demand of Widely Dispersed Units." The AWFC #16 white paper notes that

> The future Army lacks the capability to facilitate timely, agile, and precise sustainment to meet future demand over extended distances. To reduce demand, enable smaller flexible force structures, and meet demand at the point of need, the Army must exploit new technologies. Due to the shrinking formation and resources, the Army must enhance mitigation of Soldier risk and reduce equipment exposure to enemy threats through the use of advanced technologies and offer multiple dilemmas to the enemy.[109]

The second area describes the difficulty of "Sustaining Dispersed Forces over Extended Distances, Enhancing Distribution and Supplying at the Point of Need":

> Current distribution methods place heavy reliance on extended lines of communication [LOCs]. As the future force becomes leaner and operates in dispersed locations, reliance on LOCs will create capacity challenges, expose vulnerabilities, and impose increasing threats to the future force. The future Army must leverage Operational Contract Support and existing commercial networks while developing and exploiting new technologies to reduce distribution of water, fuel, ammunition, repair parts, and other vital resources needed to sustain the fight. Demand reduction is an overall Army challenge which all warfighting functions should recognize.[110]

The power management hooks in AWFC #19 are less straightforward. In general, AWFC #19 focuses on command posts as the central point for improving mission command, with an emphasis on modernization initiatives to allow commanders "at all echelons and under all conditions" to continue operations and achieve higher headquarters' intent. As described in Chapter 4.C, one critical element of the solution strategy is the incorporation of intelligent power systems and microgrid capabilities "for command posts at all echelons…to improve energy efficiency and power management. This fielding will occur as part of incremental modernization of the command post."[111]

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108 Sustainment Center of Excellence, *Army Warfighting Challenge* #16 White Paper, 22 August 2016, 2–3. Because these white papers are updated frequently, we have included the reference for the most recent version available at the time of writing.

109 Sustainment Center of Excellence, *Army Warfighting Challenge* #16 White Paper, 4.

110 Sustainment Center of Excellence, *Army Warfighting Challenge* #16 White Paper, 4.

111 Mission Command Center of Excellence, AWFC #19 (Exercise Mission Command) Information Paper, 14 January 2016, 8.

IDA concluded that the AWFCs do address power management, but only indirectly—the major focus is reducing sustainment demand and increasing endurance of widely dispersed units through precise balancing of supply distribution at the point of need. Further, command post modernization for enhanced mission command is driving the need to improve power management capability through integration of intelligent power management technology as well as microgrids for improved efficiency.

2. The Army Operating Concept

The purpose of the AOC is to take the Army Warfighting Challenges and link them to the capabilities that the Army must possess as part of the joint force. The AOC approach to the sustainment-reduction challenge, which indirectly includes elements of power management, is primarily through energy conservation initiatives and technology development.

Leveraging advances in technology is a core element that runs throughout the AOC. One area of emphasis is *logistics optimization* as a way to "improve the Army's ability to conduct expeditionary maneuver and sustain high tempo operations at the end of extended supply lines, [by increasing] logistical efficiencies and unit self-sufficiency."[112] Later, the AOC articulates its vision of the impact of technology on expeditionary electrical power generation:

> Advanced and efficient power saving and generation technologies will reduce sustainment and lift requirements. Improved power efficiency, storage, and generation from traditional and renewable sources will provide power under austere conditions.[113]

One of the tenets of the AOC is to *sustain high tempo operations*, which includes providing supplies and services "at the end of long and contested supply lines."[114] This means that

> Army forces operate with reduced logistics demand due to fuel-efficient vehicles and systems, improved reliability, locally generated power and water, and other efforts. Information systems connect the strategic sustainment base to tactical organizations to anticipate needs and provide a high degree of responsiveness and reliability in the supply chain. Every echelon maintains scalable organic sustainment capabilities to preserve freedom of action even if logistical support slows.[115]

The AOC also lists a number of technological first principles for developing the future force.[116] Of these, several are relevant to power management:

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112 US Army TP 525-3-1, "The U.S. Army Operating Concept: Win in a Complex World," 37.
113 US Army TP 525-3-1, "The U.S. Army Operating Concept: Win in a Complex World," 37.
114 US Army TP 525-3-1, "The U.S. Army Operating Concept: Win in a Complex World," 18.
115 US Army TP 525-3-1, "The U.S. Army Operating Concept: Win in a Complex World," 18.
116 US Army TP 525-3-1, "The U.S. Army Operating Concept: Win in a Complex World," 40–41.

- Design redundant systems that improve effectiveness under conditions of uncertainty
- Reduce logistical demands
- Consider scale and organizational implications

Together, the AWFCs and AOC characterize the strategic environment confronting the Army's expeditionary operations through 2040. A recurring theme throughout these documents is the need to reduce sustainment demand, particularly for liquid fuel, through innovative technologies as well as optimizing existing practices. While these new power generation and distribution systems are designed to be more efficient and intelligent, they also more complex and sophisticated than previous systems.

3. Functional Concept for Sustainment

The current Functional Concept for Sustainment, published in February 2017, defines sustainment as "the provision of logistics, personnel services, and health service support to maintain operations until mission accomplishment" and characterizes the capabilities needed to support the sustainment warfighting function as described in the 2014 Army Operating Concept.[117] A major revision of the previous sustainment concept from 2010, this document includes more references to leveraging technological advances as a means to change the future of sustainment operations and become more agile, flexible, and adaptable to austere environments.

Although the sustainment concept seeks to develop a future sustainment force that "fundamentally reduces the demand characteristics of the force and provides operational energy more effectively to optimize the sustainment footprint and enable an expeditionary Army conducting cross-domain maneuver," the concept also acknowledges that demand reduction alone cannot solve the Army's expeditionary sustainment challenges, particularly as future vehicle platforms and command posts are expected to need more energy than what they consume today. "There is risk that the demand characteristics of the force cannot be reduced sufficiently to enable semi-independent operations with the required freedom of movement and action," the authors write.[118] Demand reduction then becomes one pillar of operational energy optimization and efficiency, bolstered by the pursuit of technologies to meet demand at the point of need, including intelligent power management systems as well as improved operational energy management training programs.

The concept also explicitly calls out advanced power generation as a focus area for future science and technology research to support logistics optimization:

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[117] TRADOC Pam 525-4-1, United States Army Functional Concept for Sustainment. February 2017, 4.
[118] TRADOC Pam 525-4-1, United States Army Functional Concept for Sustainment, 11–12.

> Advanced power generation enables expeditionary sustainment to forces operating in remote areas, and allows for self-sufficient power generation capable of operating separate from existing power grids. Future fuel cells require minimal maintenance and provide a clean, continuous source of power while reducing convoy requirements and the logistics footprint associated with fuel distribution. This technology supports reduced demand characteristics, optimized sustainment footprint, improved personnel protection, and improved asset survivability.[119]

4. A Supporting View

A 2015 Army Research Labs workshop report on *Visualizing the Tactical Ground Battlefield in 2050*, which envisioned combat at a time just beyond the 2020–40 period covered by the AOC, discusses reliable power sources as a necessary component of mission effectiveness. The report notes that many technological innovations and concepts—robots, directed energy, lasers, and so on—will require a significant amount of energy in order to work. The authors conclude that "the reliable supply of this energy is essential for mission effectiveness."[120] However, the workshop participants also believed that technological advances in power sources and storage could offset the increased demand so that electrical energy would not be a limiting factor. Multiple sources of power were mentioned as a way to increase reliability and redundancy, from mobile nuclear power to organic renewable power sources.

5. A Cautionary View

In an article for *Army Sustainment Magazine*, Major Ryan T. Hulse compared current rates of fuel consumption to the rate during World War II. "During World War II," he wrote, "one Soldier used on average one gallon of fuel per day. In 2007, during Operations ENDURING FREEDOM and IRAQI FREEDOM, the average usage was 22 gallons per Soldier per day."[121] Thus, the long-term trend has been toward significant increases in fuel consumption rather than the reverse trends the Army now seeks.

There is also evidence that a significant proportion of recent increases in fuel consumption for command posts is driven by the use of environmental control units (ECU). A recent report on Marine Corps fuel consumption breaks down fuel usage as follows:

Aviation: 70% Ground (vehicles): 21% Ground (generators): 9%[122]

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119 TRADOC Pam 525-4-1, United States Army Functional Concept for Sustainment, 39.

120 Alexander Kott, David Alberts, Amy Zalman, Paulo Shakarian, Fernando Maymi, Cliff Wang, and Gang Qu, *Visualizing the Tactical Ground Battlefield in 2050: Workshop Report*, US Army Research Laboratory Report, ARL-SR-0327, June 2015, 21.

121 Hulse, "What is the Army Doing With Operational Energy?" 52–54.

122 Shields and Wolfe, *Behavioral Energy Operations Demonstration (BEyOnD) Phase I*, 12.

Later in the report it is revealed that "roughly 70% of energy delivered by tactical generators is in support of environmental control."[123] In rough numbers, then, ECU operation accounts for approximately 6% of all fuel demand, with command and control and all other non-ECU power loads accounting for the remaining 3%.[124]

Conversations with the engineering and sustainment communities suggested that the electrical power demand at battalion and brigade command posts has increased and will continue to do so, but the magnitude of this increase is unclear and may require further analysis. Often, the demand for electricity is measured in total kilowatts needed to power all of the loads connected to the grid, while sustainment planning factors typically capture electric demand indirectly through bulk fuel requirements.

6. Other Strategic Documents

In addition to the Army Warfighting Challenges and AOC, we looked for power management implications in the Army's 2013 Operational Energy Policy, the 2014 Quadrennial Defense Review (QDR), the 2015 Army Energy Security and Sustainability Strategy (ES^2), and the 2016 DoD Operational Energy Strategy.

a. 2013 Army Operational Energy Policy

The 2013 Army Operation Energy Policy recognized the importance of operational energy as a "critical enabler for the range of military operational capabilities from the individual Soldier to strategic levels."[125] The policy calls for the Army to do the following:

- Increase mission effectiveness via the efficient use of energy in dismounted, mounted, aviation, and base camp/sustainment operations
- Integrate energy considerations into operational planning activities
- Include operational energy as a key performance parameter for requirements development through JCIDS
- Reduce energy consumption in order to reduce the frequency and vulnerability of energy-related resupply operations
- Establish an energy informed culture through training and education

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[123] Shields and Wolfe, *Behavioral Energy Operations Demonstration (BEyOnD) Phase I*, 6.

[124] This supports anecdotal information collected during this project that ECU's are "the common big load across all types of formations."

[125] US Army, "Army Operational Energy Policy," 30 April 2013.

The 2013 policy codified the importance of energy considerations for future Army operations, but is only indirectly related to power management in the sense that power management capabilities will enable tactical units to burn less fuel, and burn it more efficiently.

b. 2014 Quadrennial Defense Review

The 2014 QDR sought to drive "creative, effective, and efficient ways to achieve our goals and assist in making strategic choices" with a focus on innovation as a central line of effort.[126] The QDR notes that the DoD "has invested in energy efficiency, new technologies, and renewable energy sources to make us a stronger and more effective fighting force," and that "energy improvements [will] enhance range, endurance, and agility, particularly in the future security environment where logistics may be constrained."[127]

c. 2015 Army Energy Security and Sustainability Strategy

The 2015 ES^2 Strategy is a Vice Chief of Staff/Under Secretary of the Army-level document that articulates the strategic vision and subordinate goals for the role of energy in enabling the Army as an effective arm of national security. The strategy describes five goals to "unify the Army's energy and sustainability functions across both the generating and operating force": (1) Inform Decisions; (2) Optimize Use; (3) Assure Access; (4) Build Resiliency; and (5) Drive Innovation.[128] Each of these goals includes some element of power management, and together they suggest that the Army will remain committed to building energy awareness, reducing demand for liquid fuel, diversifying power sources through advanced technologies, and driving energy innovation in support of future operations.

d. 2016 DoD Operational Energy Strategy

DoD's revision of the original 2011 operational energy strategy recognized the "crucial role of energy in enabling our forces to perform worldwide missions, while also acknowledging energy as a potential vulnerability."[129] The updated strategy lists the following DoD objectives in response to the challenges and risks associated with delivering energy in future expeditionary operations:[130]

- Increase future warfighting capability by including energy throughout future force development

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126 US Department of Defense, *2014 Quadrennial Defense Review*, vi.
127 US Department of Defense, *2014 Quadrennial Defense Review*, 25.
128 US Army, *Energy Security & Sustainability (ES2) Strategy*, 1 May 2015, 5–10.
129 US Department of Defense, *2016 Operational Energy Strategy*, 3.
130 US Department of Defense, *2016 Operational Energy Strategy*, 10.

- Identify and reduce logistics and operational risks from operational energy vulnerabilities
- Enhance the mission effectiveness of the current force through updated equipment and improvements in training, exercises, and operations

Although most of the goals supporting these objectives are aimed at including operational energy considerations at the strategic level (e.g., theater campaign plans), the general principles may also influence power management challenges at the tactical level. For example, the strategy emphasizes the importance of diversifying the sources of energy supply, particularly through renewable energy sources at contingency bases that can "harvest energy at the point of use to minimize the burden of resupplying operational forces with liquid fuel."[131] More advanced technologies and upgraded power generation and distribution equipment are also intended to reduce resupply risk at isolated contingency bases. Beyond materiel solutions, the strategy recognizes the benefits of improving individual behavior toward reducing energy consumption, reinforcing the Army's concepts of energy-informed operations and operational planning.

C. Characterizing Power Management Risk

Having considered the implications of the current and future operating environment for power management, we can now comment on the associated risks to efficiency and mission effectiveness. Because we have not conducted a full capability needs analysis, these are intended to provide a general overview of the types of risks the Army may face, as well as potential indicators that the risks are changing.

1. Power Management Risk Today

The risk to Army operations from inadequate power management is a risk to mission efficiency. More fuel is burned, more generator engine hours logged, and more labor applied to equipment maintenance and repair than would otherwise be the case if trained UPMs were available to optimize electrical power production to meet demand.

While transporting fuel to contingency bases and isolated command posts remains hazardous and costly, there have been no systematic shortages of generator fuel. Shortages have surely occurred in particular locations at particular times, but we have not found cases of sustained shortages that caused a risk to unit effectiveness. Further, most units appear to have surplus generators on hand, so the consequences of improper operations are minimized.[132]

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[131] US Department of Defense, *2016 Operational Energy Strategy*, 13.

[132] Although this was often mentioned in many of our interviews, we have not verified its accuracy.

Under present conditions, this does not seem likely to change. So long as fuel is available, supply routes remain passable, and spare generators are readily available, the Army can continue to supply electrical power to its forward deployed units in the present manner without significant risk to mission effectiveness, despite potential inefficiencies.

2. Power Management Risk in the Future

The AOC's far-term vision of leveraging new energy technologies to reduce sustainment demand may fundamentally alter the nature of power management and introduce potential risks to mission effectiveness. These risks are associated with the proliferation of new tactical energy sources, particularly when configured as a microgrid to provide electrical power to brigade and battalion command posts.

Microgrids are appealing, because they can enhance the resiliency and self-sufficiency of command posts through the integration of multiple energy sources, including renewables like wind and solar, to meet energy demands at the point of need. But their configuration is also more complex than the typical setup of spot generators, which is based on an abundance of simple equipment as well as a single energy source: electric generators and diesel fuel.

Even automated, intelligent power distribution systems will likely require close management for operation and maintenance—it is not unusual that keeping equipment running at high efficiency requires human oversight, which matches the approach of the other Services. The Army Warfighting Challenge vision of a reduced sustainment footprint may also lead units to carry smaller inventories of more efficient equipment. This, in turn, will require a rigorous maintenance program to ensure sufficient equipment is available and fully mission capable when needed.

As the portion of electric power produced from sources other than diesel generators grows, there is a risk that, without adapting the current approach to include more sophisticated training in electrical power production and distribution theory, the technical requirements for operating a unit's organic power systems will go beyond the inherent capabilities of an MOS-incidental soldier. Moreover, if the Army assigns the UPM responsibilities to the 91D career field as suggested in many of the current initiatives, shifting the primary source of electrical power supply from diesel generators to alternative fuels will move the function away from the 91D's core competency as a mechanic. In the extreme case, for example, where 100 percent of a unit's electrical power is derived from sources other than diesel generators, the 91D would be redundant and likely reassigned to other maintenance duties.

There is also a risk in relying too heavily on the integration of intelligent power generation and distribution systems as part of a command post strategy and modernization initiatives. Most of the draft documents assume that the infrastructure of future command posts can easily incorporate advanced power management technologies, but the MCCoE is not responsible for ensuring that personnel assigned to oversee and direct command post operations are trained in power management techniques—there is an expectation, stated or implied, that the non-materiel implications of newer technologies and employment concepts will be addressed by the engineering and sustainment communities that are the proponents of the relevant career fields. If a unit's organic personnel are not sufficiently trained in power management, including the configuration and maintenance of diverse power sources, command posts will likely revert to inefficient spot generation, wasting the efficiency and agility that would have been gained by employing the new technologies. Without proper coordination, the mission command community may be assuming that command post personnel have certain knowledge, skills, attributes, and training for which CASCOM and MSCoE may not be planning.

Network integration events, Army warfighting assessments, and command post exercises will likely detect tendencies in this direction; however, expeditionary command posts that require skilled personnel to manage a variety of intelligent power systems and energy sources may become vulnerable to mission failure if these personnel are not properly trained in power management techniques as well as available in sufficient numbers to perform the duties required by the role.

D. Summary of Insights from the CNA Process

Viewing power management through the capability needs analysis framework led to the following observations:

- The AWFCs address power management, but only indirectly.
- The AOC emphasizes reductions in sustainment demand through more technologically advanced systems.
- Power management risk today is primarily an issue of efficiency; it may not reach a high priority within the Army's portfolio of capabilities and unfunded requirements.
- Emphasis on mission command in expeditionary environments combined with the proliferation of networked systems is driving the need for improved power management capabilities at brigade and battalion command posts.
- Army and DoD strategic documents suggest that changes in energy technology will continue to drive the non-materiel implications of power management and may lead to a future risk to mission effectiveness.

Considering the implications of these insights leads us to our fourth finding:

Finding #4 – The need for power management is greatest at brigade- and battalion-sized command posts, but command post initiatives are not coordinated with operational energy stakeholders.

This finding is also derived from several earlier observations. As described in Chapter 2, the engineering community manages electrical power supply and demand at echelons above brigade, with adequate resources such as the prime power battalion and contracted sustainment services. At this level of organization, proper equipment and trained personnel are typically available. At echelons below brigade/battalion command posts—small combat outposts, for example—the opportunity to garner efficiencies is often minimal. The relatively small size of these installations leads to a simple electrical system, typically one or two generators, with little or no opportunity to optimize power distribution beyond properly loading the generators on hand. In addition, installations at these lower echelons tend to be highly transient, further reducing or eliminating the opportunity to gain efficiencies by careful attention to power distribution.

At the battalion- and brigade-level command posts, however, the size of the camps and their ordinary dwell times in fixed positions present opportunity for increased efficiencies. But, unlike at higher-echelon base camps, power management resources are generally inadequate. This is because personnel are not generally trained to perform the specified tasks and are, in some cases, not available. The 91D MOS, envisioned for the role of UPM according to the Tactical Power Management Concept, is a high-demand/low-density resource at these echelons. Their primary expertise in diesel engine maintenance and repair makes them highly valuable for related tasks such as maintaining vehicles, which are often prioritized over broken generators. Thus, even if they had adequate training, high demand for their technical skills diverts them to tasks deemed higher priority.

Because the TRADOC Capability Manager for Mission Command/Command Posts is MCCOE's manager for mission command and command post activities, our recommendation focuses on synchronizing CASCOM/MSCoE power management improvement efforts with the command post needs described in MCCoE's initiatives.

IDA recommends including the TRADOC Capability Manager for Mission Command/Command Posts in the Tactical Power Forum and other Operational Energy stakeholder synchronization sessions, and coordinating power management improvement initiatives with Command Post/Contingency Basing strategies.

6. Addressing Changes in Power Management Doctrine, Training, and Organizational Structure

Although the Army's operational energy proponents have taken steps to improve the non-materiel approach to power management, there are still steps that could be taken in order to change the associated doctrine, training, and organizational structures. Figure 15 shows the sequence of these steps and their decisions, namely (a) Designate a functional proponent for power management at the brigade/battalion level; (b) Clarify the roles and responsibilities of the Battalion UPM and Brigade OE Advisor; and (c) Determine the source MOS for the Battalion UPM. This chapter describes these steps and decisions in greater detail.

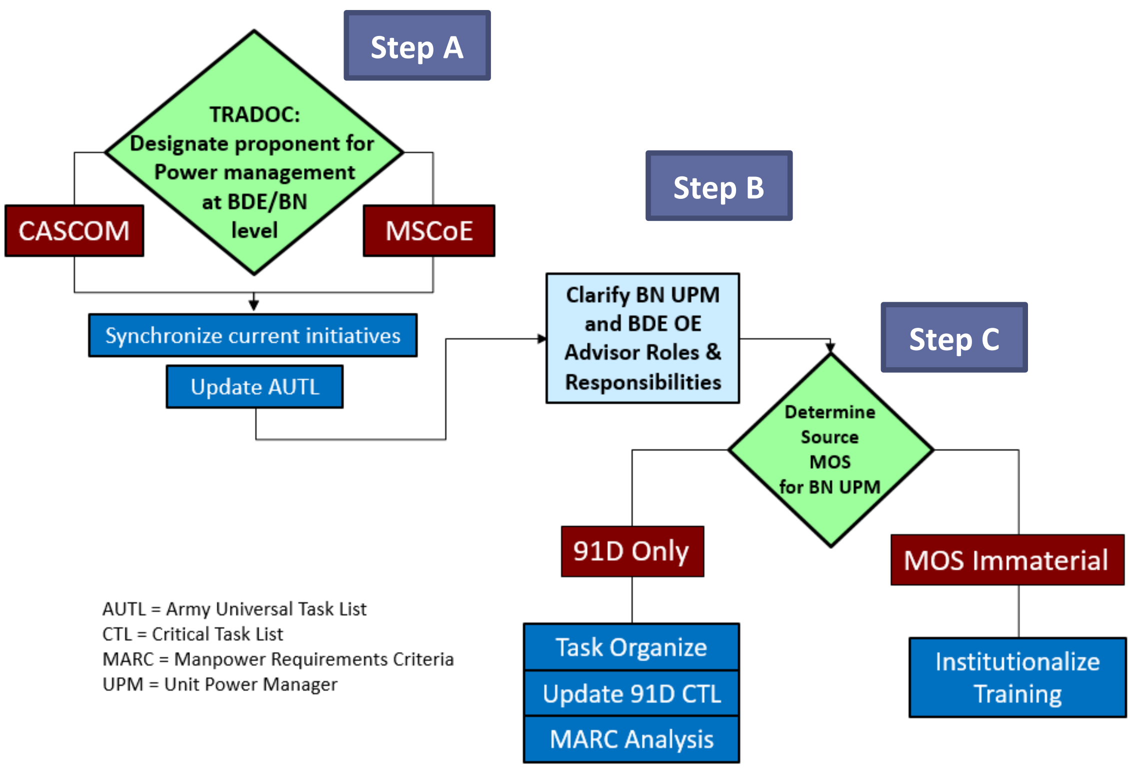

Figure 13. Steps toward Addressing Changes in Doctrine, Training, and Organizational Structure

A. Designate a Power Management Proponent

A single functional proponent is needed to champion the non-materiel power management initiatives through the Army Requirements Oversight Council (AROC) process. As described Chapter 2.C.3, power management advocacy is currently split between the maneuver support and the sustainment centers of excellence, with neither having sufficient authority to orchestrate the needed DOTmLPF-P changes.[133] In summary:

- MSCoE is the designated proponent for operational energy, water, and waste efficiencies, prime power distribution, and semi-permanent mobile electric power
- CASCOM is the designated proponent for operational energy, sustainment doctrine, and tactical electric power and distribution
- Critical MOS (91D) and the preponderance of current initiatives fall under CASCOM
- Secondary MOS (12P) and subject matter expertise falls under MSCoE

Whether power management should be a sustainment function or an engineer function is unclear. Currently, operational energy initiatives cross into both functions, but the focus in many cases is reducing the demand for liquid fuel, not necessarily improving the Army's ability to manage its tactical electric power. If the focal point is fuel, then assigning power management responsibilities to the sustainment branch is a logical choice; fuel is a critical class of supply that is procured, measured, tracked, and delivered across the battlefield by logisticians at all echelons. As we've seen in Chapter 5.B, the Army's future vision is to shift some of the energy burden away from diesel fuel and toward renewable, hybrid sources—a paradigm that could favor assigning power management to the engineers.

This is not to suggest that one of these two proponents should give up its responsibilities. But the Army should consider the long-term trends and implications of power management as a separate concept from operational energy, and should consider assigning a single proponent to coordinate non-materiel initiatives to improve power management capabilities. That proponent would then be empowered to synchronize the efforts across both communities, advocate for power management resources, and coordinate with ARCIC for cross-functional integration.

IDA recommends that TRADOC determine if power management is best assigned as a sustainment function or an engineer function and designate either MSCoE or CASCOM as the functional proponent for power management at the BCT-level and below.

The designated proponent should then update the Army Universal Task List with power management doctrine and promote additional non-materiel capability integration and synchronization through ARCIC.

133 TRADOC Pamphlet 350-70-16, *Army Training and Education Proponents*. 2 August 2016.

B. Clarify Roles and Responsibilities of the Battalion Unit Power Manager and Brigade OE Advisor

One of the key components of the efforts to improve the Army's approach to power management is the alignment of responsibilities within the BCT. The TPMC, to date the only initiative explicitly focused on power management at the brigade and battalion level, describes three target audiences for its intended training plan: (1) Leaders; (2) UPMs; and (3) TEP Operators. Yet, even with this delineation, there is an inherent seam between planning and execution of brigade- and battalion-level power management tasks.

The UPM concept is designed to address this seam. However, the UPM's roles and responsibilities as described in the current DOTmLPF-P initiatives inconsistently define what, exactly, the UPM is meant to do. For example, according to the Operational Energy Training Strategy, the UPM will "analyze, plan, and supervise the use of power, both in garrison and during tactical operations,"[134] while the draft training circular on *Tactical Electric Power Production and Distribution* states that the UPM should "plan, execute, and monitor the unit's use of power."[135] Even the TPMC implies that the UPM wavers somewhere between planning and execution, noting that the UPM is

> [R]esponsible for…the overall supervision/management of the unit's energy requirements. The Unit Power Manager will develop the unit's power distribution plan and ensure the unit TEP operators correctly balance power loads to maintain TEP efficiency. It is crucial [that] all additional power requirements are approved by the power manager to maintain a balanced and efficient tactical power grid.[136]

The distinction between tactical electric power planning and execution is critical, as ambiguity will lead to confusion and inefficiency; battalion commanders and their staffs will not know who is responsible for each element of power management as defined in Chapter 2.A.1, resulting in a series of hasty directions rather than a standard operating procedure to accomplish the mission.

In addition to the battalion UPM, the proposal to use the Brigade Engineer Battalion's 120A warrant officer as the Brigade OE Advisor lacks a clear description of the position's roles and responsibilities, particularly as they align with the battalion UPMs. MSCoE's OE Advisor initiative is limited to developing operational energy curriculum for the 120A warrant officer basic course; there is no corresponding implementation plan for BCTs on how to use these warrant officers once they arrive.

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[134] CASCOM, *Army Operational Energy Training Strategy*, 11.

[135] TC 4-37.10, Tactical Electric Power Production and Distribution, draft, 3-2.

[136] CASCOM, Tactical Power Management Leadership Training, "Operational Energy Planning," unpublished briefing, September 2016.

If the OE Advisor is meant to serve as a member of the brigade staff, what is the relationship with the battalion staffs? Is there a parallel alignment, similar to principal staff positions (S-1, S-2, S-3, and so on), or is the organizational relationship less formal? Does the OE Advisor simply provide subject matter expertise as needed, or is he responsible for analyzing battalion tactical power plans, supervising UPMs, and developing training programs? And, because the only 120A in the BCT is assigned to the Brigade Engineer Battalion, is the OE Advisor role an additional duty on top of the warrant officer's existing construction engineer responsibilities? Or will the tasks associated with the new duty supersede them? Without further clarification of these questions, the benefits of an OE Advisor will be constrained.

DOTmLPF-P efforts must clarify who is responsible for power planning versus execution as well as how the UPM and the OE Advisor fit into the brigade and battalion staff structures; otherwise, power management gaps will persist. Clarifying these roles and responsibilities will also enable better-defined knowledge, skills, and attributes required for the positions, and will lead to a more comprehensive training program of instruction. The responsibility for this action lies with the power management proponent identified in Step A of Figure 15.

IDA recommends that the proponent designated in Step A: (1) define the UPM's role within the battalion staff; (2) determine and codify which elements of power management (planning versus execution) fall under the UPM's responsibility; and (3) define the OE Advisor's responsibilities and organizational relationship to the battalion UPMs.

C. Determine if a 91D MOS should be Required to Serve as the UPM

After clarifying the UPM's roles and responsibilities in Step B, the TRADOC-designated power management proponent should then determine how to source the UPM position. Specifically, the decision comes down to whether a 91D MOS should be required to perform the UPM's duties, or if the duties are MOS immaterial.[137]

Emerging DOTmLPF-P initiatives are inconsistent on this question, perpetuating the gap between power planning and execution. For example, the TPMC notes that 91Ds are meant to "train operators and perform duties as unit power planner, completing power assessments and tactical power grid design plans," all of which are currently conceived as UPM responsibili-

137 The 12P prime power Soldier also has the appropriate skills and training to serve as the UPM, but they are not organic to BCTs. Proposing to use 12Ps as Battalion UPMs would require expanding manpower significantly, which we explicitly excluded as part of our scope given the current trends and constraints to Army end strength.

ties.[138] However, the Operational Energy Training Strategy states that the power manager is the "designated supervisor (NCO, Warrant Officer, or Officer) assigned to plan and manage tactical electric power systems, analyze and develop site layout plans, and supervise overall operation of the tactical electric power process."[139] No MOS is mentioned.

While the preference seems to be for 91Ds, the concept does not *require* a 91D MOS; that is, Soldiers with any MOS could be selected by their commanders to serve in this role. This decision hinges on how TRADOC and the power management proponent define the position's roles and responsibilities within the brigade and battalion staff structure (Step B), which should lead to better-defined knowledge, skills, and attributes required for the position and provide some clarity to the choices.

There are pros and cons for both options. And, regardless of which option the power management proponent selects, DOTmLPF-P actions are needed to address the drawbacks and to ensure that those selected to serve as UPMs are given the proper doctrine, training, and organizational structure to succeed. The following sections discuss the needed issues and actions in more detail.

a. 91D-Only as Battalion Unit Power Manager: Pro

Within a BCT, no other MOS has as much knowledge and training in power generation and distribution systems as the 91D. As of 2014, the critical task list for 91Ds included maintaining and repairing tactical power systems, emplacing mobile electric power grids, selecting proper tactical power systems to meet electrical demands, and assessing and inspecting power requirements and grid layouts for command posts and tactical operations centers.

Although MOS-incidental soldiers are responsible for operating tactical generators, 91Ds are supposed to train and certify them. During field operations, a 91D30 (E-6) is meant to serve as the battalion-level tactical power planner, advising the commander on tactical power plans and requirements while supervising 91D20 (E-4/E-5) soldiers who support company-level power plans. As described in Chapter 4.A.4, the Army Ordnance School has revised the 91D MOS duty descriptions to specify operator training and supervision as core functional responsibilities, as well as power planning responsibilities at the E-5 and E-6 ranks.

b. 91D-Only as Battalion Unit Power Manager: Con

The 91D's baseline training in power systems combined with the Ordnance School's current push to take ownership of power management tasks are powerful arguments in favor of using the 91D as the battalion UPM. This option comes with several significant drawbacks.

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[138] CASCOM, *Tactical Power Management Concept*.

[139] CASCOM, *Army Operational Training Strategy*, 10.

First, 91D soldiers already perform a maintenance function as their primary duty, and it is unclear whether manpower analyses account for the time required to also perform training and management functions. Army Regulation 71-32, *Force Development and Documentation,* provides guidance on conducting Manpower Requirements Criteria (MARC) studies to determine the minimum number of personnel needed to perform wartime combat support and sustainment functions.[140] The objective of these studies, according to the regulation, is "to produce criteria which define quantitative and qualitative wartime manpower requirements needed for the performance of a defined function in a theater of operations at varying levels of work activity."[141] These analyses are based on the workload driven by specific systems; e.g., the number of 91Ds is proportional to the number of generators on the unit's TOE as well as the number of man-hours required per soldier per system.

Time spent performing power management tasks, though, is not directly correlated with how many generators a unit has. If 91Ds are to perform the duties of the battalion UPM, but this time is not accounted for in the MARC analysis, end-strength authorizations may not reflect the true demand for 91Ds within the BCT.

Second, although the revised duty descriptions state that 91Ds are responsible for conducting and supervising generator operator training and certification, there are no 91Ds organic to maneuver units—they are assigned to the Brigade Support Battalion, with only a small number available to maneuver commanders through the Forward Support Companies. This leads to a capacity constraint as the limiting factor on their effectiveness—a typical BCT only has 23 91D soldiers to support six subordinate battalions. Figure 16 shows how the 91Ds are allocated across an Infantry BCT according to the current MTOE.

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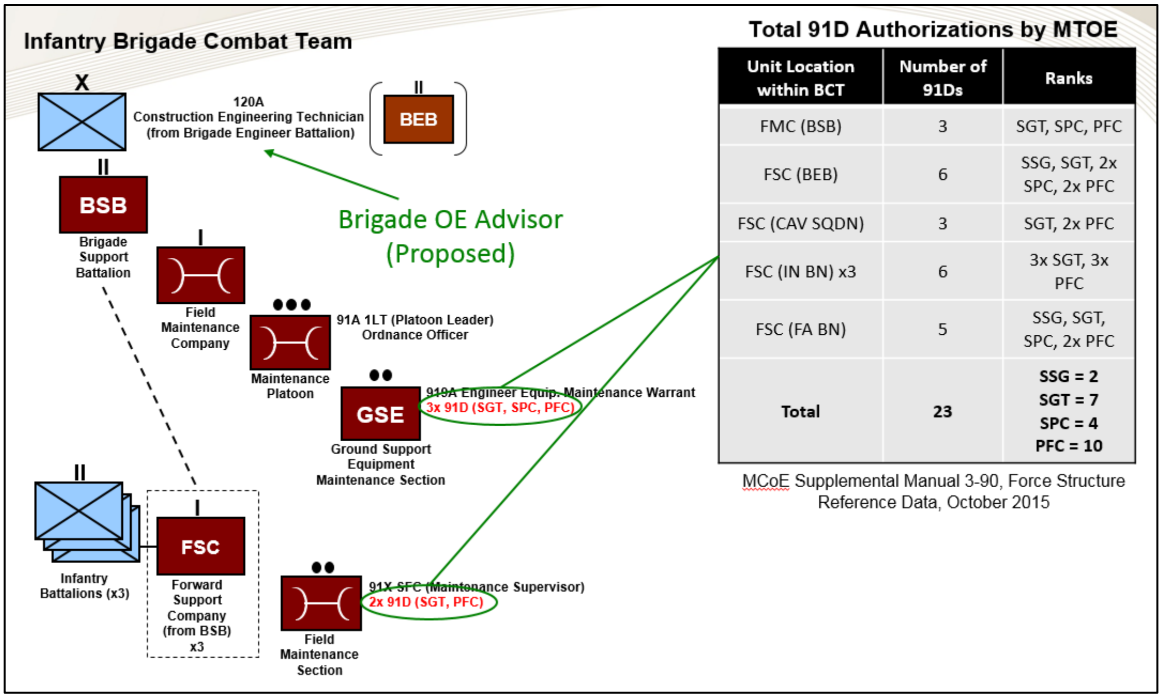
[140] Army Regulation 71-32, *Force Development and Documentation,* 1 July 2013, 25.
[141] AR 71-32, *Force Development and Documentation,* 27.



Unit Location within BCT	Number of 91Ds	Ranks
FMC (BSB)	3	SGT, SPC, PFC
FSC (BEB)	6	SSG, SGT, 2x SPC, 2x PFC
FSC (CAV SQDN)	3	SGT, 2x PFC
FSC (IN BN) x3	6	3x SGT, 3x PFC
FSC (FA BN)	5	SSG, SGT, SPC, 2x PFC
Total	**23**	**SSG = 2** **SGT = 7** **SPC = 4** **PFC = 10**

Figure 14. Task Organization of 91Ds within an Infantry Brigade Combat Team

In the figure, we see that the IBCT has only two 91D30/E-6 soldiers (one in the brigade engineer battalion and another in the field artillery battalion), the rank that, according to the 91D duty descriptions, has the majority of the power management responsibilities. That leaves the junior 91D20 (an E-4 or E-5) from the Field Maintenance Section as the de facto battalion staff representative for power management in most cases, including all three infantry battalions and the cavalry squadron.

This organizational structure has also led to the decentralized management and employment of 91Ds across the BCT. Consequently, their knowledge of tactical power systems is often subordinate to general sustainment and maintenance functions. At the same time, the lack of 91Ds at more senior supervisory ranks means that there is no one to ensure that the soldiers with the most expertise in tactical power systems are trained and employed appropriately.

If 91Ds are only performing maintenance and repair functions (as opposed to power planning), this task organization is sufficient—as mechanics, 91Ds fall into the battalion's consolidated maintenance operations, working in small teams of two or three to repair broken generators as needed. But as UPMs, these 91Ds need a closer relationship with the battalion commander and staff sections to advise and assist with tactical power planning and execution, not to mention a rank commensurate with the authority and responsibility of other staff shops. And, as a low density MOS, there will be no one to ensure that they are training and maintaining proficiency of power management tasks.

Staff alignment from the battalions to the brigade is another key component of power management, but again the decentralized task organization presents an obstacle. According to the Naval Surface Warfare Center report:

> The Army leaves [the] execution [of a tactical power plan] to a lower enlisted 91D without a trained senior noncommissioned officer to supervise, and usually without an onsite non-commissioned 91D. Additionally, that Soldier has no trained warrant officer actively advising and informing commands. One change the Army plans to make is to add an additional duty to the Construction Warrant Officer (120A) at Brigade Combat Teams to advise the Command on Operational Energy. *However, the 120A has no organizational ties to the 91Ds executing the power plan.*[142] (Emphasis added)

Training is another central issue, and there are indications that 91Ds still require more institutional instruction beyond what they currently at the schoolhouse. The BEyOnD report determined that 91D10s receive only 32 hours of electrical training, far below the 222 hours given to a comparable electrical systems technician in the Marine Corps. Further:

> Neither of these figures includes generator operation and maintenance training, which serves a separate function. The Marine in this scenario receives more electrical training in just Direct Current (34 hours) than the 91D receives in total. At a recent gathering of Army SMEs from training, acquisition, requirements, and units it was widely agreed that the amount of training provided to 91Ds is inadequate for the role and responsibility that they hold.[143]

Training time is largely driven by the MOS Critical Task List. And the two most relevant 91D critical tasks for power management—emplacing power grids using AutoDISE and inspecting grid layouts—are designated as "self-development" and are not taught at the schoolhouse, leaving a crucial element of power management training uncovered at the institutional level. Standardizing this training and adding it to the program of instruction will be essential if 91Ds are to be employed as battalion unit power managers. Justifying a curriculum expansion will also require power management to be added to the Critical Task List, though we recognize that doing so may come with a cost and likely require tradeoffs with other training elements.

c. DOTmLPF-P actions required if only 91Ds can be designated as the Battalion Unit Power Manager

As indicated in the previous section, selecting only 91Ds to serve in the battalion UPM role comes with a number of significant obstacles. We offer the following recommended ac-

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[142] Shields and Wolfe, *Behavioral Energy Operations Demonstration (BEyOnD) Phase I*, 31.

[143] Shields and Wolfe, *Behavioral Energy Operations Demonstration (BEyOnD) Phase I*, 30.

tions to overcome these obstacles should the power management proponent designated in Step A choose this option.

1) Expand power management training for 91Ds at the schoolhouse

The self-developmental curriculum for 91Ds is insufficient compared to the full range of power management components as well as the duties envisioned for the battalion UPM. Expanding the schoolhouse curriculum to include more advanced electrical theory concepts and power distribution techniques, as well as tactical grid planning using AutoDISE, would ensure that 91Ds assigned to BCTs are trained according to the proper tasks, conditions, and standards needed for power management.

2) Add power management to the 91D critical task list

In order to justify the hours of instruction recommended in the previous step, power management must be added to the 91D critical task list. To do this requires a series of analyses governed by TRADOC Regulation 350-70, *Army Learning Policy and Systems*, demonstrating why the task is needed to accomplish MOS-specific missions and duties.[144]

In addition to updating the 91D duty descriptions for each rank (Chapter 4.A.4 and Appendix C), adding power management to the 91D critical task list is an important step toward codifying these responsibilities within the career field.

3) Conduct a MARC study that accounts for power management duties

As mentioned earlier, manpower analyses that drive 91D end-strength authorizations have not accounted for time spent performing tasks that are not system-driven, i.e., power management. If 91Ds are to serve as UPMs, CASCOM should submit a request to the ARCIC Sustainment Division to conduct a new MARC study that explicitly incorporates power management duties and responsibilities into the analysis.[145]

4) Task organize 91Ds within the BCT to better support the subordinate battalions

Addressing the decentralized management and employment issues described in the previous section suggests that a modified task organization may be needed if 91Ds are to perform the duties of the battalion UPM.

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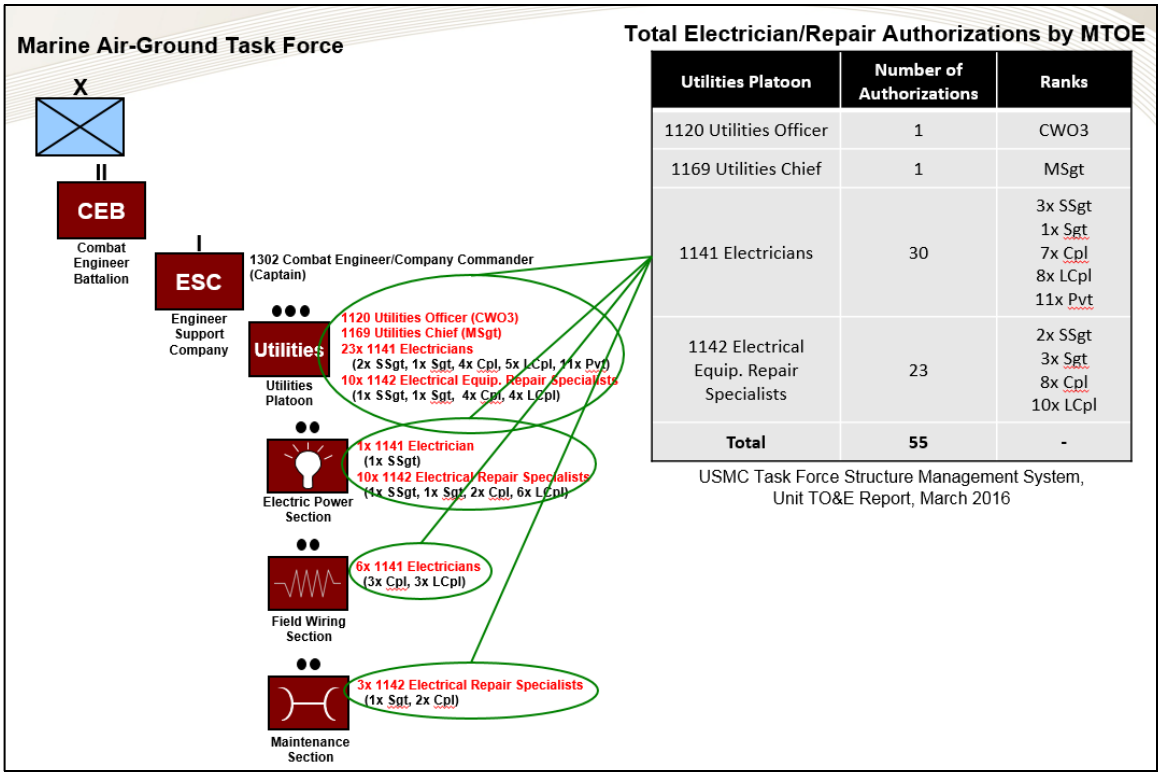
[144] TRADOC Regulation 350-70, *Army Learning Policy and Systems*, (Fort Eustis, VA: Headquarters, Department of the Army), 6 December 2011.

[145] AR 71-32 states that all requests for MARC studies go through the ARCIC Sustainment Division and are approved by the Deputy Chief of Staff for the Army G-3/5/7. AR 71-32, 26.

If planning (vice execution) is the primary responsibility, then one option could be to move the 91Ds out of the Forward Support Companies and into a battalion headquarters staff section (e.g., the S-3 or S-4), similar to other specialized functions like Chemical, Biological, Radiological and Nuclear; fire support; medical; and other sustainment functions.



Utilities Platoon	Number of Authorizations	Ranks
1120 Utilities Officer	1	CWO3
1169 Utilities Chief	1	MSgt
1141 Electricians	30	3x SSgt 1x Sgt 7x Cpl 8x LCpl 11x Pvt
1142 Electrical Equip. Repair Specialists	23	2x SSgt 3x Sgt 8x Cpl 10x LCpl
Total	**55**	-

Figure 15. USMC Power Management Organizational Structure for a MAGTF

A more radical approach could be to consolidate all 91Ds in the BCT into a single "power platoon," similar to the Marine Corps utilities platoon which is task organized to the Engineer Support Company within a Combat Engineer Battalion. Figure 17 shows how the utilities Marines are organized in the Marine Corps equivalent to the Army's IBCT organizational structure. Interestingly, in addition to the 30 MOS 1141 Electricians, the Marines have the same number of MOS 1142 Electrical Equipment Repair Specialists (the 91D equivalent) in their utilities platoon as the Army has 91Ds across the entire BCT.

In the Marine Corps case, all power management tasks (planning, setup, operations, repair, etc.) are explicitly assigned to the engineers and concentrated in a single platoon led by a senior warrant officer and utilities non-commissioned officer in charge. This structure gives the platoon leader more flexibility to support maneuver commanders, and also ensures that the enlisted teams have organizational leadership to oversee their training and development.

At the expense of having 91Ds in the Forward Support Companies, an Army version of the Marine Corps utilities platoon could keep the number of 91Ds per BCT constant while enabling a more consolidated management structure for their employment. Taking the current authorizations at each rank (two E-6/Staff Sergeants, seven E-5/Sergeants, four E-4/Specialists, and ten E-3/Privates First Class), the Army could create two electrical power sections, each with two teams, led by the 120A Warrant Officer proposed as the OE Advisor. Figure 18 shows a notional configuration of this platoon. Each authorization is a 91D unless stated otherwise.

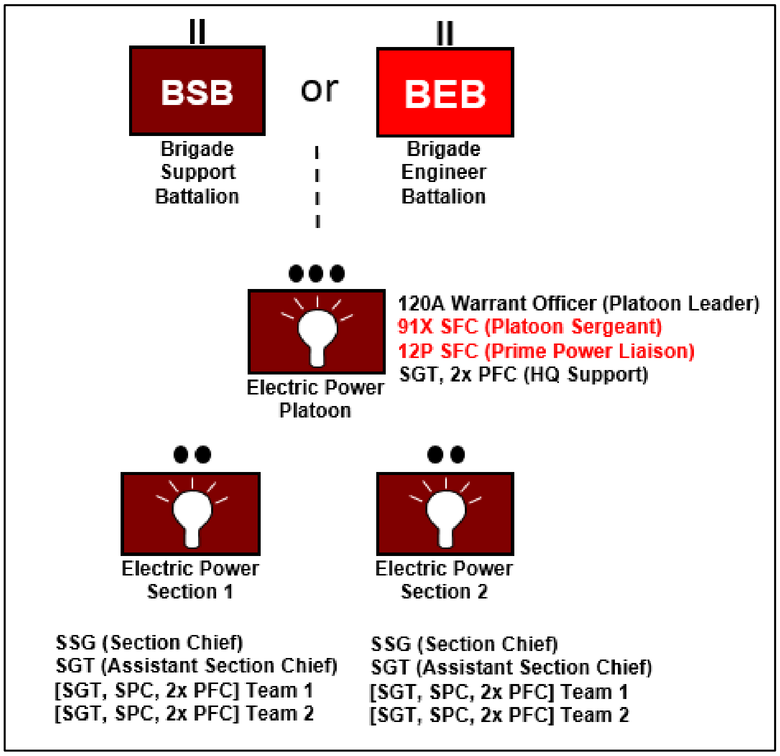


Figure 16. Notional Consolidated Army Power Platoon

Under this organization, the power platoon could be assigned to either the Brigade Support Battalion or the Brigade Engineer Battalion, with the 120A Warrant Officer serving as the platoon leader. If available, a 91X (E-7) Maintenance Supervisor platoon sergeant and a 12P prime power liaison could be in the headquarters section. An additional 91D E-5 and two E-3s would round out the headquarters section. The two E-6 staff sergeants would serve as section chiefs, with an E-5 in the assistant role. These section chiefs would employ two teams each comprised of an E-5 team leader, an E-4, and two E-3s. In total, the platoon would have four deployable teams as well as the additional flexibility provided by the headquarters section.

Organizing the 91Ds into a single platoon could alter the concept of the battalion UPM—rather than designating a single individual per battalion regardless of its power management needs, the power platoon leader could employ the section chiefs and their teams deliberately in the locations with the greatest demand; for example, during command post setup and execution. The smaller teams could be diverted to locations with power management issues, while the platoon leadership could monitor and optimize power supply and demand and advise commanders on planning considerations as requested.

This is a notional concept and, if implemented, will certainly require more detailed analysis to determine its viability during expeditionary operations, e.g., what are the tradeoffs between this organization and the current approach, and so on. But, at a minimum, it could solve the problems that arise with decentralized management of 91Ds and enable them to serve in the UPM role, even if differently from current concept. It would also address the staff alignment questions of the OE Advisor described in Step B.

5) If there are no changes to the current task organization, the power management proponent (Step A) must define the relationship and staff alignment between 91Ds, battalion staff sections, and the Brigade OE Advisor

If there are no changes to the current task organization as described in the previous section, then the power management proponent might detail how UPMs fit into the existing battalion staff structure as well as define their relationship to the proposed Brigade OE Advisor. Key questions include:

- Who does the UPM report to within the battalion staff? (S-3, S-4, Executive Officer? Other?)
- Is the OE Advisor responsible for training battalion UPMs?
- Is the OE Advisor responsible for evaluating or approving power plans produced by the unit power manager?

Answering these questions is an important step toward reducing ambiguity within the battalion staff as well as clarifying the interactions between battalion UPMs and the brigade OE advisor. Some of these issues may be addressed once the unit power manager roles and responsibilities are clarified (Step B), but we include the recommendation here as well to emphasize its importance.

d. MOS-Immaterial Soldier as Battalion Unit Power Manager: Pro

Opening the battalion UPM position to soldiers with any MOS would give commanders more flexibility to choose the right person for the role rather than relying on a single, low density MOS (the 91D) that may not always be available. This is especially true during expeditionary operations where, at the tactical edge of the battlefield, 91Ds are not directly assigned to maneuver units and instead spread across the Forward Support Companies.

Having asserted that power management capability is most critical at brigade and battalion command posts, granting battalion commanders the flexibility to assign anyone to serve as the power manager could also allow battalion staffs to align their power management efforts more directly with operational practices. For example, if the commander designates a senior NCO in the S-3 as the UPM, that NCO would automatically become part of the planning team for command post operations according to current doctrine.[146] Other staff sections may also be appropriate based on the commander's preference, including the S-4 and the S-6.

e. MOS-Immaterial Soldier as Battalion Unit Power Manager: Con

Despite the flexibility this option provides, there are drawbacks. Principally, power management is trained via online, self-development modules rather than in a schoolhouse setting. Mastery of complex training objectives may be less certain if left to online curricula.

f. DOTmLPF-P actions required if Soldiers with any MOS may be designated as the Battalion Unite Power Manager

As with the option to use only 91Ds as battalion UPMs, choosing the option to allow any MOS to become the UPM also comes with recommendations needed to address the associated drawbacks.

1) Develop comprehensive, standardized training for UPMs, and track qualified soldiers with an additional skill identifier

Because training is at the heart of the UPM role, it is crucial that the power management proponent designated in Step A also develop standardized curriculum for those soldiers who are assigned the duty.

There are several options for this training. The first choice is location—is it better to deliver the training via a resident course, or with a mobile training team? Options for the resident course include leveraging the Army's existing prime power curriculum as well as the utilities training at the Marine Corps Engineer School. Additional analysis would be needed to determine how many hours of instruction are needed as well as how much of the existing curriculum is relevant to the roles and responsibilities defined for the UPM, or if tailored modifications would be required.

A mobile training team could also provide standardized training for UPMs but with a lesser burden on the individual units compared with sending their soldiers to attend a temporary duty course at another installation. In this case, the power management proponent would develop the curriculum and then train the trainers who would travel to units' home stations. A good ex-

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[146] Army Field Manual 6-0, *Command and Staff Organization and Operations*. May 2014, 2-10.

ample of this model is the Master Driver Trainer Qualification Course taught through the Army's Transportation School, a mobile training course designed to train master drivers at the unit level who would then train and certify other soldiers to drive specific vehicle platforms.[147]

In both cases, it is important to track soldiers who become qualified unit power managers with an additional skill identifier in their personnel file.

2) Tailor UPM roles and responsibilities to leverage 91Ds as a resource

Even if the proponent from Step A determines the MOS-immaterial option is best for the battalion UPM, the 91Ds within the BCT would still be available as power management resources. For that reason, it is important that the proponent clarify how the 91Ds complement or augment the unit power manager position. Ideally, the relationship would be a byproduct of describing the UPM roles and responsibilities in Step B.

g. Summary

Table 2 summarizes the pros and cons for each of the options listed in the previous section. There does not appear to be an obvious "best" choice, as both options come with benefits as well as obstacles that must be overcome. One potential deciding factor could be the comparative costs of the proposed DOTmLPF-P recommendations for each option, but that analysis is beyond the scope of this paper.

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[147] US Army, "Transportation School touts advantages of traveling Master Driver Course." January 12, 2015. www.army.mil/article/140973/Transportation_School_touts_advantages_of

Table 2. Summary of Pros and Cons for Unit Power Manager Source Options

	91D as Battalion UPM	MOS-Immaterial as Battalion UPM
Pros	• Already has baseline knowledge of power generation and distribution systems • Ordnance School initiatives currently incorporating power management tasks into the 91D roles and responsibilities	• More flexibility for commander to choose UPM; not reliant on low density 91D MOS to fill position • Easier to align staff power management efforts; e.g., if assigned UPM works in the S3 shop, he/she would automatically become part of the planning team for command post operations according to current doctrine
Cons	• Capacity constraint; typical BCT only has ~23 91Ds • Prohibitive task organization; 91Ds are spread across multiple battalions in small teams of two or three • Highest rank is E-6, with only two per BCT; E-5 would be the de facto battalion staff representative for power management • Without MARC adjustments, UPM duties may take away from 91D principal responsibility as generator mechanics and trainers of generator operators	• No standard institutional training available beyond self-development (online) • Variance in backgrounds and skills; assigned Soldier not necessarily familiar with power generation and distribution theory, equipment, operations, and so on.

The results of the TPMC testing during Army Warfighting Assessment 17.1 may provide insight into the effectiveness of non-91D soldiers serving as the UPM. If successful, these two groups may be able to complement each other—a trained (non-91D) UPM could refer certain issues to the senior 91D if needed. Regardless, additional data collection and concept evaluation during these warfighting assessments and exercises should reveal which of the DOTmLPF-P efforts should be prioritized.

Ultimately, the choice for who should be the UPM rests on how the designated proponent in Step A describes the position's roles and responsibilities in Step B—specifically the responsibilities for planning, execution, or both. Table 3 maps our recommended DOTmLPF-P actions to this choice.

Table 3. DOTmLPF-P Considerations for Unit Power Manager Source based on Roles and Responsibilities

Designated UPM Roles and Responsibilities	Preferable MOS?	Recommended DOTmLPF-P Actions
Planning Only	Immaterial	• Develop standardized institutional training for UPMs • Define organizational relationships with battalion staff
Execution Only	91D	• Add more power management training to schoolhouse curriculum • Define organizational relationships with battalion staff
Both Planning and Execution	Unclear	**If Any MOS, then proponent should:** • Develop standardized institutional training for UPMs • Define organizational relationships with battalion staff • Leverage 91Ds for tactical power execution **If 91Ds Only, then proponent should:** • Add power management to 91D Critical Task List; add more power management training to schoolhouse curriculum • Consider moving 91Ds into battalion staff sections, or organizing them into single platoon • Conduct MARC analysis to account for power management duties • Define organizational relationships with battalion staff

If the UPM's primary responsibility is planning, then the preferable option is to use an MOS-immaterial soldier. If the primary responsibility is execution, then the 91D is the better choice. If, however, the UPM will be responsible for both planning and execution, there is no clear choice, and further analysis of the associated DOTmLPF-P recommendations would be needed to determine if one option would be more cheaper or more effective.

IDA recommends that the designated power management proponent determine whether the UPM should be sourced with 91D-qualified soldiers only, or open to any MOS. After this decision, the proponent might address the DOTmLPF-P considerations as outlined above.

7. Summary of Findings and Conclusions

Concerned about the Army's ability to integrate future advanced power generation and distribution systems into tactical units, PM E2S2 asked IDA to look at the Army's non-materiel approach to power management and identify changes in doctrine, organizational structure, and training needed to support the integration of advanced power generation and distribution systems into Army units.

Our review of the Army's current approach to power management as well as the joint requirements and capability gaps literature found that:

- Power management tasks and responsibilities span the engineer, sustainment, and operational communities
- Power management capability gaps identified through the JCIDS process have not led to DOTmLPF-P changes to improve power management at the brigade-level and below

The Army's power management challenges have been well-documented through external studies and after-action reviews, and the Army's functional proponents for Operational Energy, namely CASCOM and MSCoE, have recognized that the Army's non-materiel approach to power management could be improved. Engagements and interviews with these organizations as well as other stakeholders revealed that, despite the absence of official DOTmLPF-P change requests, there are multiple parallel initiatives to improve elements of power management that focus on updating doctrine, developing training support packages, and revising operational energy roles and responsibilities within the BCT. These efforts have made progress addressing many of the underlying issues that affect that Army's approach to power management.

TRADOC's CNA framework allowed the IDA research team to assess the Army's approach to power management, including the ongoing improvement initiatives, in light of the current and future strategic operating environments. This analysis asserted that power management is most critical beyond the base camp at brigade and battalion-sized command posts—the proliferation of networked systems and increased command post size are driving the need to employ fewer generators more efficiently (e.g., via a microgrid) or risk an unnecessarily heavy footprint and inflated demand for liquid fuel.

The ability to manage power at these command posts will yield the greatest benefits; however, we found that command post modernization initiatives are not coordinated with operational energy stakeholders working to improve power management. To address this, we recommend that the TRADOC Capability Manager for Mission Command/Command Posts attend the Tactical Power Forum and other Operational Energy stakeholder synchronization sessions, and coordinate their Command Post/Contingency Basing strategies with the ongoing power management improvement initiatives.

After comparing the results of our literature review, stakeholder interviews, and the future implications for power management based on the CNA framework, we determined that the Army should consider taking several steps in order to address changes in doctrine, training, and organizational structure. These steps are:

- **Step A:** Designate either CASCOM or MSCoE as the proponent for power management at the brigade/battalion level
- **Step B:** Clarify the roles and responsibilities of the battalion UPM and Brigade OE Advisor
- **Step C:** Determine whether only 91D-qualified soldiers can serve as battalion UPMs, or if the duties can be MOS-immaterial

For Steps A and B, we concluded that TRADOC, as the lead for capability development, should determine if power management is best assigned as a sustainment function or an engineer function and designate either MSCoE or CASCOM as the lead proponent organization for power management at the BCT-level and below. The designated proponent should then

- Update the Army Universal Task List with power management doctrine and promote additional non-materiel capability integration and synchronization through ARCIC
- Define the UPM's role within the battalion staff
- Determine and codify which elements of power management (planning versus execution) fall under the UPM's responsibility
- Define the OE Advisor's responsibilities and organizational relationship to the battalion UPMs

For Step C, we recognized that there are pros and cons for both options (91D only or MOS-immaterial), and that either choice would require DOTmLPF-P actions to address the drawbacks. Further, this choice hinges on how the proponent designated in Step A defines the UPM's roles and responsibilities in Step B.

There are also opportunities for future research in this area. First, it is important to quantify the value of battalion UPM for maneuver commanders—what does the commander gain by managing the unit's tactical electric power more efficiently and effectively? A related component of this is to find the best ways to translate this value in operational metrics beyond traditional fuel calculations that convert gallons saved from sustainment functions into extra vehicle miles and aircraft sorties—for example, how long can a command post power its required systems without fuel resupply if configured as a microgrid with hybrid power sources?

Another opportunity is to conduct a more thorough analysis of the electrical power needs at future command posts. Our research uncovered that future command posts are becoming more complex and will require sophisticated power management capability in order to reap the benefits of any integrated, advanced technological solutions intended to optimize the supply and demand of electric power. However, the changing magnitude of these electrical power requirements is unclear, and could have implications for some of the ongoing initiatives to improve the Army's approach to power management.

Today, power management is primarily an issue of efficiency and may not reach a high priority for action within the Army's broad portfolio of capabilities and requirements. While doing nothing is rarely an appetizing alternative, resource constraints and other priorities may crowd out the desire for improved power management capability. As the strategic environment changes, though, power management may become an issue of mission effectiveness based on its importance to command posts, which require uninterrupted power to enable maneuver units to conduct mission command. Analyzing power management through the AROC, as we have recommended, will quantify the magnitude and scope of the power management gap and expand on many of the findings highlighted in our research. And, even without the near-term TRADOC intervention we have recommended in Chapter 6, better synchronization of current non-materiel efforts could help bridge the gap between the planning and execution elements of power management.

As DoD continues to develop and field more advanced tactical electric power generation and distribution systems, the Army has an opportunity to adapt its non-materiel approach to power management, ensuring the effective and efficient supply of electrical power to tactical consumers.

Appendix A. Official Gaps

Table A-1. Capability Gaps Identified in initial capabilities documents for Operational Energy for Sustained Ground Operations (2012)

Soldiers, rotary aerial platforms, and ground systems lack sufficient endurance to conduct persistent and dispersed missions (dismounted, mounted, and aerial). Current force Soldiers, rotary aerial platforms, and ground systems lack energy sources that provide sufficient power to enable operations for extended times without sustainment.
The force lacks the ability to accurately monitor and manage energy demand and supply processes to appropriately balance the logistics challenges to operational requirements through situational awareness, campaign planning, and operational agility.
The force lacks the ability to correctly assess, plan, design, and manage tactical power load, distribution, and conditioning systems which provide high efficiency energy conversion and prime power needed for uninterrupted and sustainable support to soldier and platform systems, command and control operations, and life support facilities.
The force lacks interoperable interfaces on or between soldier systems and platforms (manned or unmanned) or base camp power and energy systems in order to rapidly refuel or recharge soldier power and energy systems or reduce vehicle main engine run time to support operational agility, battlefield logistics, and force protection.
Ground forces lack the ability to efficiently store energy, generate and distribute power at precise moments as required to employ sensors and weapons systems search, targeting and engagement effects on an enemy in order to achieve a decisive advantage on the battlefield.
The force lacks the ability to minimize reliance on petroleum-based energy and power systems to reduce the dependence on limited fuel resources.
The force lacks the ability to provide sufficient electrical power to tactical vehicles non-propulsion systems when in an extended security mode and to provide power storage or exportable power thereby reducing the need for stand-alone generators and provide enhanced force protection through reduced signature.
The force operation, force protection, and logistics efficiencies are inhibited by a lack of compliance to a standard single fuel for ground based systems.
The force lacks sufficient commonality of Soldier carried energy sources to increase operational agility and flexibility as well as reduce load and sustainment requirements.
The force cannot decrease collective system energy demands without a reciprocal decrease in endurance and performance for sustained operations and an increased demand on sustainment capabilities.
The force lacks the ability for command posts to assess and efficiently generate power to support current and emerging communications and battle command systems.
The force lacks a comprehensive, institutional awareness of the impact of energy use on operational effectiveness and the need to consider efficient use of energy as a mission enabler.
Base camps cannot efficiently sustain operations and life support facilities of forces operating in austere environments and import or export power from or to non-US military systems (e.g. NATO, coalition, multinational, non-governmental organization, PVO), respectively.
Base camps lack effective plans and designs for bulk POL storage and distribution systems (logistics infrastructure) used in combat operations areas to provide high efficiency energy management across all environments.
Base camps lack alternative and renewable energy sources to compliment or replace existing power and energy systems to support operational agility, battlefield logistics and force protection.
Soldiers, rotary aerial platforms, and ground systems lack sufficient endurance to conduct persistent and dispersed missions (dismounted, mounted, and aerial). Current force Soldiers, rotary aerial platforms, and ground systems lack energy sources that provide sufficient power to enable operations for extended times without sustainment.

Table A-2. Capability Gaps Identified in ICD for Contingency Basing

Integration and synchronization of contingency basing as a holistic system does not exist in the Joint Force.
The Joint Force lacks sufficient capability for contingency location master planning and facilities design.
The Joint Force lacks sufficient and proficient capabilities for contract management and construction of contingency locations.
The Joint Force lacks sufficient and proficient functional area capabilities to operate contingency locations.
The Joint Force lacks sufficient and proficient capabilities to manage and integrate contingency location operations.
The Joint Force lacks sufficient guidance and proficient capabilities to transition/close contingency locations.

Table A-3. Capability Gaps Listed in the ARCIC Capability Needs Analysis Database

Gap 460081: The Infantry Brigade Combat Team (IBCT) lacks the ability to provide and sustain power during persistent operations in all environments under unified land operations at all echelons brigade and below, and an inability to recharge batteries to support organic systems.
Gap 462206: The Armored Brigade Combat Team (ABCT) lacks the ability to execute critical tasks during unified land operations due to the physical limitations of the systems that have exceeded the original required size, weight and power margin specifications
Gap 500742: The Stryker Brigade Combat Team (SBCT) lacks sufficient tactical mobility to execute mission-essential tasks during unified land operations due to demands of the systems that have exceeded the original required size, space, weight, and electrical power growth margin specifications.

Table A-4. Relevant Non-Material Recommendations from JCIDS Documents

Source Document	Category	Recommendation
ICD for OESGO	Doctrine	Modify existing field manuals to include tactics, techniques and procedures (TTPs) that specifically address operational energy integration across soldier, surface, and aviation systems and bases
ICD for OESGO	Doctrine	Modify existing concepts and doctrine to support the need to institutionalize operational energy awareness and conservation across the force, from soldier to senior commander, so they better understand the impact of energy on mission accomplishment
ICD for OESGO	Doctrine	Modify field manuals with TTPs that specifically address integrated power generation, storage, management, distribution, and harvesting as critical aspects of campaign and mission planning and operational execution across the range of military operations
ICD for OESGO	Doctrine	"Operationalize" energy implications on mission planning and execution into concepts and doctrine
ICD for OESGO	Organization	Identify organizational changes required to support doctrine and training development and execution procedures
ICD for OESGO	Organization	Assess power demands by unit type and adjust force structure required to establish, operate, maintain, and sustain expeditionary power and energy infrastructure with organic capabilities
ICD for OESGO	Organization	Establish a capability integrator and material systems integrator who can collaborate to provide well-defined capabilities and solutions for operational energy
ICD for OESGO	Organization	Designate a collateral duty energy officer or position in operational units
ICD for OESGO	Organization	Establish an expeditionary construction organization to design, build, and manage base camps and their required energy infrastructure
ICD for OESGO	Training	Consideration should be given to developing a comprehensive training program that includes institutional, self-developmental, and unit training products for energy management based on emerging or revised concepts or doctrine
ICD for OESGO	Training	Develop training for expeditionary force power generation and management system planning, coupled with soldier and leader energy awareness and conservation training curriculums
ICD for OESGO	Training	Developing and implementing energy management training programs with certified trainers will reinforce energy safety and operating standards across the force
ICD for OESGO	Training	Energy management principles should be assessed and evaluated through training scenarios, workshops, and exercises
ICD for OESGO	Leadership & Education	Educate leadership at all levels in the importance of energy management processes to operations
ICD for OESGO	Leadership & Education	Develop energy management reachback capabilities and institutionalize them through professional military training opportunities

Cont'd on next page

Source Document	Category	Recommendation
ICD for OESGO	Leadership and Education	Develop on-line knowledge centers for energy management that would inform the force of lessons learned and best practices
ICD for OESGO	Facilities	Develop virtual capabilities that support system-of-systems integration and engineering of solutions, achieving increased understanding of costs and benefits through operational modeling
ICD for OESGO	Personnel	The Army can identify additional personnel requirements to support expanded force-wide energy generation and management positions; providing more trained and certified personnel in utility management (base electric, water, waste, and bulk fuel operations) will improve operational energy efficiency and effectiveness
ICD for OESGO	Personnel	Energy and power systems should be automated to the maximum extent possible to reduce the need for additional manpower
ICD for OESGO	Policy	Designate an organization to integrate and strategically oversee and manage the development of soldier, surface, aviation, and base camp energy systems and capabilities
ICD for OESGO	Policy	Develop policies to incorporate existing and future sustainability requirements into the planning, design, construction, and operation of Army systems
ICD for Cont. Basing	Doctrine	Develop joint doctrine to address contingency basing
ICD for Cont. Basing	Doctrine	Publish a joint publication, or include in current joint pubs, the preferred or best practices for organizing, designing, managing, operating, and transitioning or closing a contingency location
ICD for Cont. Basing	Organization	Organize the services to provide dedicated, scalable, interoperable, and deployable capabilities to plan, design, construct, operate, manage, and transition or close contingency locations; services are organized with standard methods and structures, and are interoperable
ICD for Cont. Basing	Training	Ensure the Services develop and standardize comprehensive contingency location training to eliminate the ad-hoc execution of contingency location tasks, and to ensure consistent and integrated contingency location management.
ICD for Cont. Basing	Training	Include consideration of contingency locations throughout their lifecycle in war games and exercises.
ICD for Cont. Basing	Leadership & Education	Ensure the Services develop or modify leadership training and professional military education that trains all levels of leadership on the new contingency location doctrine and policy.
ICD for Cont. Basing	Personnel	Ensure Services are capable of providing personnel with the appropriate competencies to support JFCs on contingency location requirements.
ICD for Cont. Basing	Facilities	Recommend the establishment of a location that enables cross-Service integrated development, testing, and evaluation of contingency location solutions.

Appendix B. AUTL Performance Measures

Table B-1, taken from the Army Universal Task List, shows the measures of performance associated with ART 4.1.7.4 (Supply Mobile Electric Power).

Table B-1. Measures of Performance for Army Universal Task List 4.1.7.4

Number	Scale	Measure
1	Yes/No	Mobile electric power met users' needs.
2	Yes/No	Unit constructed electrical system and installed power generation and regulation devices per operation order specifications and within the time stated in the directive.
3	Yes/No	Mobile electric power systems adhered to local and national electric code specifications.
4	Yes/No	Unit had and followed planning and procedures for environmental considerations.
5	Yes/No	The construction directive stated the exact assignment, project location, and start and completion times; specified additional personnel, equipment, and materials available; prioritized the entire project; and specified type and frequency of construction reports, time needed for special procurement, and coordination instructions with user agency.
6	Time	To refine mobile electric power service program for the area of operations (AO) after receipt of warning order.
7	Time	To prepare engineer construction estimate that determined the effort needed to meet the requirements, assigned operational and construction responsibilities, and determined additional personnel and equipment requirements.
8	Time	To reconnoiter to evaluate the site for suitability and conditions, identify construction problems and possible courses of action, and update or revise the engineer estimate.
9	Time	To prepare construction directive for a facility to house mobile electric power generators, power grid substations or transformers, and electric power lines and issue it to the construction unit.
10	Time	To coordinate for and receive engineer assets to perform task.
11	Time	To monitor construction and perform quality assurance inspections.
12	Time	To perform location survey to establish permanent benchmarks for vertical control and well-marked points for horizontal control.
13	Time	To perform construction layout survey. *Cont'd on next page*

Number	Scale	Measure
14	Time	To verify accuracy of construction plans and specifications to include ensuring the bill of materials included all required materials to complete construction.
15	Time	To rough in the structure to accommodate electrical service.
16	Time	To install cable and conduit.
17	Time	To complete installation by connecting joints; grounding system at service entrance; connecting bonding circuit; attaching wire to switch terminal, ceiling and wall outlets, fixtures, and devices; and connecting service entrance cable and fusing or circuit breaker panels.
18	Time	To test and repair the system.
19	Percent	Of difference between planned and actual mobile electric power requirements in the AO.
20	Percent	Of planned mobile electric power generation and distribution capabilities gained in the AO.
21	Percent	Of units in the AO that required mobile generation power.
22	Percent	Of electrical power in the AO generated by mobile generation units and distributed through a tactical grid.
23	Percent	Of electrical power in the AO provided by existing power generation facilities and distributed through a commercial grid.
24	Percent	Of power generation systems operational.
25	Percent	Of required kilowatt hours provided by mobile generation units.
26	Percent	Of power provided in the AO that meets voltage, frequency, and amperage standards.
27	Number	And types of mobile generation systems required that met user requirements
28	Number	Of kilometers of electric power lines that formed the tactical grid in the AO.
29	Number	Of substations and transformers required by the tactical grid.

Appendix C. Updated 91D Duty Descriptions

This appendix shows the revisions to the duty descriptions for each skill level of the 91D military occupational specialty (MOS), effective October 2017.[148] The baseline text is taken from the 2009 duty descriptions. Strikethrough text indicates deletion in the updated version, while red text indicates text that has been added. Note that the official title of the 91D MOS has changed from *Power Generation Equipment Repairer* to *Tactical Power Generation Specialist*.

a. Major duties. The ~~power generation equipment repairer~~ Tactical Power Generation Specialist supervises operation and performs field and sustainment level maintenance functions, including overhaul, but not rebuild of power generation equipment, internal combustion engines and associated equipment up through 200KW (except for turbine engine driven generators). Duties for MOS 91D at each skill level are:

(1) MOSC 91D1O. Perform field or sustainment level maintenance on ~~tactical utility, precise~~ tactical power generation sets, power distribution systems, internal combustion engines and associated items of equipment. Assists operators in proper employment of tactical power generation equipment.

(2) MOSC 91D2O. Perform duties in preceding skill level, supervises lower grade Soldiers and provides technical guidance to the Soldiers in the accomplishment of their duties. Repairs/overhauls starters, alternators, generators, fuel injectors, voltage regulators, switches, control circuits, etc. Perform duties as unit power planner. Determine proper generator selection in order to meet efficient power demands. Train operators in the proper maintenance and employment of tactical power generation and distribution systems.

(3) MOSC 91D3O. Perform duties in preceding skill levels, supervises lower grade Soldiers and provides technical guidance to the Soldiers in the accomplishment of their duties. Supervise activities of a section performing field or sustainment maintenance on ~~tactical utility, precise~~ tactical power generation ~~sets~~ and distribution systems, internal combustion engines and associated equipment. Apply maintenance management and quality control including production and quality control in maintenance activities. Perform duties as tactical power planner. Complete power assessments and tactical power grid designs in order to achieve proper operating efficiencies. Advises unit staff personnel on how best to employ tactical power generation and distribution systems to meet unit power requirements.

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[148] Chapter 10 (Enlisted MOS Specifications) of Department of the Army Pamphlet 611-21, *Military Occupational Specialty Classification and Structure.*

Appendix D. Illustrations

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Appendix F. Abbreviations

ADRP	Army Doctrine Reference Publication
AMMPS	Advanced Medium Mobile Power Sources
AOC	Army Operating Concept
ARCIC	Army Capabilities Integration Center
AROC	Army Requirements Oversight Council
ART	Army Tactical Task
ATP	Army Techniques Publication
AutoDISE	Automated Distribution Illumination System, Electrical
AWA	Army Warfighting Assessment
AWFC	Army Warfighting Challenge
BCT	Brigade Combat Team
BEyOnD	Behavioral Energy Operations Demonstration
CASCOM	Combined Arms Support Command (US Army)
CDID	Capability Development and Integration Directorate
CNA	Capability Needs Analysis
CPI2	Command Post Integrated Infrastructure
DA PAM	Department of the Army Pamphlet
DCR	DOTmLPF-P change request
DoD	Department of Defense
DOTmLPF-P	Doctrine, organization, training, materiel, leadership and education, personnel, facilities, policy
DWG	Distribution Working Group
E2S2	Expeditionary Energy and Sustainment Systems
ECU	Environmental Control Units
ES2	Army Energy Security and Sustainability Strategy
IBCT	Infantry Brigade Combat Team
ICD	Initial Capabilities Document
JCIDS	Joint Capabilities Integration and Development System
JROC	Joint Requirements Oversight Council
JSB	Joint Standardization Board
kW	Kilowatt
MARC	Manpower Requirements Criteria
MOS	Military Occupational Specialty

MSCoE	Maneuver Support Center of Excellence (US Army)
MTOE	Modified Table of Organization and Equipment
NCO	Non-Commissioned Officer
OE	Operational Energy
OE-M	Operational Energy Management
OESGO	Operational Energy for Sustained Ground Operations
OSD	Office of the Secretary of Defense
OV-1	Operational View-1
PDISE	Power Distribution Illumination System, Electrical
PM E2S2	Project Manager for Expeditionary Energy and Sustainment Systems
PM MEP	Project Manager for Mobile Electric Power
QDR	Quadrennial Defense Review
SME	Subject Matter Expert
TC	Training Circular
TCM	Training and Doctrine Command Capability Manager
TEP	Tactical Electric Power
TOC	Tactical Operations Center
TPMC	Tactical Power Management Concept
TRADOC	Training and Doctrine Command (US Army)
TSP	Training Support Package
TTP	Tactics, Techniques and Procedures
UPM	Unit Power Manager
USACE	United States Army Corps of Engineers
USMC	United States Marine Corps

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14. ABSTRACT This paper reviews the Army's non-materiel approach to tactical electric power management—with an emphasis on doctrine, organizational structure, and training—to assess how well the non-materiel elements will support the integration of advanced power generation and distribution systems into Army formations at the brigade level and below. Opportunities remain to more fully define power management capability gaps at the brigade-level and below through the DOTmLPF-P Change Request process. The need for power management is greatest beyond the base camp at brigade- and battalion-sized command posts. We recommend three steps that TRADOC could take to improve them: (1) Designate a functional proponent for power management at the brigade/battalion level; (2) Clarify roles and responsibilities of the Battalion unit power manager and Brigade OE Advisor; and (3) Determine the source MOS for the Battalion unit power manager.					
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