



Microgrid Standard Development

Securing the sustainable future

Safety. Science. Transformation.™

© 2024 UL LLC. All rights reserved.

Table of contents

Introduction

Microgrid standard development: Securing the sustainable future

The world finds itself at an energy crossroads.

Global energy demand is rising, estimated to grow at an average of 3.4% annually through 2026, according to the International Energy Agency (IEA). The increased use and demand come as extreme weather makes power generation and grid stability more challenging than ever.

Data center power consumption is a key driver of energy demand. According to IEA estimates, electricity consumption to power artificial intelligence (AI) and blockchain technologies could double by 2026. These data centers drive demand and underpin the technological innovation necessary to counteract challenges brought on by climate change.

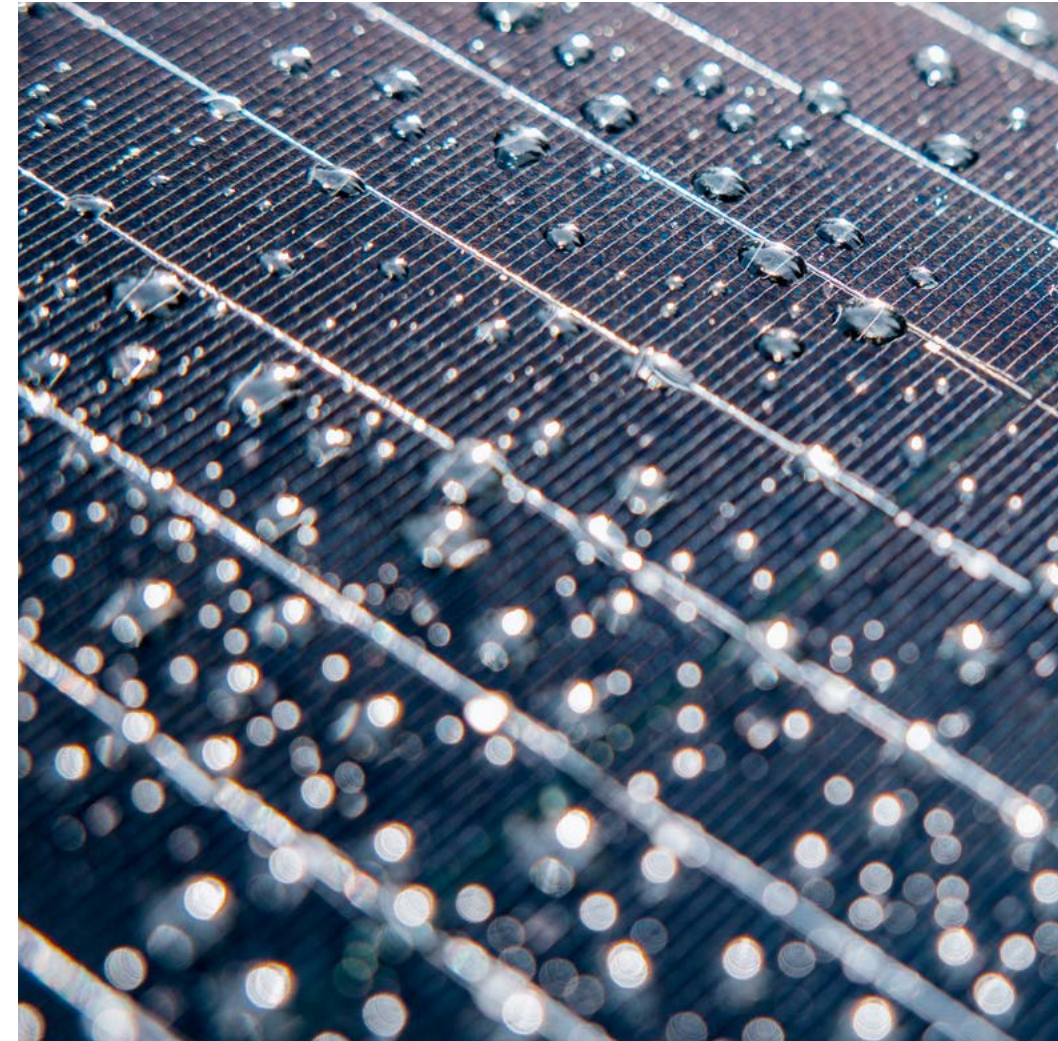


INTRODUCTION

As fossil fuels give way to a renewable, resilient energy future, the way forward will need to focus on managing the inherent risks of microgrid proliferation. The market has so far responded with an array of new, cleaner energy production and storage technologies. These products aim to replace combustion-based energy production with scalable and flexible wind, solar and geothermal power production. Microgrids will play a central role in this movement for clean and safe energy production, tying together these sources and allowing end users greater control of their consumption.

This e-book discusses UL Solutions' role in sharing data and insights to help regulatory bodies identify requirements contributing to published standards. Alongside its scientific, regulatory and industry partners, the UL Solutions' engineers and industry experts work to advance sustainable production and power management initiatives.

This work forges the path toward democratized and de-risked energy management.





Understanding the standards development process

Industry participants and safety science experts develop safety standards through a consensus process that considers and integrates input and agreement of relevant stakeholders. These may include engineers, product design and development experts, manufacturers, systems installers and others. This collaborative approach enables development of standards used across industries, balancing the needs and interests of different parties to achieve broad support and implementation.

The development process typically involves multiple stages:

- Initial data collection and review.
- Stakeholder discussion and feedback.
- Drafting activities and revisions.
- Consensus and finalization.
- Publication of the consensus standard.

Consensus partners help develop new standards through an iterative process, using data from product testing and design in the real world to create unified codes for use by installation, inspection and enforcement stakeholders.

The consensus standard development workflow

The standard development process is made up of five stages with a flexible timeline to seek input and collaboration, discuss acceptable risk and finalize standard language for clear and consistent model code development:

Stage 1: Technical data collection and interpretation

Translating and disseminating product information and testing data is critical to developing technically sound standards. Input from product-side stakeholders is vital in helping consensus partners outline technical specifications for the safe installation of microgrid products and systems. Technical teams consisting of principal engineers and product partners develop technical requirements for transmission to the consensus body.

Stage 2: Consensus body discussion

During standard deliberation, consensus members convene to discuss the technical requirements outlined by principal engineers and product developers. The stakeholders examine each requirement's feasibility, safety implications and potential impact on different sectors. Through these discussions, the consensus group balances market needs against risk impacts so that the standard is practical and forward-looking. The main deliverable of this process is a refined set of guidelines poised for broader review and code modeling.

Stage 3: Model code development and release

The results of the consensus work are to develop model safety codes for national use. While model codes are not enforceable independently, they form the basis for jurisdictions to codify safety standards and requirements. Engineers and architects draft and refine the model codes with input from product developers and regulatory officials. These teams review the consensus group's refined guidelines and conduct further research to develop code language that can be implemented in practice.

Once the consensus group develops and approves the model code, it is released publicly for adoption by jurisdictions. This process allows for feedback and improvements before the code becomes fully enforceable. Model codes serve as a key tool for establishing consistent safety standards across regions and industries.

Releasing a new model code prompts municipalities to adopt and revise existing codes. This workflow facilitates safety standards in moving from the consensus body to municipal use and enforcement.

Stage 4: Jurisdictional and municipal code adoption

Once published, municipalities have access to the updated model codes. These stakeholders review and adopt the codes into their local requirements and regulations for future installation and inspection actions. Enforcement entities rely upon these codes to assess microgrid risks and suggest remedial actions to bring systems into compliance.

Stage 5: Code enforcement

With model codes in place, authorities having jurisdiction (AHJs) have the power to enforce compliance and safe operation of microgrids at the local level. Enforcement entities — fire departments, building inspectors and electrical inspectors — use the information within adopted codes to assess microgrid installations, approve them and enforce continued compliance in subsequent assessment activities (such as yearly inspections).

Current development efforts for microgrid safety standards

Safety standards development requires teamwork. It relies on expertise and data from product manufacturers, input from energy and technology experts and cooperation with municipal stakeholders and governing authorities.

As microgrid use increases across residential, commercial and industrial sectors, the need for unified safety standards grows more pressing. In response, UL Solutions experts sit on technical boards and committees to provide information and guidance to bodies developing microgrid systems standards, such as UL Standards & Engagement, Institute of Electrical and Electronics Engineers (IEEE) and National Fire Protection Association (NFPA).



UL Standards & Engagement

UL Standards & Engagement mobilizes a wide array of global safety science experts to oversee the creation of trusted standards and public outreach programs that guide the safe and sustainable use of both emerging and legacy products. UL Standards & Engagement has several technical committees dedicated to defining standards for microgrid systems, of which UL Solutions engineers are a part. New standards being developed for microgrid systems include the following:

UL 3001: Distributed Energy Resource Systems

This standard applies to large, commercial-scale microgrids that power corporate campuses, hospitals, universities and communities.

UL 3010: The Outline of Investigation for Single Site-Energy Systems

This Outline of Investigation is being developed for residential and small commercial microgrids found in single-family homes or small commercial environments.

Both documents speak to gaps that may not be adequately addressed by the current National Electrical Code® (NEC). Risks addressed include the following:

- Power quality during islanded or stand-alone operation.
- Interoperability between energy sources.
- Synchronization of energy sources with the public utility or other microgrids.
- Abnormal operation, system faults and foreseeable operator misuse.
- Cybersecurity.

UL 3005: The Outline of Investigation for Distributed Energy Resource Management Systems (microgrid controls)

This Outline of Investigation specifies requirements for stand-alone microgrid controllers for systems other than strictly generator-based microgrids.

These documents and resulting model codes inform municipal codes and protocols that promote safe installation, sustainability and integration with the public grid — without compromising safety or efficiency.





National Electrical Code® (NEC)

The National Electrical Code® (NEC) is a widely adopted set of guidelines for the safe installation of electrical wiring and equipment in the United States. Developed by the National Fire Protection Association (NFPA), it seeks to prevent hazards from electrical installations, ensuring safety in residential, commercial and industrial settings.

The NFPA is currently developing microgrid safety standards requirements. These new components of the NEC, expected to be implemented in 2026, will provide information for the safe installation of microgrid systems for all purposes.

Current/OS DC microgrid standards

As a founding member of the international research body Current/OS, UL Solutions contributes to the body of research and technical expertise concerning the installation and operation of direct current (DC) microgrid systems.



Impacts of microgrid safety standards development

Technological advancements in energy management are moving the world toward more flexible, reliable power generation and use. While the direct use of UL 3001 is to codify safe microgrid installation and operation for municipal enforcement, the impacts of a unified standard are far-reaching.

Energy democratization

Microgrids have the potential to make energy resources more accessible and affordable, empowering consumers to generate, store and manage their own electricity; practice independent energy management; and participate in the wider energy marketplace.

As a blueprint for the safe installation and operation of microgrids — both as autonomous entities and in conjunction with the public grid — UL 3001 can help put more power in the hands of consumers. The standard

provides clear safety guidelines for power production and distribution and can empower communities to manage their energy resources more effectively and sustainably.

Microgrids can make it easier for communities and organizations to generate, store and share energy. In turn, this may reduce dependence on centralized power systems and allow for more equitable access to energy resources across diverse communities.

Grid code compliance

Grid code compliance requires products and technologies to adhere to technical regulations for stability and reliability in the power system. These codes define the operational behavior of inverters during normal and fault conditions so that energy fed back into the public grid meets specific quality and safety standards. Compliance is critical for maintaining the electrical grid's stability, preventing disruptions and promoting efficient energy exchange between microgrids and larger utility networks.

Interoperability

Much as a single computer uses components from a constellation of manufacturers, the gold standard of microgrid system design is for operators to choose which components and devices best suit their needs. The complexity and potential risks of integrating microgrid components make a unified standard foundational to these interoperability efforts. Components such as power generation units, battery storage systems and software platforms must operate and communicate seamlessly within a microgrid ecosystem to operate safely. Interoperability establishes that devices and

software from different manufacturers can exchange data and manage power flows effectively. A unified standard provides a basis for all manufacturers to produce compatible components, devices and software.

Cybersecurity

The advent of advanced software and AI-assisted power management has given microgrid operators the opportunity to build more sophisticated control processes. Management software helps operators understand what is going on within the power system in real time, react autonomously to emerging conditions and provide information and intervention safely and appropriately. During nominal performance conditions, these systems help operators maximize power performance and optimize consumption for more cost-effective use.

However, the inherent connectivity needed for autonomous management and the Internet of Things (IoT) presents a vector for cyberattacks. As microgrid systems proliferate, so do the risks of infiltration by threat actors. As the energy landscape moves from a large, centralized structure (such as a nuclear reactor or a





natural gas facility) to a distributed energy infrastructure, security measures must address the risks of decentralized loads and the potential for large-scale attacks.

For instance, an intentional intrusion into an electrical vehicle charging network can bring large geographic areas to a standstill. A unified code provides fewer gaps in network security, reducing risk and giving cybersecurity and systems penetration experts more tools. Collaboration between energy stakeholders allows them to proactively harden a rapidly emerging energy infrastructure, with a specific emphasis on microgrid security.

Meeting the standard: UL Solutions product testing and certification

With the introduction of the consensus standard, product designers and component manufacturers must be able to demonstrate adherence to the standard. Certification communicates to the market that a product's technical specifications and safety parameters meet the requirements stated in the standard.

UL Solutions provides information about whether a specific process or system meets the criteria or requirements outlined in the standard.

Through comprehensive testing, inspection and certification services, UL Solutions determines whether product systems meet standard requirements. UL Solutions helps customers demonstrate compliance with a standard or regulation. Products that meet the standard earn certification, which can help companies boost trust and differentiate their products in the marketplace.

UL Solutions: A partner in a safe and sustainable future

The planet and its inhabitants need fast and decisive action to overcome our energy challenges and mitigate scenarios of climate change. By participating in the development of comprehensive, forward-thinking standards to govern power production and distribution, UL Solutions demonstrates its commitment to innovation within energy infrastructure design and deployment.

If your organization needs guidance in demonstrating compliance, safety and sustainability for its products, [reach out to a UL Solutions expert](#) to learn more about our testing and certification services.



