

POWERGRID EBOOK



# BEYOND THE GRID:

DEMAND, SUPPLY,  
AND THE FUTURE





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## EXECUTIVE SUMMARY

### Global Electricity Crisis

Global electricity demand is surging at an unprecedented pace and is projected to accelerate over the next three years, increasing by an average of 3.4% annually through 2026, according to [IEA](#).

Urbanization, electrification of industries, and the rise of energy-intensive technologies are pushing power grids to their limits. However, the infrastructure supporting these grids is aging, leading to inefficiencies, outages, and an inability to meet growing energy needs.

### Why Demand is Outpacing Supply

From residential homes to industrial facilities, the dependency on electricity has never been greater. The push for electric vehicles (EVs), AI data centers, and renewable energy sources adds further strain to an already overloaded grid. Supply constraints, transmission inefficiencies, and lack of adequate energy storage solutions exacerbate the issue, creating a widening power gap.

### The Consequences of an Aging Grid

Outdated power infrastructure leads to frequent blackouts, voltage instability, and an increased risk of catastrophic failures. Without modernization, economies will suffer from energy shortages, businesses will experience disruptions, and consumers will face higher costs and unreliable service.

**3.4%**  
ANNUAL GLOBAL ENERGY INCREASE

## SECTION

## 1

## THE POWER GRID UNDER PRESSURE

### THE STATE OF THE POWER GRID: A SYSTEM AT ITS BREAKING POINT

#### How Demand is Exceeding Energy Availability

For nearly two decades, electricity consumption in the U.S. remained relatively stable as energy efficiency advancements balanced out demand growth. However, since 2021, a dramatic shift in the energy landscape has reignited [electricity demand](#), placing immense pressure on [supply chains and infrastructure](#).

### THE ELECTRICITY GAP

**-66%**

of current electrical producing plants and scheduled to be retired by 2040 in the U.S., UK and EU.

Source: Ignition Research and US-EIA

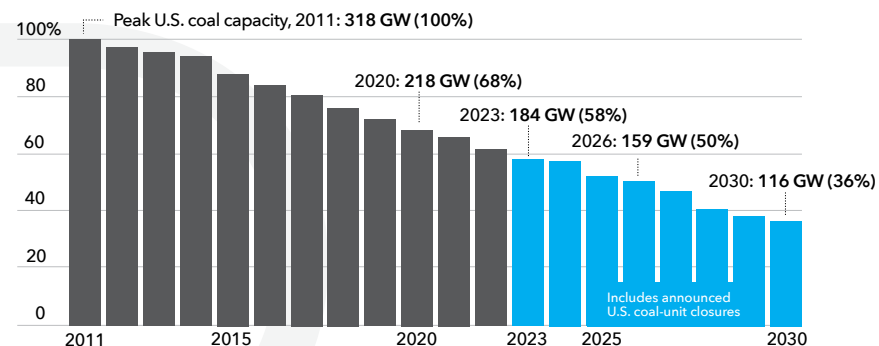
**-5000**

Plants across the U.S., UK and EU will close that equal -50% of all power generation

Source: Ignition Research and US-EIA

#### Half of Peak Coal-Fired Generation Capacity to Close in U.S. by 2026

The peak of coal's power generation capacity was in 2011, at 318.6 GW. Just 15 years later, in 2026, half of that capacity will be gone – replaced by gas, wind and utility-scale solar



Sources: EIA; PJM; S & P Global; IEEFA research (2021-2030) End of each year, as of March 7, 2023 IEEFA

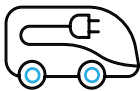
## Key Drivers of Surging Demand



1. **Manufacturing Boom** – Massive investments in manufacturing—spurred by the Inflation Reduction Act (IRA) and the [CHIPS](#) and Science Act—have driven a surge in electricity demand. As of early 2024, construction spending in manufacturing has increased 181% compared to pre-pandemic levels, with over 200 planned facilities dedicated to energy transition components and semiconductor production.



2. **AI and Data Centers** – The rapid adoption of artificial intelligence has drastically increased energy needs. Data center electricity consumption is projected to rise from 2.5% of total U.S. consumption in 2022 to 7.5% by 2030, an increase from 130 terawatt-hours (TWh) to 390 TWh. These facilities require continuous power, which traditional renewable sources like wind and solar struggle to provide consistently.



3. **Electrification and Climate Factors** – The accelerating rollout of electric vehicles (EVs), the expansion of hydrogen hubs, and extreme weather conditions are all contributing to skyrocketing energy demand. Higher temperatures and severe weather events are driving peak demand to new highs, stressing an already strained grid.

# 7.5%

INCREASE IN DATA CENTER ELECTRICITY CONSUMPTION BY 2030

## Supply Chain Struggles and Infrastructure Bottlenecks

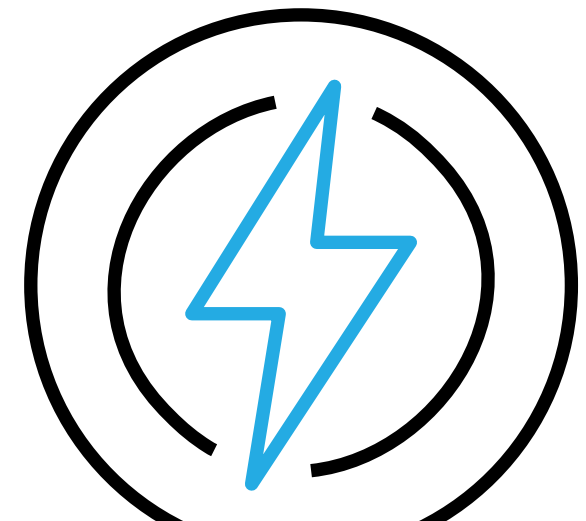
The resurgence of load growth has exposed critical weaknesses in the power supply chain, with key electrical components struggling to keep pace:

**Transformer Shortages** – Transformers have become a major bottleneck, with domestic production covering only 20% of U.S. demand. Prices have risen 40%-60% since 2022, and lead times have soared from 78 weeks in early 2022 to 127 weeks by the end of 2023.

**Switchgear and Circuit Breaker Constraints** – Lead times for high-voltage circuit breakers have surged 130% year-over-year, reaching an average of 151 weeks in Q4 2023. Medium-voltage switchgear prices have increased by 26% since January 2022.

**Transmission and Distribution (T&D) Infrastructure Limitations** – The existing grid struggles to handle the expanding capacity needs. Utilities must rapidly invest in upgrades to prevent worsening congestion and reliability issues.

As investment in manufacturing, data centers, and clean energy technologies continues to accelerate, demand for electrical equipment will remain high. Utilities face mounting pressure to expand generation capacity and reinforce grid infrastructure, yet supply shortages and soaring costs threaten to prolong the energy gap. Without decisive action, the strain on the power grid will continue to escalate, jeopardizing long-term energy stability.



## The Impact of Aging Infrastructure on Reliability

The U.S. power grid is increasingly strained by aging infrastructure and growing reliability challenges. According to the [Smart Electric Power Alliance \(SEPA\)](#), since the mid-2010s, overall grid reliability has been in decline, with 70% of power lines and transformers now over 25 years old as of 2023. Much of the existing grid infrastructure—built in the 1960s and 1970s—is approaching the end of its 50- to 80-year lifespan, making it more susceptible to failures.

Climate change has further exacerbated these issues, as extreme weather events become more frequent and intense. Record-breaking storms, wildfires, and heatwaves in 2023 highlighted the vulnerabilities of an outdated grid, leading to sagging or broken power lines, damaged transformers, compromised substations, and overextended generators. In fact, 2023 set a record for billion-dollar weather and climate disasters in the United States, underscoring the urgent need for grid modernization.

Without significant upgrades, the consequences of an aging grid will only worsen—resulting in more frequent blackouts, voltage instability, and increased risks of catastrophic failures. These disruptions impact economies, disrupt businesses, and leave consumers facing higher costs and unreliable service. Modernizing grid infrastructure is no longer just an option—it is a necessity for ensuring energy security and resilience in the face of mounting challenges.

**MODERN  
IZE** | **70%** OF POWER LINES AND  
TRANSFORMERS NOW  
OVER 25 YEARS OLD

## Key Challenges Reshaping the Power Grid

- 1 Rising Energy Demand and Consumption Shifts** – AI, data centers, and EVs are pushing electricity consumption to new highs, with demand surging 160% in key sectors. This rapid growth is already causing energy surges, straining infrastructure, and contributing to rolling blackouts.
- 2 Aging and Brittle Infrastructure** – Existing power grids were not designed for today's energy loads, leading to reduced reliability, increased cyber vulnerabilities, and costly outages. Without major upgrades, the risk of economic disruption due to grid failures will continue to rise.
- 3 Energy Price Volatility** – Fluctuating costs, shifting subsidies, and unpredictable tariffs are making energy investments riskier. Businesses and consumers alike face uncertainty as geopolitical and economic factors drive price instability.
- 4 Material Shortages and Supply Chain Constraints** – The energy transition relies on scarce materials like lithium, cobalt, and rare earth minerals. Supply chain disruptions, trade barriers, and geopolitical tensions are further compounding shortages, affecting clean energy production and storage capabilities.
- 5 Scaling Clean Energy Technologies** – While there is a massive 2,600 GW backlog of clean energy projects, integrating them into the grid remains a significant challenge. Infrastructure constraints and regulatory hurdles are slowing the deployment of crucial renewable energy solutions.

As the energy sector navigates these challenges, innovative solutions like advanced capacitor technologies and grid modernization efforts will be essential to ensuring a stable, resilient, and sustainable power future.



## THE SHOCKING REALITY: THE WORLD'S ELECTRICITY GAP

### Data-Driven Insights into Power Shortages

Statistics show that power shortages are not just a third-world problem. Even developed nations are experiencing supply constraints due to inadequate grid expansion and climate-related disruptions.

According to the [United States Census Bureau](#), roughly 33.9 million households—about one in four nationwide—experienced a complete power outage at least once in the 12 months leading up to the 2023 American Housing Survey (AHS). Of those affected, approximately 70% (23.6 million households) reported at least one outage lasting six hours or longer. These can be caused by natural disasters, severe weather, falling trees, system malfunctions, poor maintenance, vehicle collisions with power infrastructure, or high demand overloads.

### Countries and Industries Most at Risk

Developing economies, high-tech manufacturing industries, and areas dependent on extreme weather-prone energy sources face the highest risk of energy shortages.

### The Economic and Societal Consequences of Energy Shortfalls

Unreliable energy leads to billions in economic losses, reduced industrial productivity, and socio-political instability. Businesses face operational downtime, and essential services such as hospitals and emergency response are put at risk.

APPROXIMATELY **70%** (23.6 MILLION HOUSEHOLDS) REPORTED AT LEAST ONE OUTAGE LASTING SIX HOURS OR LONGER.

## THE FUTURE OF ENERGY: TOP RISKS SHAPING TOMORROW'S GRID

The energy sector is undergoing a rapid transformation, driven by surging electricity demand and the adoption of emerging technologies like AI, electric vehicles (EVs), and advanced manufacturing. However, today's power grid is struggling to keep pace. As industries transition to cleaner energy alternatives, they face a growing set of challenges that threaten the stability, affordability, and reliability of power supply.

### Key Challenges Reshaping the Power Grid

- **Cybersecurity threats and grid vulnerabilities:** Growing reliance on digital control systems makes grids susceptible to cyberattacks.
- **Climate change and extreme weather events:** Hurricanes, heatwaves, and wildfires threaten grid reliability.
- **The challenge of integrating renewable energy sources:** Solar and wind energy introduces variability, requiring advanced grid management solutions.
- **Rising costs and supply chain constraints in grid expansion:** Delays in infrastructure projects slow progress toward modernization.



## THE RISE OF HIGH-FREQUENCY SWITCHING

The need for a more adaptive, secure, and resilient grid has accelerated advancements in power transmission, distribution, and consumption. Power grids are undergoing rapid evolution as operators seek to accommodate increasing demand and respond to shifting power generation trends.

Here are a few of the key changes underway:

- **Renewable integration** - Grid operators continue to contend with the ramifications of an evolving mix of energy sources, including expanding solar and wind generation.
- **Expansion of energy storage systems** - To contend with increasingly large fluctuations in both production and demand, operators need to continue to increase energy storage capacity.
- **Adoption of smart grid technologies** - Technology advances continue to be made in virtually every aspect of grid operations. Smart grid technologies are a critical component of modernizing power systems. These innovations include digital monitoring, automated fault detection, and real-time data analytics, which enable operators to optimize energy flow and improve overall grid efficiency.
- **Mobility and resilience** - As they contend with the heightened risk of devastating cyber attacks and natural disasters, grid operators have grown increasingly reliant on mobile energy production that can safeguard power delivery and enhance overall grid reliability.



# HIGH-FREQUENCY SWITCHING

## Upgrading the Backbone: The Role of High-Frequency Switching

Power factor correction (PFC) has long relied on bulky inductor-based designs to improve power quality, but these systems come with significant drawbacks—large size, high material costs, and inefficiencies at light loads. The rise of high-frequency switching (HFS) in PFC marks a transformative shift, enabling smaller, more efficient, and cost-effective power conversion solutions across industries.

### How High-Frequency Switching Improves Efficiency and Scalability

By operating at frequencies in the hundreds of kHz to MHz range, HFS dramatically reduces the size of inductors and capacitors while improving efficiency. This innovation allows power systems to achieve higher power density without major infrastructure overhauls, making it easier to integrate renewable energy sources, enhance grid stability, and support evolving market demands.

### The Impact of Next-Gen Materials like NanoPlex in Power Grid Optimization

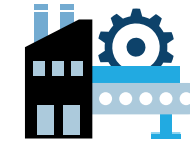
The shift to HFS introduces new challenges, particularly in thermal management and component lifespan. Traditional BOPP-based capacitors struggle to withstand the high temperatures and rapid charge-discharge cycles required for HFS. NanoPlex LDF capacitors address these limitations by supporting temperatures up to 150°C, extending lifecycle performance 3-5x, and optimizing energy storage for next-generation power systems.

As HFS continues to shape the future of power electronics, advancements in semiconductor technology, digital control, and high-performance materials will drive even greater efficiency, scalability, and cost savings.

## MAINTAINING A GOOD POWER QUALITY IS A SHARED RESPONSIBILITY BETWEEN:



Energy Suppliers

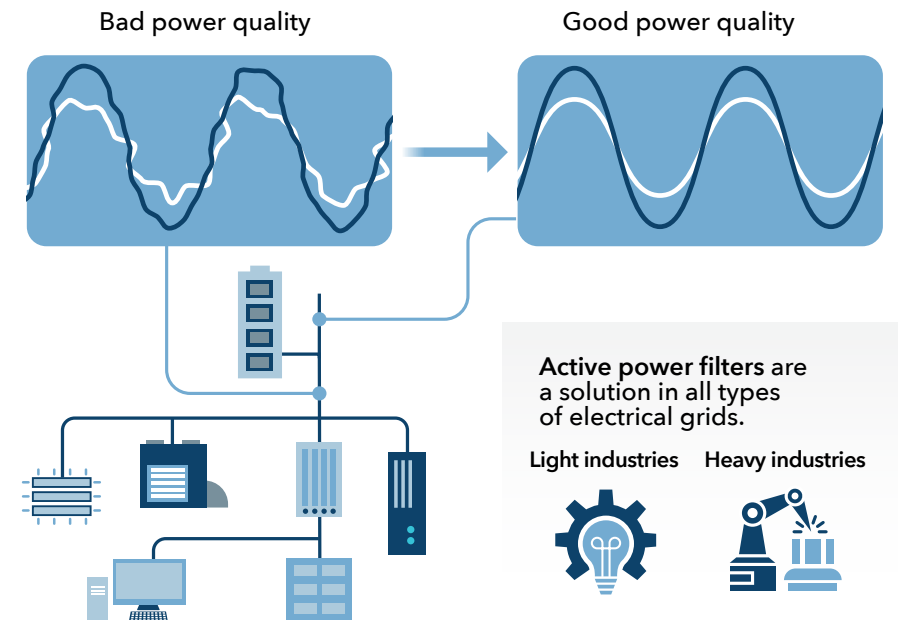


Manufacturers

+



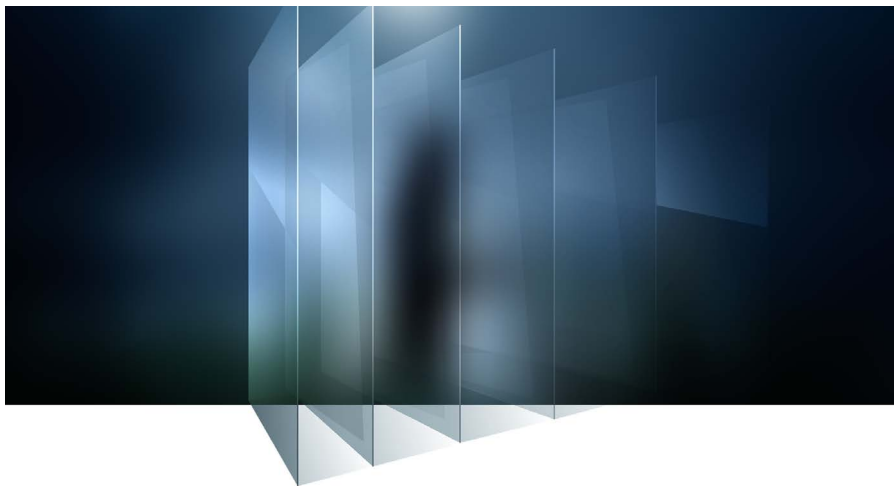
Energy Users





## NANOPLEX™: THE FUTURE OF POWER TRANSMISSION AND DISTRIBUTION

### NanoPlex - Nanolayered Dielectric metamaterials



**MILLIONS OF  
METAMATERIALS**

NanoPlex is a family of nanoscale (1/billionth of a meter) metamaterials that can be programmed to meet various applications, including optics, energy storage, product packaging, and protective films, to name just a few.



**OPTICS, POWER  
& PACKAGING**

Peak's nanoscale technology changes our ability to bend and block light, sound, and electromagnetic waves, conduct or insulate electricity, and control atmospheric conditions, ushering in previously unimaginable possibilities.



**NANOPLEX™**



**OVER 20  
GLOBAL  
PATENTS**

NanoPlex is protected by over 20 global patents for our core technology, manufacturing processes, and product implementations, which creates a defensible and differentiated position in our markets.



**100% US-BASED  
SUPPLY CHAIN**

Peak technology and products are engineered and manufactured in the United States. We provide a strategic advantage to our customers, who must ensure they have secure supply chains




## Overcoming Transmission Losses with Advanced Capacitor Technology

Step-up and step-down transmission systems are the backbone of modern electrical grids, ensuring efficient long-distance power transmission. While transformers have traditionally driven these systems, capacitors play a crucial role in stabilizing voltage, improving efficiency, and mitigating power losses.

[NanoPlex capacitors](#) revolutionize power transmission by enhancing voltage regulation, reducing energy dissipation, and adapting to modern grid demands. Unlike traditional BOPP film capacitors, NanoPlex capacitors operate efficiently at high temperatures and voltages, making them a superior choice for today's evolving energy landscape.

### Key Challenges Facing BOPP Films:

- 1 Temperature Limitations** - BOPP films struggle with an upper operating temperature below 105°C, where electrical conduction loss rises sharply. This restricts their use in high-temperature environments.
- 2 Structural Homogeneity Issues** - Silica agglomerates create localized weak points, affecting dielectric breakdown performance under extreme field stress.
- 3 Limited Permittivity Enhancement** - Achieving higher permittivity requires high-volume fraction fillers, which can lead to electric field enhancement, increased breakdown probability, interfacial polarization loss, and compromised tensile strength.
- 4 Energy Density Constraints** - The growing demand for higher energy density in applications such as electric vehicles and power grids calls for materials with superior performance over BOPP films.
- 5 Environmental and Regulatory Challenges** - Stricter regulations may force manufacturers to invest in higher-quality materials and processes, potentially increasing costs.
- 6 Competition from Alternative Technologies** - Advanced power factoring solutions, such as Static Var Generators (SVG) and thyristor-switched capacitors, may offer superior performance in certain applications.



# STEP-UP/ STEP-DOWN

## Stepping Up and Stepping Down Power Efficiently

[Step-up and step-down transmission systems](#) are the backbone of modern electrical grids, ensuring efficient long-distance power transmission. While transformers have traditionally driven these systems, capacitors play a crucial role in stabilizing voltage, improving efficiency, and mitigating power losses.

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## STEP-UP<sub>vs</sub> STEP-DOWN TRANSFORMERS

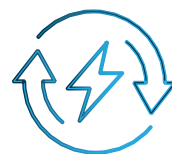
### What is a Step-Up Transformer and How Does it Work?

Step-up transformers increase the voltage from the input to the output of the transformer. This configuration, the primary winding feature fewer turnings than the secondary winding. This greater number of windings produces a higher voltage in the secondary side, increasing the output voltage. Power companies rely heavily on step-up transformers to efficiently transfer electricity over long distances. The higher voltage supplied across power grids is then reduced to a safe, usable level by step-down transformers

### What is a Step-Down Transformer and How Does it Work?

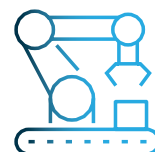
A step-down transformer decreases the voltage from input to output. With fewer turns on the secondary winding, the voltage from the primary winding decreases as it passes through the transformer. Step-down transformers create safe levels of alternating current (AC) for use in various products, such as televisions and voltage stabilizers, welding equipment, transmission lines, and adapters for electronics like cell phones.

## Key Differences Between Step-Up Step-Down Transformers



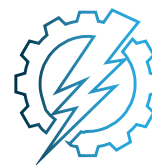
### VOLTAGE INCREASE VS. VOLTAGE DECREASE

Step-up transformers increase voltage from 220v up to 11,000v or greater, while step-down transformers will decrease voltage from 220v to 110v, 24v, 20v or lower.



### APPLICATIONS AND USAGE

Step-up transformers are used to increase the voltage for better energy transmission. Step-down transformers take that voltage and reduce it to safer levels for use in household appliances, electronics and industrial equipment.



### PRIMARY AND SECONDARY WINDING

In a step-up transformer, the primary winding has fewer turns, while the secondary winding has more turns. This configuration causes the voltage to increase.



## Step-Up Transformers

Step-up transformers increase voltage while reducing current, making long-distance power transmission more efficient. Key characteristics include:



- **Voltage Increase:** The secondary winding has more turns than the primary, resulting in a higher output voltage.
- **Current Reduction:** As voltage increases, current decreases to minimize energy loss.
- **Winding Design:** The primary winding, which carries higher current, uses thicker wire, while the secondary winding uses thinner wire.
- **Common Applications:** Used in power plants and transmission networks to elevate voltage for efficient long-distance power delivery.

## How NanoPlex Enables a More Resilient and Flexible Grid

With the rapid expansion of renewable energy sources and increasing demand from AI, electric vehicles, and economic growth, power grids must evolve. NanoPlex technology supports smart grid modernization by:

- Providing dynamic voltage regulation for fluctuating energy loads.
- Enhancing power quality by filtering harmonics and stabilizing power flow.
- Supporting high-frequency power electronics for efficient energy conversion.

As the demand for electricity surges, integrating NanoPlex capacitors ensures a more adaptive, reliable, and future-ready power transmission network.

## Step-Down Transformers

Step-down transformers lower voltage levels for safe distribution and end-use applications. Key features include:



- **Voltage Decrease:** The primary winding has more turns than the secondary, reducing the output voltage.
- **Current Increase:** As voltage drops, current rises to maintain power balance.
- **Winding Design:** The secondary winding, which handles higher current, uses thicker wire.
- **Common Applications:** Used in distribution systems to step down high transmission voltages for homes, businesses, and industries.

By increasing voltage for transmission and decreasing it for local use, transformers ensure efficient power delivery while minimizing energy loss and maintaining safety.



## SECTION

## 3

RELIABILITY AND EFFICIENCY:  
ADVANCING SUBSTATION

## WHAT IS A SUBSTATION?

A substation is a vital control point in the power grid where electricity is transformed, regulated, and routed between generation sources and end users. These facilities manage voltage levels, ensure efficient power flow, and maintain grid stability.

## Key Functions of a Substation:

- **Voltage Transformation** - Steps up power for long-distance transmission or down for local distribution using large transformers.
- **Switching & Routing** - Directs power flow, isolates faults, and ensures service continuity through circuit breakers and switches.
- **Regulation & Protection** - Maintains voltage stability and power quality using capacitor banks, voltage regulators, relays, and surge arresters.

## Substations in a Modernized Grid

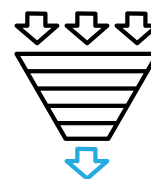
As part of grid modernization, substations are evolving with smart controls, renewable energy integration, and resilience features like remote monitoring, predictive maintenance, and grid-edge analytics. They're also becoming more adaptable to extreme weather and cyber threats.

As substations transition to more compact, modular, and high-efficiency designs, capacitor performance is increasingly crucial.

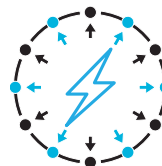
This is where Peak Nano's LDF and HDC film capacitors play a critical role—enhancing substation performance by:



- **Power Factor Correction** - Peak capacitors improve reactive power compensation, helping substations maintain optimal power factor levels. This reduces wasted energy, improves transformer loading efficiency, and minimizes utility penalties for poor power factor performance.



- **Harmonic Filtering** - In environments with nonlinear loads (such as industrial motors, renewables, or inverters), Peak's film capacitors help filter out harmonic distortions. Their low loss and high-frequency stability ensure cleaner waveforms and improved power quality across the network.



- **Voltage Regulation Under Load** - LDF and HDC capacitors deliver fast, stable support during voltage sags, spikes, and transient conditions, voltage spikes, and frequent cycling—conditions that typically degrade BOPP performance. Ideal for rugged, space-constrained environments like military, off-grid, or disaster response applications, NanoPlex capacitors reduce maintenance needs and enable more resilient, future-ready mobile power systems.



## SECTION

## 4

THE ROLE OF MOBILE  
POWER DISTRIBUTIONMAXIMIZING MOBILE POWER DISTRIBUTION:  
A STOPGAP FOR GRID FAILURES

[Mobile power distribution systems](#) play a critical role in providing temporary or emergency electricity during grid failures, natural disasters, construction projects, and remote operations. To ensure efficiency, reliability, and high power quality, capacitors are an essential component of these systems. They enhance performance in several key ways, making mobile power solutions more stable and cost-effective.

## The Role of Capacitors in Mobile Power Systems

**Energy Storage** – Capacitors offer short-term energy storage, helping to smooth out brief power interruptions and support rapid load changes. This ensures a more stable and responsive power system.

**Voltage Regulation** – By quickly storing and releasing electrical energy, capacitors help maintain consistent voltage levels despite fluctuations in power demand or supply. This is especially crucial in mobile setups, where temporary loads can create significant voltage variations.

**Power Factor Correction** – Many electrical devices introduce inductive loads, which can reduce system efficiency. Capacitors correct the power factor, minimizing energy losses and improving overall efficiency—critical in mobile power setups where resources may be limited.

**Harmonic Filtering** – Power systems often face harmonic distortion due to non-linear loads and electronic devices. Capacitors, when used with inductors, act as harmonic filters to eliminate unwanted frequencies, protecting sensitive equipment and improving power quality.

**Reactive Power Compensation** – Mobile power grids may lack sufficient reactive power sources, leading to voltage instability. Capacitors help compensate for reactive power needs, ensuring stable voltage and improved system performance.

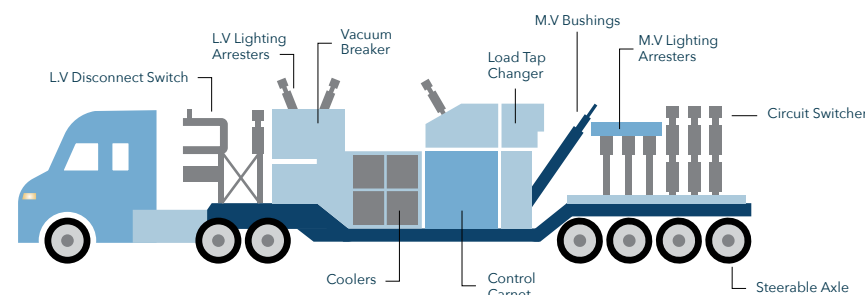
**Enhanced System Flexibility** – Capacitors provide greater control over power distribution, allowing operators to manage load conditions more efficiently and adapt to changing power requirements in mobile environments.

**Cost Reduction** – By optimizing power usage and minimizing energy losses, capacitors reduce operational costs—an essential advantage for temporary and emergency power applications.

As mobile power solutions continue to evolve, capacitors remain a cornerstone for enhancing their efficiency and reliability. Their ability to regulate voltage, correct power factor, and improve overall power quality makes them indispensable in ensuring uninterrupted electricity during grid failures and temporary deployments.

NanoPlex™ capacitor designs support mobile power stations by delivering higher energy density, superior thermal stability, and longer operational life in a compact form factor. Their nanolayered polymer structure allows for smaller, lighter capacitor designs that withstand high temperatures, voltage spikes, and frequent cycling—conditions that typically degrade BOPP performance. Ideal for rugged, space-constrained environments like military, off-grid, or disaster response applications, NanoPlex capacitors reduce maintenance needs and enable more resilient, future-ready mobile power systems.

## MOBILE POWER DISTRIBUTION



## HOW MOBILE POWER UNITS ARE BRIDGING THE ELECTRICITY GAP

Mobile power distribution systems must deliver stable, high-quality electricity that meets the reliability standards of utility grids. This requires high-voltage power capacitors to manage critical factors such as voltage stability, phase balance, and power factor correction. Without these elements, mobile energy deployments risk power fluctuations, inefficiencies, and disruptions that can impact homes, industries, and critical infrastructure.

### The Role of Capacitors in Mobile Power Systems



#### NANOPLEX Advantage

NanoPlex energy films are designed to meet next generation demands for power grid, EVs and Charging.

Peak's higher power density enables new solutions for power grids and military pulsed power applications.

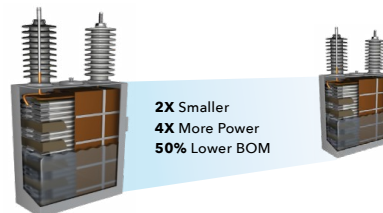
Peak enables our customers to lower product costs, reduce complexity and increase capabilities.

Peak is in second level field trials with major defense and power grid customers.



#### Power Grid Capacitors NANOPLEX HDC

- 4X more power w/ HDC vs BOPP
- 2X smaller footprint than BOPP
- 60+% lower BOM costs
- 3-5X Longer Lifetimes HFC temperature support
- Creates competitive advantage
- 100% allied supply chain
- Commercial & military channels



NanoPlex-based capacitors offer an advanced solution for ensuring predictable, stable power delivery in mobile energy applications. These capacitors enhance mobile power systems in several key ways:

**Voltage Stability** – NanoPlex capacitors help maintain consistent voltage levels, preventing dips and surges that can damage sensitive equipment or cause power interruptions.

**Phase Stability** – By ensuring proper phase alignment, these capacitors improve power system synchronization, reducing inefficiencies and improving overall power quality.

**Power Factor Optimization** – Mobile power grids often experience variations in load demand. NanoPlex capacitors correct power factor issues, reducing energy losses and enhancing system efficiency.

**Reliable Grid Integration** – Whether supplying energy to residential areas, industrial facilities, or remote operations, NanoPlex capacitors enable seamless integration with utility grids, ensuring compliance with industry standards.

**Durability in Harsh Environments** – Mobile power systems frequently operate in extreme conditions, from disaster recovery zones to construction sites. NanoPlex capacitors are designed to withstand temperature fluctuations, mechanical stress, and environmental factors, ensuring long-term performance.

**Scalability for Diverse Applications** – These capacitors support various mobile energy deployments, from temporary emergency power setups to industrial-scale mobile grids, adapting to different power demands with ease.

[By leveraging NanoPlex-based capacitors](#), mobile power distribution systems can achieve the stability, reliability, and efficiency required to meet modern energy needs. Whether powering homes, businesses, or large-scale industrial applications, these capacitors play a crucial role in ensuring a consistent and high-quality power supply—anywhere, anytime.

## THE GROWING DEMAND FOR ON-SITE POWER SOLUTIONS

Industries such as construction, healthcare, and telecommunications are increasingly relying on mobile power units for operational continuity, recognizing the critical role these solutions play in ensuring productivity, safety, and reliability. The shift towards mobile and on-site power solutions is driven by a need for flexibility, especially in environments where power infrastructure is either absent, temporary, or unreliable.



### CONSTRUCTION INDUSTRY

In construction, job sites are often located in remote areas where access to a permanent power grid is limited or unavailable. Mobile power units, such as portable generators, provide the necessary energy for tools, equipment, and lighting, ensuring that projects stay on schedule.

The ability to move power sources quickly between different locations also reduces downtime, enabling construction companies to respond to shifting project demands and unpredictable weather conditions. As construction projects grow more complex, the demand for specialized power solutions that support larger equipment and machinery, such as cranes and mixers, continues to rise.

### HEALTHCARE INDUSTRY



For healthcare providers, mobile power solutions are not only a matter of convenience but a critical component of patient care and safety. Mobile units are essential for powering emergency medical equipment, diagnostic tools, and life-saving devices in field hospitals, mobile clinics, and during natural disasters.

Hospitals and medical facilities also rely on on-site power units to support backup systems during power outages, ensuring that critical functions like lighting, ventilation, and refrigeration for medicines remain operational. As the healthcare industry continues to embrace telemedicine and remote healthcare services, portable power solutions become even more vital to support mobile health initiatives and temporary healthcare setups.

### TELECOMMUNICATIONS INDUSTRY



The telecommunications sector faces an ongoing challenge to maintain uninterrupted service, particularly in regions prone to power outages or in areas where electricity infrastructure is less reliable. Mobile power units, including solar-powered generators and backup battery systems, play an essential role in ensuring that telecom towers, routers, and other network infrastructure remain operational.

These units provide backup during outages, prevent data loss, and help sustain communication lines for both emergency and everyday use. As the demand for 5G infrastructure grows, the need for more resilient and scalable power solutions increases as well, further emphasizing the role of on-site power units in maintaining connectivity.

As industries continue to evolve, the adoption of mobile power units is poised to expand, driven by technological advancements and a growing emphasis on operational resilience. These solutions provide not only convenience but also security, allowing businesses to operate efficiently regardless of their location or the challenges posed by unreliable power systems.

## CASE STUDIES OF MOBILE POWER IN DISASTER RECOVERY AND INDUSTRIAL USE



### Emergency Response

In the wake of natural disasters or emergencies, mobile power systems play a vital role in quickly restoring electricity to critical infrastructure and affected communities. Capacitors help stabilize power delivery, ensuring consistent voltage and frequency—essential for hospitals, emergency services, and communication networks that rely on sensitive equipment.



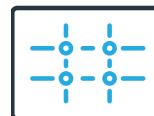
### Temporary Power for Events

Large-scale events such as concerts, sports tournaments, and festivals require substantial temporary power solutions. Mobile distribution systems equipped with capacitors provide stable and efficient energy, preventing fluctuations that could disrupt lighting, sound systems, and other critical event operations.



### Construction and Industrial Applications

Construction sites and temporary industrial operations demand reliable power to support heavy machinery and sensitive electronic equipment. Mobile power systems, enhanced with capacitors, improve power quality and stability, reducing the risk of voltage drops or surges that could impact productivity and equipment.



### Grid Support and Maintenance

During infrastructure maintenance or upgrades, mobile power systems act as temporary substitutes to ensure uninterrupted service. Capacitors play a key role in synchronizing mobile power with the primary grid, preventing disruptions and ensuring a smooth transition conditions.



### Military Operations

Reliable power is critical for military operations in remote or hostile environments. Mobile power units, supported by capacitors, provide stable electricity for mission-critical applications such as communication systems, medical facilities, and operational bases, ensuring continuity even in the most demanding conditions.

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## SECTION

## 5

## HYBRID POWER: THE FUTURE OF ENERGY STABILITY

## NANOPLEX AND THE EVOLUTION OF HYBRID POWER FACTOR CORRECTION

[Hybrid power factor correction \(PFC\)](#) is revolutionizing the way we manage electricity across power systems, and NanoPlex-based capacitors are at the forefront of this innovation. Traditional power grids have always faced inefficiencies stemming from reactive power—unused energy that puts unnecessary strain on the system, causing waste.

The introduction of NanoPlex-based capacitor technology into hybrid PFC systems brings a transformative solution. These capacitors enable precise, dynamic regulation and optimization of power distribution, ensuring a smoother, more reliable flow of electricity while enhancing system efficiency.

## The Role of Capacitors in Hybrid Power Factor Correction

Capacitors have always been essential to power factor correction, but modern hybrid systems now combine traditional capacitor technologies with more advanced solutions like thyristor-switched capacitors (TSCs) and [static synchronous compensators \(STATCOMs\)](#). These systems are designed to offer precise, real-time reactive power compensation, providing faster and more accurate responses compared to older passive systems.

THE INTRODUCTION OF NANOPLEX-BASED CAPACITOR TECHNOLOGY INTO HYBRID PFC SYSTEMS BRINGS A TRANSFORMATIVE SOLUTION.

Key advantages of NanoPlex in hybrid power factor correction systems include:

1. **Optimized Energy Distribution:** NanoPlex capacitors stabilize voltage levels, enhancing energy transfer efficiency across hybrid power systems.
2. **Reduced Energy Waste:** By correcting power imbalances, NanoPlex capacitors prevent unnecessary energy loss, resulting in cost savings and contributing to sustainability efforts.
3. **Extended Equipment Lifespan:** The reduction in system strain extends the operational life of key infrastructure components such as transformers and generators.

## THE ROLE OF HYBRID POWER IN STABILIZING THE GRID

As power grids modernize and renewable energy sources become more integrated, hybrid power systems are playing a critical role in grid stability. Hybrid systems balance power loads, mitigate fluctuations, and support overall grid performance—particularly during periods of high demand or when intermittent renewable energy sources like solar and wind generate variable power.

## Key Benefits of Hybrid Power for Grid Stability:

- **Better Renewable Integration:** Hybrid systems store excess energy from renewables and distribute it efficiently, smoothing out the fluctuations inherent in solar, wind, and other variable energy sources.
- **Load Balancing:** Hybrid systems effectively distribute power across diverse sources, preventing overloads and ensuring consistent voltage regulation.
- **Enhanced Grid Resilience:** In the event of outages, hybrid systems provide backup power, minimizing disruptions and reducing the risk of widespread failures.



## HOW POWER FACTOR CORRECTION IMPROVES EFFICIENCY AND REDUCES WASTE

The importance of power factor correction (PFC) cannot be overstated. Poor power factor leads to inefficient energy usage, higher operational costs, and increased strain on the grid. With the integration of NanoPlex-based capacitors, hybrid PFC systems are able to more effectively minimize reactive power losses, improving energy efficiency across the grid.

### Key Impacts of Hybrid PFC on the Grid:

- **Lower Energy Costs:** Hybrid PFC reduces the need for excess power generation by improving power quality, helping lower electricity expenses for consumers and utilities.
- **Greater Grid Capacity:** Optimizing power factor enables utilities to transmit more usable energy without the need for costly infrastructure upgrades.
- **Sustainability Gains:** Reducing energy waste contributes to lower carbon emissions and promotes a greener, more environmentally friendly power system.



## INNOVATIONS IN ENERGY STORAGE AND POWER BALANCING

The future of hybrid power lies in advancements in energy storage and smart grid management. NanoPlex capacitors are integral to the evolving landscape of energy storage and distribution systems, particularly as AI-driven grid management technologies improve real-time energy balancing. These innovations will enable more efficient energy distribution, enhance grid stability, and drive greater efficiency across the energy system.

### Key Innovations Driving Hybrid Power Stability:

- **Next-Gen Capacitor Technology:** NanoPlex capacitors offer exceptional performance for high-voltage applications, facilitating faster energy transfer and providing greater grid stability.
- **Advanced Battery Storage:** Lithium-ion, solid-state, and flow batteries provide high-capacity storage solutions to manage fluctuating energy demands, further supporting hybrid power systems.
- **Smart Grid Optimization:** AI-powered energy management systems predict usage patterns and adjust power distribution dynamically, optimizing energy efficiency and improving overall grid performance.

As we continue to integrate more renewable energy sources and smart technologies, the role of NanoPlex in hybrid PFC systems will only grow, providing more reliable, cost-effective, and sustainable solutions for modern power grids.

## A CALL TO ACTION FOR A RESILIENT GRID

### PEAK FOR POWER GRIDS

The challenges facing modern power grids demand immediate action. Investing in NanoPlex capacitor technology for mobile power solutions, and hybrid power correction is essential for creating a resilient, efficient, and future-ready grid. As the latest power electronics designs—such as DC fast chargers—rely on Active Power Factor Correction (PFC) and robust DC bus capacitor banks, NanoPlex-based capacitors stand out as an ideal choice.

Their high efficiency, elevated temperature tolerance, and extended operational life make them perfectly suited for next-generation infrastructure, helping bridge the energy gap and ensuring reliable, high-performance power delivery for decades to come.

