



Energy Leadership: Energy Storage Systems and Microgrids

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Overview

- The NEC is expanding to include requirements and there are many terrific opportunities that exist in large-scale photovoltaic systems, energy storage systems and DC microgrid systems.
- This program will discuss the forces driving these changes, the evolution of the infrastructure landscape and how energy storage and micro-grid applications are quickly becoming the means to address demand response.

Objectives

- Industry Trends
- The Electrical Safety System
- Terminology
- Smart Grid Initiatives
- Internet of Things (IoT)
- Renewable Energy
- Energy Storage
- Codes and Standards
- Safety (Installation and Workplace)
- First Responder safety

Industry Trends

- The Energy Independence Act and Department of Energy (DOE) mandates are driving change to building electrical systems designs and installations.
- Alternative Energy Sources are becoming more reliable and affordable.
- There is a tremendous need to store produced energy for later use, demand response, load leveling, and to serve standby power systems.





Industry Trends

- Various energy storage technologies are rapidly gaining adoption for variety of grid applications in recent years.
- Pumped Hydro, Thermal Storage and Lead Acid batteries have been used for grid support and back up applications for 100+ years

Industry Trends

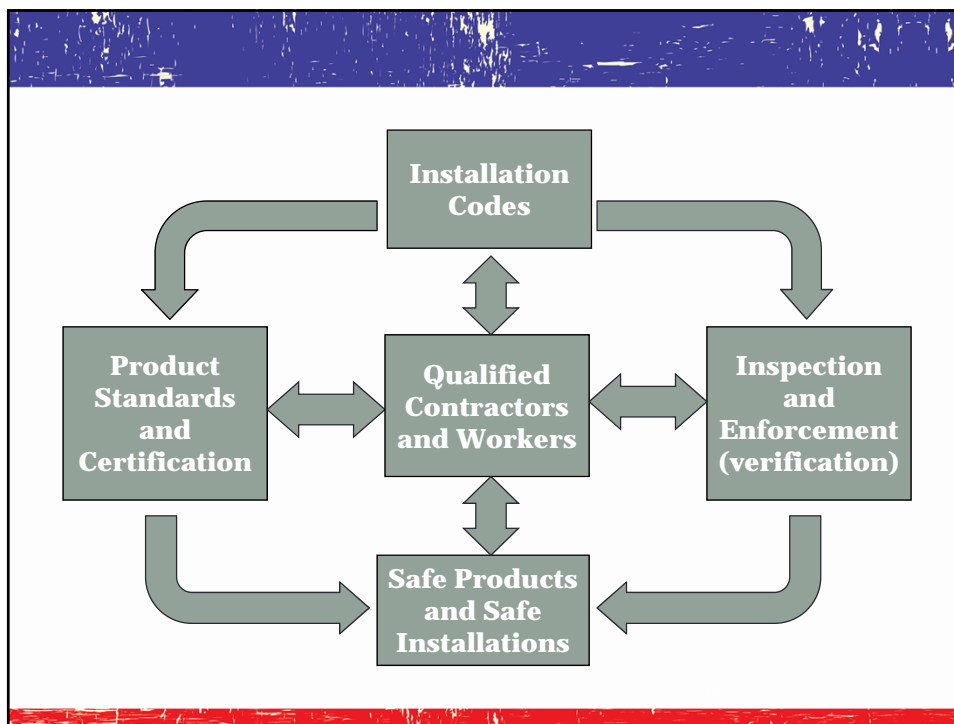
- Li-Ion batteries are gaining rapid adoption for short duration applications, and reduction in cost and improved performance is also enabling use for applications such as peak load management, renewable integration and diesel reduction.
- Other battery technologies are in development as are associated safety standards.



Industry Trends

- Advanced Lead Acid and Flow batteries also have promise for significant improvements and enabling newer applications in next 3-5 years.
- Regulatory intervention coupled with utility and private sector innovation is expected to drive large scale adoption of energy storage in next 2-3 years.





Terminology

- Proper application of codes and standards requires use of common terminology.
- Defined words and terms provide the means to enhance comprehension and application of rules to installations and systems.

Terminology

- Energy Storage System (ESS). Equipment and systems capable of storing energy for use at a future time. ESSs include but are not limited to electrochemical storage devices (batteries), flow batteries, ultra-capacitors (or super-capacitors), and kinetic devices (flywheels, pumped hydro storage, and compressed air), among others.
- Energy Storage System (ESS) Device(s). One or more devices assembled together that are capable of storing energy for use at a future time.



Smart Grid Initiative

- It is the policy of the United States to support the modernization of the Nation's electricity transmission and distribution system to maintain a reliable and secure electricity infrastructure that can meet future demand growth.
- About 28% of the grid is capable of communication and interoperability between locations.
- The following collectively characterize a “Smarter Grid.”

Smart Grid Initiative

- Increased use of digital information and controls technology to improve reliability, security, and efficiency of the electric grid.
- Dynamic optimization of grid operations and resources, with full cyber-security.
- Deployment and integration of distributed resources and generation, including renewable resources.
- Development and incorporation of demand response, demand-side resources, and energy-efficiency resources.

Smart Grid Initiative

- Deployment of “SMART” technologies (real-time, automated, interactive technologies that optimize the physical operation of appliances and consumer devices) for metering, communications concerning grid operations and status, and distribution automation.
- Integration of “SMART” appliances and consumer devices.
- Deployment and integration of advanced electricity storage and peak-shaving technologies, including plug-in electric and hybrid electric vehicles, and thermal storage air conditioning.

Smart Grid Initiative

- Provision provided to consumers of timely information and control options.
- Development of standards for communication and interoperability of appliances and equipment connected to the electric grid, including the infrastructure serving the grid.
- Identification and lowering or removing unnecessary barriers to adoption of smart grid technologies, practices, and services.

Smart Grid Essentials

- Must have adequate power capabilities (robust)
- Other primary objectives are to ensure grid flexibility, self-healing functions, and easily reconfigured (automated)
- Must be equipped with effective interoperability through optimal communications and controls.

Internet of Things (IoT)

- The Internet of Things (IoT) is best described as the rapid growing network of physical objects that feature an IP address for internet connectivity, and the communication that occurs between these objects and other Internet-enabled devices and systems.
- Connectivity and use of the Internet is an essential component of effective operation of energy storage systems and microgrids and the “SMARTER GRID.”

Renewal Energy Systems in the NEC

- Solar PV Systems – Article 690
- **Large Scale PV Systems – Article 691**
- Fuel Cell Systems – Article 692
- Wind Power Systems – Article 694
- **Energy Storage Systems – Article 706**
- **Stand Alone Systems – Article 710**
- **DC Microgrids – Article 712**
- Energy Management Systems – Article 750



Article 691

- Article 691 - Large-Scale Photovoltaic (PV) Electric Supply Stations
- A large-scale photovoltaic (PV) is designed for the supply of power into the electricity grid.
- Differs from building-mounted and other decentralized solar power applications in that they supply power at the utility level, rather than to local users.
- Often referred to as solar farms, especially when sited in agricultural areas.



Article 691 (cont.)

- Section 691.4 provides specific requirements that must be satisfied before use of the article is permitted.
- Electrical circuits and equipment shall be maintained and operated only by qualified personnel.
- Access to PV electric supply stations shall be restricted by fencing or other adequate means in accordance with 110.31.
- Field-applied hazard markings shall be applied in accordance with 110.21(B).

Article 691 (cont.)

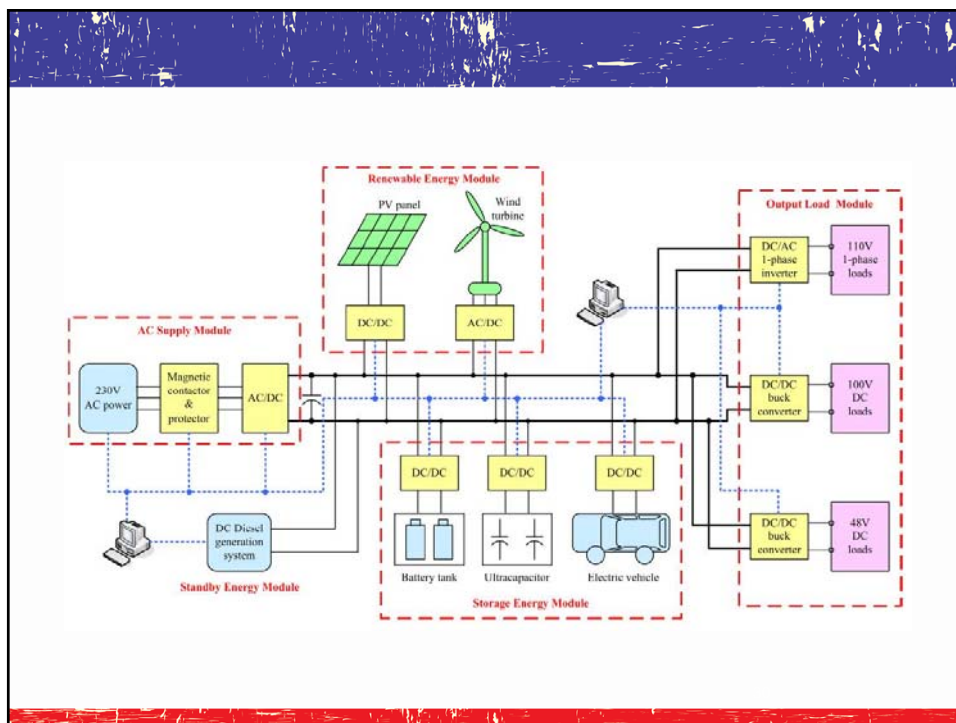
- The connection between the PV electric supply station and the system operated by a utility for the transfer of electrical energy shall be through medium or high-voltage switch gear, substation, switch yard, or similar methods whose sole purpose shall be to safely and effectively interconnect the two systems.
- The electrical loads within the PV electric supply station shall only be used to power auxiliary equipment for the generation of the PV power.
- Large-scale PV electric supply stations shall not be installed on buildings.

Article 710 Stand Alone Systems

- This article covers electrical power production sources operating in stand alone mode.
- 710.6 All equipment shall be listed and labeled or field labeled for the intended use.
- 710.15 Premises wiring systems shall be adequate to meet the requirements of this *Code* for similar installations supplied by a feeder or service.
- The wiring on the supply side of the building or structure disconnecting means shall comply with the requirements of this *Code* , except as modified by 710.15(A) through (F).

Article 712 Direct Current Microgrids

- Article 712 - A direct current power distribution system consisting of one or more interconnected dc power sources, dc-dc converters, dc loads, and ac loads powered by dc-ac inverters.
- DC power sources to direct current loads such as LED lighting, communications equipment, computers & servers, variable-speed motor drives, HVAC equipment, etc.



Article 706 Energy Storage Systems

- This article applies to all permanently installed energy storage systems (ESS) operating at over 50 volts ac or 60 volts dc that may be stand-alone or interactive with other electric power production sources.
- The term Energy Storage System is defined as one or more components assembled together capable of storing energy for use at a future time.

Article 706 Energy Storage Systems

- ESS(s) can include but is not limited to batteries, capacitors, and kinetic energy devices (e.g., flywheels and compressed air). These systems can have ac or dc output for utilization and can include inverters and converters to change stored energy into electrical energy.
- Applies to all permanently installed energy storage systems (stand-alone or interactive).



Article 706 Energy Storage Systems

- Article 706 Arrangement
 - Part I General
 - Part II Circuit Requirements
 - Part III Electromechanical Energy Storage Systems
 - Part IV Flow Battery Energy Storage Systems
 - Part V Other Energy Storage Technologies

Energy Storage Systems – Uses

- Energy Storage systems have multiple applications depending on each unique design or application.
- Standby power systems such as emergency systems and legally required standby systems.
- Load leveling use in grid and microgrid applications
- Storing energy produced by renewable energy technology such as wind and PV systems.
 - UPS power systems
 - Demand response
 - Others

Applying NEC Rules

- NEC Chapters 1 through 4 have general application.
- Chapter 4 Equipment for General Use
 - Article 460 Capacitors
 - Article 480 Storage Batteries
- Chapter 7 Special Conditions
 - Article 706 Energy Storage Systems
 - Article 710 Stand Alone Systems
 - Article 712 DC Microgrids

Other Codes and Standards

- Workplace Safety
 - OSHA 1910 and 1926
 - NFPA 70E Workplace Safety
- Equipment and Product Safety
 - Product Certification (Listing) to Safety Standards
- Maintenance Requirements
 - NFPA 70E and 70B
- Quality and Performance Standards
 - Recommended Practice for Installing and Maintaining Energy Storage Systems

NECA 416

- Recommended Practice for Installing and Maintaining Energy Storage Systems (**ANSI approved January 2017**)
 - Scope
 - Definitions
 - Site Preparation
 - General Installation Requirements
 - Electrical Installation Requirements

NECA 416 (cont.)

- Recommended Practice for Installing and Maintaining Energy Storage Systems
 - Battery Systems
 - Flywheels
 - Capacitors and Ultra-capacitors
 - Smart Chargers

NECA 416 (cont.)

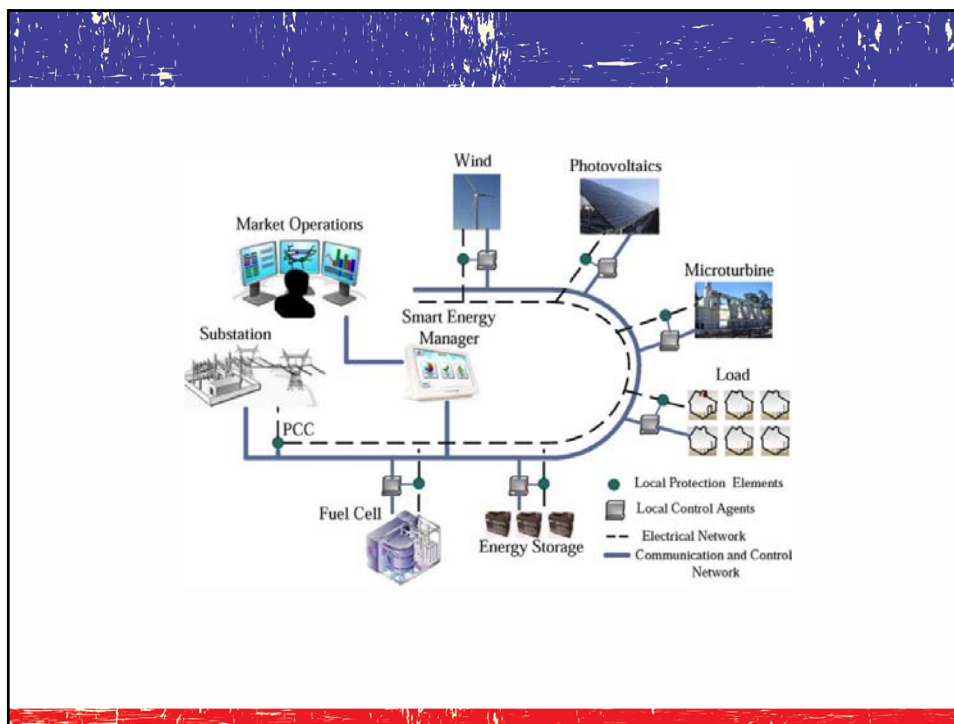
- Recommended Practice for Installing and Maintaining Energy Storage Systems
 - Annex A: Battery Technologies
 - Annex B: Compressed Air Energy Storage (CAES)
 - Annex C: Pumped Hydro Storage (PHS)
 - Annex D: Thermal Energy Storage (TES)

Design and Engineering Integrity

- NEIS describe specific installation practices that go beyond the minimum safety requirements in the NEC®.
- NEIS assist in standardizing the understanding of quality in workmanship.
- NEIS help insure that electrical installation practices live up to expected professional electrical design integrity.

What is a Microgrid?

- A microgrid is a discrete energy system consisting of distributed energy sources (including demand management, storage, and generation) and loads capable of operating in parallel with, or independently from, the main power grid.
- A microgrid generally operates while connected to the grid, but importantly, it can break off and operate on its own using local energy generation in times of crisis like storms or power outages, or for other reasons.



Microgrid Power Sources

- A microgrid can be powered by distributed generators, batteries, and/or renewable resources like solar panels. Depending on how it's fueled and how its requirements are managed, a microgrid might run indefinitely.

Why Install a Microgrid?

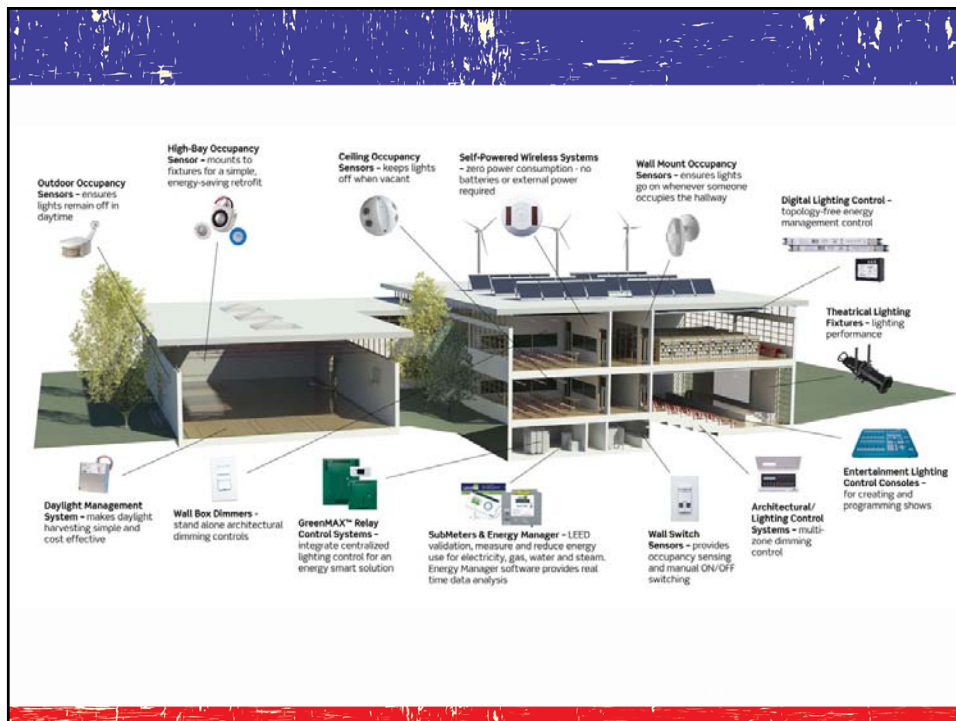
- Integrate renewal energy sources to supplement utility sources
- Compensation for power variability (load leveling)
- Improvement of system reliability
- Bridging intermittency
- Some concerns are two-way power flow and voltage regulation.

NECA 417 (in development)

- Recommended Practices for Designing, Installing, Maintaining and Operating Microgrids.
- Draft stages in progress.
- ANSI PINS submittal anticipated summer of 2017

Energy Management

- Energy management includes planning and operation of energy production and energy consumption units.
- Objectives are resource conservation, climate protection and cost savings, while the users have permanent access to the energy they need.



Energy Management Systems – NEC

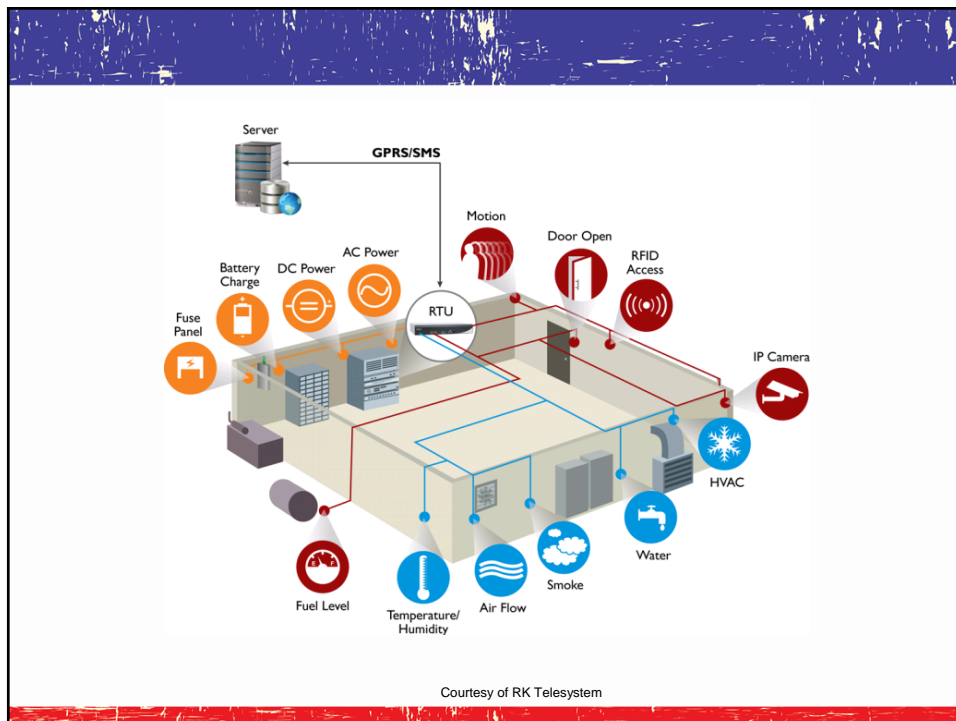
- Article 750 Energy Management Systems
- This article applies to the installation and operation of energy management systems.
- Performance provisions in other codes establish prescriptive requirements that may further restrict the requirements contained in this article.

Energy Management Systems – NEC

- Control. The predetermined process of connecting, disconnecting, increasing, or reducing electric power.
- Energy Management System. A system consisting of any of the following: a monitor(s), communications equipment, a controller(s), a timer(s), or other device(s) that monitors and /or controls an electrical load or a power production or storage source.

Energy Management Systems – NEC

- Monitor. An electrical or electronic means to observe, record, or detect the operation or condition of the electric power system or apparatus.



Energy Management Systems – NEC

Section 750.20 indicates the EMS shall not override any control necessary to ensure continuity of an alternate power source for:

- Fire Pumps
- Health Care Facilities
- Emergency Systems
- Legally Required Standby Systems
- Critical Operations Power Systems

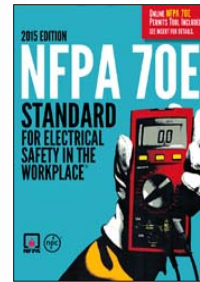
Energy Management Systems – NEC

Section 750.30(A) indicates the EMS shall not override the load shedding controls that ensure minimum electrical capacity for Fire Pumps, Emergency Systems, Legally Required Standby Systems, and Critical Operations Power Systems

- Section 750.30(B) contains a list of equipment and systems that the energy management system is not allowed to disconnect.

Training, Policies and Best Practices

- Applicable Safety Regulations and Standards
 - 1910 General Industry
 - 1926 Construction
- NFPA 70E Standard for Electrical Safety in the Workplace
- NFPA 70B Recommended Practice for Electrical Equipment Maintenance



Safety from the Inside Out

- Safe energy storage equipment, installations, and systems.
- Installation and operational safety and building occupants.
- Safety for buildings (building envelopes and fire suppression systems).
- Safety for installers and maintainers of energy storage systems.

Safety Outside In

- First Responders manage safety the event of energy storage system failures.
- Training needs identified for First Responders.
- Training for Building owners about monitoring, safe operation, and necessary maintenance of energy storage systems.

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Questions

Up Next: Interactive Break in the Cibolo Canyon Ballroom

- Eat This Not That
- The Airplane Stretch Break
- Open Q & A Session: Apps
- Get to Know Your iPad Inside & Out

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