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Powering the Fight: Lessons from the Grid at War

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Powering the Fight: Lessons from the Grid at War

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Abstract

Over the last half century, technological innovations have transformed modern warfare and intertwined U.S. military operations with the reliability and durability of the U.S. power grid. While these advancements in defense capabilities have strengthened the U.S. security posture in many ways, the current electric grid poses a severe vulnerability. During the two major world wars of the last century, the power grid played the more subtle yet foundational role of powering the defense industrial base — a hallmark of the American war machine that helped lead America and its allies to victory in each war. Yet those victories were not assured. In both wars, the U.S. faced severe challenges providing adequate power for the uptick in defense manufacturing. If the United States had to fight a major war today, the power grid would immediately be tapped to deliver uninterrupted electricity for critical defense missions at domestic installations while simultaneously supporting an uptick in wartime manufacturing that the country has not witnessed in more than 80 years. Drawing on lessons from last century's major wars, the paper identifies a path forward to ensure critical military missions and defense industrial manufacturing have the transmission infrastructure necessary to support the success of the U.S. Armed Forces. Understanding how these challenges were overcome offers a roadmap for policymakers, utilities, and grid operators to follow as they work to strengthen the resilience and reliability of the electric grid—the foundation of our force and the defense industrial base—in order to prepare for and deter future conflict.

"The history of the two great world wars has proved dramatically the vital part of electric power: literally speaking, those who won had enough; those who lost, not enough. It will be equally true in any future conflict in which we may be forced to engage."

– Walker Cisler, Founder of the National Academy of Engineers

Introduction

The commercial power grid is vital to a globally-networked U.S. military and represents a significant vulnerability to national defense readiness. Today, the U.S. energy system is increasingly challenged to support peacetime needs, and is dangerously unprepared to support a major war if the United States was called on to fight one. Over the last half century, the U.S. military has become increasingly dependent on domestic installations tied to the commercial power grid to support force projection and combat operations overseas.[1] Domestic installations are no longer simply preparing forces to deploy for combat missions or providing "reachback support" to troops abroad; they are now conducting pivotal operations alongside U.S. forces — from offensive and defensive cyber squadrons disrupting adversaries in the digital domain, to drones providing special operators with overwatch and fire support. Electricity outages that interrupt these critical missions are not just a nuisance; they can cause avoidable casualties on the battlefield and may be strategically decisive in a future fight.

It was not always this way. During World War I and World War II — the last major wars that required a complete mobilization of U.S. economic and societal might — the power grid played a more subtle role in national defense compared to today. Overseas combat relied mostly on access to "operational" energy, particularly fuel. Domestic electricity generation powered the factories that produced the rivets, aluminum and other industrial components of the American war machine. Even with the stakes high and most of the nation's electricity needs concentrated in the industrial base, the power grid struggled. Defense manufacturing faced the prospect of energy shortages that threatened the U.S. military's readiness and civilian access to power, requiring the federal government to implement wartime policies to restrict energy use and rapidly build new infrastructure. The need to power defense manufacturing also fundamentally changed the grid by accelerating public-private collaborations and partnerships that continue to influence the electricity system.

If the United States had to fight a major war today, the power grid would immediately be tapped to deliver uninterrupted electricity for critical Department of Defense (DoD) missions at domestic installations while simultaneously supporting an uptick in wartime manufacturing that the country has not witnessed in more than 80 years. This would come at a time when the grid faces an unprecedented surge in demand from energy-intensive commercial operations, such as Artificial Intelligence (AI), data centers, and semiconductor chip manufacturers that are also important to U.S. national security. These strategic and energy-intensive industries are forecast to increase electricity demand by as much as 25% by 2030. All the while, the grid remains exposed to a litany of manmade and natural threats that could potentially cause local and regional outages. Unless the United States builds a more reliable and resilient power grid, the current system risks falling short, and the consequences could prove disastrous.

This paper discusses the nature of warfare through the lens of the U.S. power grid.

In Part One, the paper considers the U.S. military's early relationship with the grid and the role electricity played in the mobilization of the defense industrial base during the two world wars of the twentieth century. It discusses the challenges the power grid faced meeting the total war requirements put on the defense industrial base, and what steps the United States took to overcome these challenges before they caused irreversible harm to the war effort.

In Part Two, the paper examines the evolution of U.S. domestic installations and their increasing dependence on the power grid. Noting the fundamental change in the nature of the U.S. military and its globally-networked forces tied to domestic bases, this section emphasizes the military's increasing dependence on a vulnerable and aging U.S. power grid. The section concludes by using the lessons from the last major wars to infer what might happen if the United States had to fight a major war today while relying on the current electric grid.

In Part Three, the paper explores important steps that policy makers, defense leaders, utility owners, and grid operators should consider today to begin to build an electric grid that will help the U.S. military succeed in the future.

Part One: The Grid, the Industrial Base, and Major War

The relationship between the U.S. military and the power grid — an interconnected network generating, transmitting, and distributing electricity to customers — has evolved slowly over time. The creation of electromagnetic energy that could be transferred via a current had immediate military implications, ones that were conceived well before Thomas Edison famously put electric power on display with the Pearl Street Station. Shortly before the Civil War, Samuel Morse communicated over wires via an electrical current in what became the telegraph — demonstrating one of the first uses of electricity for military purposes. The idea that the power grid would become so central to military operations would take more than a half century to realize as the military's relationship with the grid evolved from the energy serving defense critical manufacturing to today's grid-dependent installations supporting worldwide missions.

World Wars I and II demonstrated the importance and strength of a reliable power grid to domestic and foreign operations. During this time, the electric grid was essential to the defense industrial base that produced weaponry and was integral to achieving America's war aims. Yet even with the grid having a concentrated role in wartime manufacturing, it was not guaranteed that the United States could produce enough power to support the requirements for total war — at least not without government intervention.

This section of the paper explores the challenges the grid faced in responding to surging demand for wartime production and what steps the U.S. government took to avoid energy shortfalls that could have been catastrophic to the war effort.

World War I

When World War I broke out in Europe, roughly 10% of the U.S. population had access to electricity. However, demand was increasing as the country began to embrace the transformative potential of grid-tied power. In 1900, U.S. electricity consumption totaled roughly 5 Gigawatt hours (GWh); by 1914, it reached 24.8 GWh.

As electricity access increased across the nation, the power grid became central to producing the weaponry critical to U.S. allies and, ultimately, the outcome of the conflict. Modern electricity had unleashed the "capacity of civilian firms to manufacture large numbers of standardized weapons [that] became increasingly central to the conduct of industrialized warfare. Though the United States was officially neutral until 1917, demand for industrial, agricultural, and other wartime goods drove production and overseas trade. According to an after action report published for the War Department in December 1919, U.S. electricity demand was steadily increasing prior to 1912, before jumping nearly 156% from 1912 to 1918.

By the time Congress declared war in April 1917, the power situation was dire. The War Department later concluded that "exhaustion, soon after our entry into the war, of the reserves of central-station electric power in our principal manufacturing communities," was a critical problem.

Shortly after the United States entered the war in 1917, a coal shortage and severe winter weather exacerbated looming electricity supply concerns and highlighted the structural mismatch between where power was produced and where it was consumed. There were no regional grids to transmit the unprecedented amounts of power required to meet the demand from factories, shipyards, and other critical facilities that manufactured munitions, combat platforms, and other essential supplies. As a result, industrial suppliers had to curtail production to match the energy supply that was available, with energy shortages setting the pace of wartime production.

The War Department found that chemical and steel manufacturers in upstate New York — referred to at the time as the Niagara Falls and Buffalo district — had about 20,000 horsepower of excess production capacity (equivalent to roughly 15 megawatts (MW)) because there was not enough electricity to meet the total industrial demand that existed to support the war effort.

The electricity shortages in the Niagara Falls-Buffalo district threatened production of critical materials, including the chlorine used in chemical gas, phosphorus used in smoke bombs, abrasives used in metal shops, and ferroalloys used in shell forgings and rifles. A lack of electricity supply also constrained wartime production of both materiel and fuel in Appalachia. Roughly 40% of the total amount of steel required for munitions and steel ship construction was produced in western Pennsylvania and eastern Ohio. Appalachian coal mining also depended on electricity, and the War Department concluded that: “Had an ample amount of power been available [for mining], the severity of the coal shortage during the war could have been partially relieved. The War Department also found that there should have been more than enough electricity generating capacity to meet demand. However, the power lines needed to link the industrial energy loads to generation were inadequate and could not address the shortages.

To resolve these challenges, the federal government imposed strict conservation measures, including blackout policies and the prioritization of electricity for essential industries. Recognizing that isolated power systems left essential wartime production vulnerable to disruption, the federal government coordinated efforts to connect independent utilities and construct transmission lines. Both industry and government leaders called on utilities to interlink their systems and run them at maximum efficiency to ensure wartime loads were met. These interconnected systems proved vital for conserving fuel and meeting surging demand. “Notably, ten utilities serving New England, including Boston Edison, reported improved reliability as a result of interconnected and enforced operating capacity.

In July 1917, three months after the United States declared war on Germany, President Woodrow Wilson created the War Industries Board (WIB) to centralize production across industries essential to the war effort. Initially, the board served as an advisory body with limited power. However, as demands grew, it became increasingly evident that stronger oversight was essential to improve industrial efficiency and coordination. The WIB worked closely with the U.S. Fuel Administration to ensure that energy resources were allocated and directed to industries essential for the war effort.

In August 1918, the WIB requested that Representative T. W. Sims, Chairman of the House Committee on Interstate and Foreign Commerce, introduce a bill granting the President authority to centralize control over existing electric infrastructure and develop new sources of generation for the advantage of wartime production. The proposed bill included the construction of an interconnected distribution and transmission system. By regionally linking local grids, power could be redirected from areas with surplus electricity to those experiencing shortages, creating a flexible and resilient system that could meet shifting demands. Congress did not pass the bill before the war ended with the November 1918 Armistice, leaving the issue of an interconnected electric grid unresolved.

These wartime efforts evidenced the emerging view that the power grid was a strategic asset. Though the technology for long distance, high voltage transmission lines was not yet fully developed, the war led to temporary cooperation among regional utilities and the public and private sectors. Government and industry representatives recognized that an interconnected grid reduces vulnerabilities, improves reliability, lowers costs for consumers, and supports economic activity.[2] In the months following the war’s resolution, industry leaders advocated for a nationwide power network. Guy Tripp, chairman of the Board of Westinghouse and an officer in the U.S. Army, called for “one reservoir” of power to reduce the power industry’s profound fuel waste, low load factor, and the inefficiency of small utilities. Commonwealth Edison engineer Rudolph E. Schuchardt strongly endorsed universal interconnection with a common frequency of sixty cycles. Lieutenant Charles Keller’s guidance on avoiding future wartime energy shortfalls, offered in his report The Power Situation During the War, was predicated on interconnecting systems through long-distance power lines. While a nationwide grid has yet to come to fruition, the Federal Power Commission (FPC) was established in 1920 to promote and regulate interstate transmission — a function that became essential before, and during, the next major war.

World War II

During the interwar period, the role that the power grid played in the lives of everyday Americans grew significantly. This was particularly true for those from rural America, which had been largely unelectrified until President Franklin D. Roosevelt established the Rural Electric Administration (REA) in 1935. The REA, and related agencies, helped to increase the reach of electricity from 11% of rural households in 1921 to 25% by 1940.

As World War II loomed, and Germany's hold on Europe slowly tightened during the 1930s, the importance of the U.S. power grid grew alongside the increased need for weapons to prepare for potential war. Though the United States remained neutral during the first years of the conflict, the U.S. government began initial plans for war, with the energy challenges of World War I casting a long shadow over those preparations. President Roosevelt, understanding those lessons and their importance in the context of total warfare, was determined to avert power shortages that might undermine America's success.

In March 1938, with the ambition of creating a national defense power plan, President Roosevelt instructed the FPC and the War Department to work together to survey the nation's wartime power capacity. Four months later, the two agencies concluded that "if a wartime load were superimposed, widespread and critical shortages of generating capacity would occur. The analysis deemed the nation's electricity landscape "so serious as to require immediate attention," recommending the expansion and coordination of power systems; the strategic placement of generation to meet manufacturing and defense needs; and reduced demands on the nation's transportation system, fuel supply, and manpower pool.

In contrast to the U.S. government's assessment, the electric power industry was optimistic that it was ready to meet the country's needs. "I am sure I speak the sentiments of every electric utility in this land when I say that the industry is ready and willing to do its best to aid our government and its armed forces in bolstering the national defense," said Charles W. Kellogg, president of the Edison Electric Institute (EEI), in June 1940. "It did so in 1917 to the limit of its plant facilities, and it is ready to do it again, this time with much more ample resources, so that the electric power supply need place no limitations on the production of munitions of war.

According to the government's analysis, the power situation was especially perilous in existing war production locations, with critical industries mostly concentrated east of the Mississippi and north of Tennessee. The East Coast was home to what was considered "fifteen principal centers for the production of war material", which accounted for 45% of the total installed power capacity of the United States. The FPC estimated that the United States needed an additional 1.14 gigawatts (GW) of electricity to satisfy peacetime economic growth. When the nation eventually entered the war, demand for electricity was expected to jump an additional 5 GW to supply war production.

Both the FPC and the War Department understood that the government and private sector needed to work together to avoid power shortages. The joint report recommended that a government agency finance plant expansion and infrastructure development, addressing one of the outstanding issues from World War I cooperation: who pays for construction. After careful deliberation, the Reconstruction Finance Corporation (RFC) was provided authority to grant loans to utility companies when proven necessary for construction. The RFC's expanded authority resulted in new electricity generation, including a $22.5 million hydroelectric project for the Public Utility District No. 1 of Pend Oreille County, Washington.

Despite the U.S. government's support for expanding generation, it was evident by the time that Congress declared war on Japan and Germany that the electricity needed to produce adequate supplies of aluminum, magnesium, synthetic rubber and other wartime materials dwarfed what generators could deliver. Within three weeks of the Japanese attack on Pearl Harbor, Charles Kellogg of EEI reported that installed generating capacity had fallen short by 600,000 kilowatts, renewing concerns about industry's ability to meet projected wartime demand.

To address this discrepancy, utilities began to share power and interconnect their networks into power pools. Just days after Congress declared war on the Axis Powers of Japan, Germany, and Italy, 11 southwestern utilities signed an agreement to share power for aluminum production in Arkansas, which required 120 MW of power in a state with only 100 MW of capacity. The Southwest Power Pool (SPP) was formed and, with it, the utilities estimated an additional 200 MW of power would become available from existing sources by building additional transmission lines to connect the various systems. Later, in 1942, the Northwest Power Pool (NPP) was created and brought together 130 investor-owned power plants and 20 public power plants — including new hydroelectric power stations constructed as part of President Roosevelt's New Deal. The NPP created a total power reservoir of more than 3.3 GW of electricity, all on a voluntary basis. This supported a massive increase in aircraft manufacturing and shipbuilding, as well as the top secret Hanford Nuclear Reservation, which housed the world's first full-scale plutonium production reactor, and produced the plutonium eventually used in the bombing of Japan.

Perhaps most significantly, the establishment of the Southwest and Northwest Power Pools allowed industrial wartime production to diversify away from the eastern Mississippi, northern Tennessee, and other areas where it had concentrated during the interwar period. Now, production could be distributed across geographies that benefited from a diversity of generating sources — particularly hydroelectric power — as well as multiple time zones where demand could be more evenly shared across regions, depending on peak energy needs.

While power pooling began as a voluntary program between private and public generating plants, the War Production Board (WPB) quickly understood the value of interconnected systems and established power pools as a standard practice throughout the war. In May 1942, the WPB published Limitation Order L-94 in the Federal Register which required that "Each utility shall so operate its reservoirs, generating plants, sub-stations, transmission lines and other facilities and shall so interchange electric power with other utilities as to achieve the maximum coordination of power supply for war production and essential civilian uses, and for relief of power shortages. The idea was simple: an interconnected system would serve as the foundation for a future, nationwide power grid. To design and implement a unified grid and pool power, the FPC provided technical assistance and engineering expertise to private utilities.

While the Roosevelt Administration had done its best to coordinate private and public power production, it could not entirely mitigate the risk of power shortfalls during the war. Because of the outsized demand on electricity producers, there were occasional limitations, voltage drops, and fuel shortages that caused unexpected disruptions to factories and aluminum smelters. Facilities managed these disruptions by adopting alternative work shifts or staggered manufacturing schedules, avoiding the need to curtail operations. As a hedge against supply disruptions, the U.S. government imposed nationwide electricity conservation measures to ensure that the power being produced was made available first and foremost for the war effort.

It is hard to imagine what would have been, had President Roosevelt listened to the confidence of industry in the summer of 1940 that they were well prepared to meet wartime needs. Ultimately, the agility of industry in alignment with U.S. government instruments ensured there was adequate power for defense production. As historian Vaclav Smil noted, “There is no doubt that the rapid mobilization of America’s economic might, which was energized by a 46% increase in the total use of fuels and primary electricity between 1939 and 1944, was instrumental in winning the war against Japan and Germany.

Part Two: Domestic Installations and Shifting Dependence on the U.S. Electric Grid

The U.S. electric grid played an unquestionable role in the outcomes of the two world wars. While that role largely unfolded in America’s manufacturing centers, domestic military installations have increasingly become dependent on the electric grid. As new technologies emerged and the nature of warfare has evolved, U.S. domestic bases have grown increasingly more central to military missions. Today, domestic installations are foundational to the globally-networked U.S. forces, tying many of the outcomes of overseas operations directly to the reliability of the U.S. power grid.

This section explores the trajectory of the military’s dependence on commercial power from the pre-war to the post-Cold War era. Following the evolution of new technologies and how they have dramatically reshaped adversarial competition, this section assesses the ever-greater importance the U.S. power grid plays in the conduct of modern warfare.

Domestic Installations During the Major World Wars

While critical defense manufacturing during the two world wars drove U.S. dependence on the electric grid during this time, modest uses for electricity at domestic installations were also introduced and began to form ties between forces on the home front and the U.S. grid. During World War I, U.S. domestic bases relied on electric power from the grid for searchlights at naval forts and incandescent lights providing nighttime signaling. In World War II, electric power was important for several domestic facilities supporting overseas operations, such as cryptology and communications intelligence. The U.S. Signals Intelligence Service and its domestic operations at Arlington Hall outside of Washington; field support activities in Warren, Virginia and Petaluma, California; as well as its listening posts at Bellmore, New York, and Reseda, California, relied on the power grid to enable electric code ciphers that helped to support U.S. military operations abroad. Yet, the relationship between the power grid, the work of those signals intelligence squadrons, and overseas combat was still indirect compared to the way the grid powers critical missions at domestic installations today.

Nighttime illumination, made possible by the expanding grid, was viewed by many at the time more as a liability than as an enabler to wartime operations. “In the first months after the United States entered [World War II], blackouts and ‘dim-outs’ were widely adopted and enforced,” writes historian David Nye. “A Westinghouse executive warned that German bombers based in Norway could fly 7,000-mile round trips, which made blackout precautions advisable in Boston, Buffalo, Cleveland, Detroit, and Chicago. Fears that city lights would spotlight merchant ships for German U-boats along the eastern seaboard hastened the move to darken urban communities. The Office of Civilian Defense, a wartime agency established to coordinate federal and state preparedness, issued national blackout guidance in March 1942. Although German bombers never struck U.S. cities, the civil defense drills and desensitization of the U.S. public to blackouts — and later brownouts, a temporary reduction in electricity as opposed to a complete loss of power — would help the U.S. war effort manage the outsized electricity demand that became a feature of the wartime era.

The Cold War and the Changing Dependence on the U.S. Power Grid

The end of the Second World War and the beginning of the Cold War serves as an inflection point for the U.S. military's relationship with the power grid. In the postwar era, the U.S. military's reliance on the power grid grew as electricity demand surged alongside America's technological innovation, electrification, and suburban sprawl. The Cold War drove investment in military command and control systems grounded in computer-based communications and energy-intensive radar systems designed to monitor the Soviet nuclear threat. As missile sites, nuclear facilities, and radar installations became the forefront of U.S. national defense, the nature of the U.S. electric grid's importance in supporting defense priorities shifted.

The growing investment in technological advancements for the U.S. military underscored the need for a fortified grid to support increasingly diversified military efforts. This demanded a reimagination of large-scale infrastructure projects to ensure the military had the power necessary to drive innovation. During this time, DoD began to site backup generators on military bases to harden defense critical systems against potential disruptions to the power grid.

Cold War-era technological innovations laid the groundwork for decades of investment in advanced computing, surveillance, and autonomous systems. Now, the post-Cold War drive to harness emerging technologies for strategic advantage has brought the U.S. electric grid to the forefront of modern military operations.

The Grid and Modern Warfare

Today, the U.S. military is more dependent on the electric grid than ever. Technological advancements have reshaped the nature of war, tying overseas missions such as the use of drones and cyber operations directly to domestic installations that are overwhelmingly reliant on the power grid. Modern communication systems are critical to this globally networked force, and electricity is foundational to making these systems function. Intelligence collected overseas is processed and exploited at domestic facilities where it can be analyzed and disseminated to enable real-time operations in the field. Senior DoD officials have increasingly recognized the nexus between domestic installations, overseas operations, and assured power from the grid.

The connection between domestic installations and overseas operations is increasingly seen as an opportunity for near-peer adversaries and threat actors to upend America's decisive military advantage. General Dave Goldfein, former Air Force Chief of Staff from 2016 to 2020, warned that, "Our competitors have studied the way we fight and the way we operate and are investing in and training in ways to take those advantages away from us. General Terrence O'Shaughnessy, former commander of U.S. Northern Command and North American Aerospace Defense Command, noted that it is in part one of the reasons why the U.S. "homeland is no longer a sanctuary.

The U.S. military's dependence on the commercial energy system to mobilize and deploy forces from the continental United States and support overseas missions makes energy infrastructure a priority in an adversary's effort to slow the ability of America's warfighters to respond to a contingency crisis and hinder any U.S. war effort. The Commission on the National Defense Strategy asserted that a modern day conflict would bring disruptions to critical infrastructure, impacting civilian access to power, water, and all the goods on which they rely. The Commission noted that the U.S. public is largely unaware of the dangers they face, stressing that engaging in war with a near-peer actor would cause inconceivable hardship in everyday life. Besides disruptions to the American way of life, an attack on the civilian electric grid would impact defense industrial suppliers crucial to wartime efforts and undermine the readiness of U.S. military and civilian personnel living in communities facing critical resource shortages.[3]

None of this is theoretical. One need only to look at Russia's war of aggression against Ukraine to see how the targeting of the civilian electric grid has become a tactic of 21st century conflict. Ukrainian officials have reported more than 1,000 attacks against the country's electric grid since the expansion of the war in February 2022, in part as an effort to undermine social and economic stability. The Department of Homeland Security has warned that a Chinese state-sponsored cyber group known as Volt Typhoon has pre-positioned itself in U.S. critical infrastructure systems, including the power grid, allegedly with the intent to disrupt key systems during a time of conflict.

In recent years, DoD has invested considerably in on-base power generation, storage, and microgrids for critical missions to address its dependence on the power grid. Per DoD policy, U.S. military installations are required to have a minimum of 14 days of backup power for critical missions, but there is considerable discretion given to the Military Services over how to achieve this goal (or set a new one entirely). As a result, each of the Military Services has set their own goal, with the Army and Navy pushing for up to 14 days of backup power, and the Air Force pursuing up to 7 days of backup power.

Even at the upper end, 14 days of backup power seems significant on its face but increasingly insufficient in practice. The DoD's planning factor assumes that two weeks of backup power is enough time for a U.S. military installation to ride out any disruption to the electric grid, and that its primary backup energy source — diesel generators — can be continuously refueled and run for weeks without experiencing mechanical issues.[4] Most U.S. military installations are still working toward achieving their service-specific backup power goals. Even where they have reached this goal, recent extreme weather events have caused outages that exceed DoD's assumptions. From Winter Storms Uri and Elliott to Hurricane Helene, DoD installations remain vulnerable to extended grid outages that could cause risk to the military's critical missions. On-base backup power sufficient to meet facility-level needs also does nothing to protect two-thirds of troops and civilians living in the community who may be affected by an extended outage, facing personal distress, and unable to perform mission critical tasks on those very installations served with backup power.[5]

A January 2017 Department of Energy report to Congress succinctly described the risks that DoD faces with its reliance on the power grid. According to the report:

> DOD's (sic) reliance on commercial power presents many of the same challenges faced by all electricity customers: the transmission system is highly vulnerable to weather-related damage, natural disasters such as earthquakes, and physical attacks; electricity substations are vulnerable to cyber and physical attacks, as well as to geomagnetic storms; the distribution system is highly vulnerable to weather, and natural disasters, and control centers are vulnerable to cyber and physical attacks.

Charles Kosak, then the Deputy Assistant Secretary of Defense for Defense Continuity & Mission Assurance, emphasized these conclusions in testimony to the Federal Energy Regulatory Commission and noted that "A stronger and more resilient grid is a national security priority. A grid that is stronger and more resilient around certain loads, nodes, and communities is the most effective way to manage risk and cost for the Department and in turn the nation as a whole.

Besides physical and cyber threats to the grid, the U.S. military faces steep competition from energy-intensive commercial sectors. As noted before, demand for electricity to serve AI data centers and plants for semiconductor and biotechnology manufacturing is forecasted to surge as much as 25% by 2030. While that demand may soften as energy-intensive customers fall out of electric interconnection queues, it is evident that the power grid will likely experience a period of demand-driven growth in the future, with national-security sensitive technologies driving increased energy consumption. Indeed, these technology sectors are critical to safeguarding America's strategic edge in a future fight, which further underscores the imperative for ensuring reliable access to electricity for these critical technologies. Utilities and grid operators are racing to build demand into their resource plans as these new commercial operations come online. As they do, however, they face the choice of prioritizing these loads over those from the U.S. military, unless there is an adequate build out of the grid to sufficiently support both. As hyperscalers and other large load commercial customers consider paying premiums for their energy, the electricity market may inadvertently incentivize transmission owners and power generators to prioritize serving energy-intensive sectors over the U.S. military.[6]

When it comes to energy reliability, the needs of today's modern military are far more complex than those in conflicts of the last century. If the United States had to fight a major war today — a conflict in scale that is unimaginable to most of the American public — success would rest, in part, on how well the power grid could meet the incredible demands for electricity. Unlike the major wars of the twentieth century, that demand would include the simultaneous requirements of a globally-networked military force reliant on domestic U.S. installations; the needs of a defense industrial base expected to produce weapons, combat platforms, and other wartime material; and the activation of energy-intensive national security commercial technologies exploiting AI, cyber, and cloud-based communications to ensure that the U.S. military maintains its overmatch in the terrestrial, space, and digital domains.

Part Three: Lessons Learned and the Way Ahead

The U.S. military now faces a threat environment that involves great powers wielding sophisticated technologies designed to neutralize historic U.S. advantages. Planning for conflict in this environment is very different from preparing for the counterinsurgencies of the early 21st century. The U.S. military services have ambitious modernization strategies focused on acquiring the capabilities that future conflicts are likely to require.

Despite DoD's considerable efforts to build the force of the future, the Department has only recently begun to consider the importance of the electric grid, which will inevitably play a critical part of its warfighting strategy. When it comes to the electric grid and the assured power that DoD expects it will provide to U.S. military installations and the defense industrial base when they need it, the United States is preparing to fight the next conflict with an electric grid that it relied on to fight the much more localized wars of Iraq and Afghanistan. That grid — largely the same today — is woefully unprepared to meet the demands that will come if the U.S. military must fight a major war akin to World War I and World War II. The consequences may prove disastrous.

Fortunately, history can help inform best practices and potential ways to strengthen the resilience and reliability of the electric grid now. The experiences of World War I and World War II are instructive for America's war planners as they look toward a future fight. These wars demonstrate that a large-scale, successful transformation of the power grid to serve national defense is possible with proactive coordination between the federal government and industry. But DoD's influence in shaping the future of the grid is more limited than in World Wars I and II, and many lessons of those eras do not translate to the current moment. There are, however, important steps that federal agencies, utilities, and grid operators can begin to take now to ensure they are working together to build a grid that will help the U.S. military fight and win in the future.

Prioritize Interregional Transmission

Of the many lessons from the past century, perhaps none stands out more than the need for interregional transmission to redirect surplus power to areas of the country facing power shortfalls. Today, there are roughly 1,250 GW of installed electric generating capacity on the grid, but only about 85 GW of interregional transfer capacity. That is simply not sufficient to ensure resilience and reliability across the entire system. The North American Electric Reliability Council (NERC) published an Interregional Transfer Capability Study in November 2024 that argued for at least 35 GWs of additional transfer capability to hedge against extreme weather (importantly the NERC report did not consider the forecasted load growth on the grid when developing its recommendations, so it is reasonable to assume that 35 additional GWs is a conservative figure).

Expanding interregional transfer capacity will improve the resilience of the grid to meet wartime needs if the time comes to surge for energy-intensive operations and defense manufacturing. A wartime surge will almost certainly face the challenges of a contested homeland, as America's adversaries attempt to use cyber and other means to disrupt the electric grid. Interregional transfer capacity can blunt those efforts by ensuring sufficient supply of electricity to restore systems that may be affected by any attack on the grid — whether that comes from an adversary or Mother Nature.

Foster Interagency Collaboration

In both World Wars I and II, interagency communication was foundational to coordinating regional power sharing and allocating available resources to critical defense industries. The consolidation of oversight power in the WIB during World War I and the FPC in World War II centralized planning across separated sectors and streamlined coordination to meet defense production needs. These agencies worked closely with the U.S. Fuel Administration and the War Department respectively, to ensure defense needs were prioritized across energy planning, construction, production, and allocation processes.

Effective engagement across critical agencies, however, cannot be reserved for times of war. It must be a preemptive measure to prepare for and deter conflict. Particularly today, as the energy landscape grows more complex and contested, the interdependence of military operations and the diversity of national energy stakeholders requires enhanced collaboration to ensure strategic readiness and operational continuity.

Yet the Federal Energy Regulatory Commission — the independent agency responsible for regulating interstate transmission and wholesale energy markets — Department of Energy (DOE), and DoD remain largely stovepiped. Poor communication between these agencies creates major vulnerabilities for our national defense, including regulatory and operational misalignment, failure to prioritize mission-critical assets, and delayed or disjointed emergency responses. Lessons from past conflicts indicate the need to identify a centralized authority to coordinate across these departments. In a study on defense critical infrastructure, the Defense Science Board underscored the importance of this collaboration, noting that: "These [energy] complexities demand a degree of partnership within the interagency and with civilian stakeholders well in excess of DoD's demonstrated cultural inclinations. Given the mandate and participation of the relevant federal stakeholders, the National Energy Dominance Council should consider making this a primary objective in the short-term and work to develop consensus among all interagency heads on the appropriate permanent home for this collaboration moving forward.

Prioritize Defense Critical Electric Infrastructure

In the near term, the National Energy Dominance Council has an opportunity to focus interagency collaboration around Defense Critical Electric Infrastructure (DCEI). Congress amended the Federal Power Act in 2015 to define DCEI as “any electric infrastructure that serves a critical defense facility but is not owned or operated by the owner or operator of such a facility.” DOE and DoD designated critical defense facilities (CDFs) in 2019, and DOE informed the utilities that serve the CDFs of their designation. DOE had also announced plans to roll out a DCEI Program in 2020. DOE and DoD signed a memorandum of understanding (MOU) in September 2020, on collaborating in support of DCEI, with significant attention toward engaging in planning processes for civilian electricity infrastructure. The DOE Electricity Advisory Committee (EAC) drafted a set of recommendations for DOE on strengthening the resilience of DCEI in 2022.

Despite the first Trump Administration’s success with laying the groundwork for a DCEI program, it has yet to receive significant focus from the federal agencies charged with safeguarding these critical assets. Many of the EAC recommendations have not been implemented, and DOE and DoD have not yet operationalized the partnership envisioned in the MOU. The National Energy Dominance Council should consider directing DOE and DoD to focus on DCEI as a centerpiece of engagements with federal, state, and utility partners on bulk-power system resilience.

Strengthen Public-Private Collaboration for Transmission Expansion

The costs of transmission build out are currently borne primarily by electricity customers — households and businesses. Most transmission in the United States is privately owned by utilities and investors, and regulators allow “reasonable” transmission infrastructure costs to be recovered from electricity ratepayers. The scale of investment in interregional transmission that is required to build a more resilient and reliable electric grid would likely mean asking electricity customers to shoulder a significant financial burden, one that may not pass muster with regulators or the public.

To get ahead of potential affordability challenges, the U.S. government should leverage both financial and policy tools to de-risk transmission expansion. For example, the U.S. government could take on a more direct role in reducing the risks and the costs of building transmission infrastructure similar to the way that it did after World War I when it granted the RFC the authority to grant loans to utility companies. This is not to suggest that the U.S. government needs to take on full responsibility for building out the transmission system. Rather, to minimize financial risk while investing in infrastructure that directly supports defense loads, the DoD could act as an “anchor tenant” for large transmission lines serving defense facilities, communities, and industries. This creates a guaranteed revenue stream and attracts lower-cost financing by providing early, long-term commitments to use line capacity. In terms of policy, the U.S. government should continue to pursue targeted permitting reform to reduce today’s lengthy project timelines and help protect developers from potential financial risk by increasing the certainty of development.

Support a Flexible, Efficient, and Lean Grid

Gretchen Bakke at the University of Chicago, describes American conceptions of the grid as “occupy[ing] a space of abundance” where there is “plenty of power and good enough infrastructure to ensure that most of the time electricity gets to where it’s needed. This perception persists because most Americans have never experienced electricity shortages or curtailments comparable to those during the two World Wars when government and industry were forced to make hard choices about which loads to turn off in the interest of national defense. A future conflict would bring with it a new era of hard choices. The ability of the electricity system to supply national requirements could be strained by surging wartime demand or degraded by attacks, forcing decision makers to once again prioritize power delivery.

Unlike the electricity system of the last century, today's grid offers capabilities to reduce the need for drastic measures. Technological advancements now allow grid operators to do more with existing infrastructure. Software innovations and advanced transmission technologies can improve efficiency, reduce congestion, and accelerate grid restoration after disruptions. Reconductoring transmission lines with advanced conductors has the potential to quadruple the capacity of the current grid at one-fifth the cost of new transmission.

Equally important is the rise of grid flexibility. Markets across the country provide price signals to loads ranging from homes to hyperscalers to shift or temporarily reduce their power draw from the grid at times of high demand or during periods of grid instability. There are a broad range of emerging technologies, strategies, and programs designed to support flexibility for large loads such as data centers. Large load customers also have the potential to design their energy systems to allow for power grid segmentation, prioritizing critical lines when resources are constrained. This enhanced flexibility is a defense asset, and a dramatic improvement over the blunt power shutoffs of the last two major wars. Improvements in technological efficiency have also created opportunities to lower energy intensity, creating leaner civilian loads and easing the hard choices that policy makers may need to make during times of scarcity. Flexibility and efficiency gains can create additional headroom to add strategic defense loads to the grid.

Private and public sector investment in grid enhancing technologies and flexible solutions pay dividends in both peacetime and conflict. The U.S. government should support efforts to maximize the current electric system while simultaneously working with utilities and grid owners to expand new transmission infrastructure to meet future needs. The government should also support demand-side investments in efficiency and onsite power to enable residential loads — such as the homes of military personnel — to be leaner, resilient, and flexible. There may also be emerging opportunities for large inflexible loads to make investments in residential demand flexibility to support grid reliability.

Build DoD Loads into Grid Planning

When major wars broke out in the past century, the federal government stepped in to prioritize electricity to meet DoD's warfighting needs. That intervention was appropriate and vital to ensuring America's success, but it required the American public to make significant sacrifices. DoD's energy needs have only grown in complexity. A future fight will not just require the grid to surge electricity to support the manufacturing of materiel from the defense industrial base; it will demand electricity to serve the increasing tempo of a highly networked, globally responsive force, driven by AI and other energy-intensive data inputs. Given the increased competition between defense and commercial electrical loads — and the commingling of advanced commercial technologies for national security — similar federal intervention may be more complicated in the future. What is more, asking the American public to curtail energy in service of an enduring conflict may be untenable and could undermine political support.

By building the current and forecasted electrical loads of military installations, defense communities, and defense manufacturing into transmission planning now, utilities and grid operators can ensure sufficient capacity to prevent a future situation where the federal government is forced to choose winners and losers. DoD has begun the process of identifying the energy resilience needs of defense communities through the Office of Local Defense Community Cooperation, and grid owners and operators could draw on these efforts to inform their planning. DoD leaders should also collaborate with energy infrastructure stakeholders to ensure that their future integrated resource and regional transmission expansion plans reflect the anticipated electricity needs of critical defense regions and identify sufficient investments to meet those requirements.

Conclusion

The U.S. military's relationship with the power grid has evolved considerably during the past century. If the United States had to fight a major war today, the outcome would likely rest on how well the electric grid could meet the simultaneous demands of a globally-networked military force reliant on domestic U.S. military installations, the unanticipated demand of a defense industrial base that would be expected to produce weapons, combat platforms, and other wartime material, as well as new energy-intensive national security commercial technologies exploiting AI, cyber, and cloud-based capabilities to overcome any potential adversary in the terrestrial, space, and digital domains.

The world wars of the last century demonstrate that a reliable and resilient electric grid is vital to America's national defense, and even when the stakes were high success was not guaranteed without proactive public and private collaboration. In each conflict, coordinated regional power sharing was essential to meeting the rapid increases in energy demand. Wartime production catalyzed significant advancements in the U.S. power system, fostering public-private partnerships, necessitating regional power sharing, and demanding a coordinated approach across independent energy systems. The rapid wartime efforts to meet demand were pivotal to securing victory in each conflict.

It is critical that the United States both expand and fortify its power grid. Inaction is simply not an option. The U.S. government stepped up in World War I and World War II before energy shortages could materially affect America's war aims, but we may not have that luxury in the future. The U.S. government and industry must work together now to invest in the energy infrastructure that will safeguard the American way of life, deter our adversaries from picking a fight because they see the electric grid as a glaring vulnerability, and ensure that if the United States must fight a major war, that we will ultimately prevail.

Appendix A: The Korean Conflict: Lessons from a Limited War

Observations from one of America's more limited wars suggest that it may not even take a major war to strain the grid and constrain the U.S. military's efforts.

Though the Korean War didn't require a full mobilization of the U.S. economy in the same manner as the two previous world conflicts, it still demanded a rapid acceleration of energy development nationwide as well as a coordinated approach to allocating resources to defense industries. The Korean War came on the heels of a massive buildout of U.S. electricity infrastructure. Between 1944 and 1950, U.S. electricity consumption grew by 53%, predominantly driven by an increase in household appliances and growth in rural electricity with the automation of agricultural equipment.

As with World War I and World War II, the emergence of large-scale defense production at the onset of the Korean War led to immediate and widespread energy shortages. Within months of the war's outbreak in June 1950, energy deficits began to appear across major industrial regions. In the Pacific Northwest, aluminum production — vital to aircraft manufacturing — was halted for nearly three weeks due to an inability to meet electricity needs. Similarly, in North Carolina, aluminum plants faced curtailments, while in South Carolina, production of ferroalloys essential for steelmaking was restricted by inadequate power supplies. The industrial centers of the Southeast, Pittsburgh, and Texas experienced comparable shortfalls, causing delays in critical defense manufacturing.

These challenges were exacerbated by delays in planned expansions of generation and transmission infrastructure. Postwar optimism had driven ambitious electric utility planning, but shortages of key materials — such as copper, steel, and transformers — slowed new construction. The energy crisis thus became both a supply-side and logistical problem, requiring federal intervention to ensure that defense priorities could be met without crippling the domestic economy.

To address these shortages, President Harry S. Truman signed the Defense Production Act in December 1950, six months into the war. The Act established the Defense Electric Power Administration (DEPA) as the central coordinator for the energy industry. The Act granted DEPA authority to review and prioritize proposed energy projects serving defense loads, direct scarce materials to high-priority energy and manufacturing uses, approve accelerated depreciation schedules, support loan applications for critical projects, and facilitate system-wide coordination among utilities.

A key element of DEPA's strategy was the acceleration of regional interconnection between previously independent utility grids to redirect surplus power from low demand areas to high-demand regions. The Joint Committee on Defense Production noted "it seemed obvious that the more complete our power interconnections are, the more power can be made available where needed without requiring the use of as many scarce materials as would be required to build unconnected systems to a point capable of delivering a like peak power load.

To fast-track interconnection agreements, the FPC assumed an oversight role to expedite the review and approval of new transmission lines and upgrades to existing systems. The Commission encouraged utilities to enter power-sharing agreements with reduced contractual red tape. They harmonized interstate regulatory inconsistencies and standardized operational protocols across utilities, reducing interstate regulatory conflicts, a frequent barrier to coordinated power sharing.

The urgency of the Korean War catalyzed innovation and reform across the energy sector. By necessitating public and private partnerships and expanding the powers granted to centralized authorities to streamline this collaboration, the war created new pathways for the expansion of the U.S. electricity system. These efforts laid the groundwork for the ongoing modernization of the national power system and the postwar economic boom.

Notes

[1] Force projection is generally the capacity to rapidly mobilize and deploy military forces from multiple locations in the United States, and sustain those military forces overseas in support of a theater campaign plan or contingency operation.

[2] For example, historian Vaclav Smil notes that, "Just before WWI, the largest transformers could work with inputs of up to 150 kV and power of 15 MW; today's largest transformers are rated at more than 1 GVA and can accommodate currents up to 765 kV, and the best units come very close to an ideal device."

[3] About 70 percent of U.S. military personnel and their families live in civilian communities, not on a U.S. military installation. All defense civilians that support a U.S. military installation, including on-site critical missions, also live in the community.

[4] "The study determined a single, well-maintained emergency generator cannot guarantee emergency power for critical loads over multi-day outages."

[5] "In its policy, DOD acknowledges that it relies on the private sector to house the remaining two-thirds of service members and their families in the communities surrounding military installations."

[6] A hyperscaler is typically any company that is involved in using a large-scale data center to deliver cloud-based computing and storage for its customers. Amazon Web Services is an example.

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