Fire Safety for New Battery Technologies
What's in Store for Your Jurisdiction?

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Energy Storage System (ESS) Applications

Historical stationary battery system applications

Facility emergency and standby power

Uninterruptable power supplies

Telecommunication system continuity

Web oriented data centers

Energy Storage System (ESS) Applications

Evolving stationary battery system applications

Expanding energy storage infrastructure

- Grid balancing and resiliency
- Load shedding
- Mitigating renewable energy intermittency

“Smart meter” cost savings

Commercial and residential applications

Historical Stationary Battery Systems

Primarily lead acid battery systems

Hazards include:

- Corrosive liquids
- Hydrogen off gassing
- Electrical energy considerations

Modern Battery Technologies

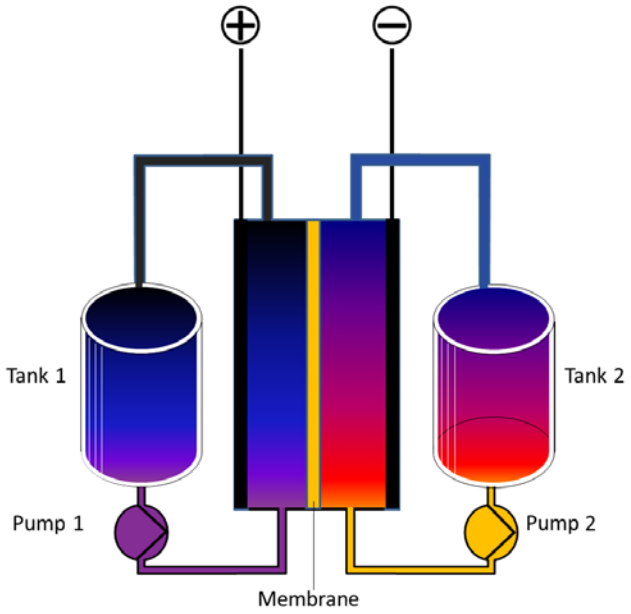
Stationary battery technologies include

- Flow batteries
- Sodium-sulfur batteries
- Lithium-ion batteries
- Others technologies on the way

Energy density and cost drive new battery technologies

Flow Batteries

- Two tanks of liquids, pumped past a membrane between electrodes
- Electric current produced while both liquids circulate in their own respective space
- System includes pumps, sensors, control units, secondary containment



Will fire and emergency services have a plan for responding to incidents?

Sodium–Sulfur Batteries

High energy density, and long cycle life

Operating temperatures of 300 to 350 °C

Sodium polysulfides are highly corrosive

Vacuum insulated boxes protect sodium from water and oxidizing atmospheres

Pure sodium spontaneously burns in contact with air and moisture

Lithium-ion Batteries

Excellent energy density

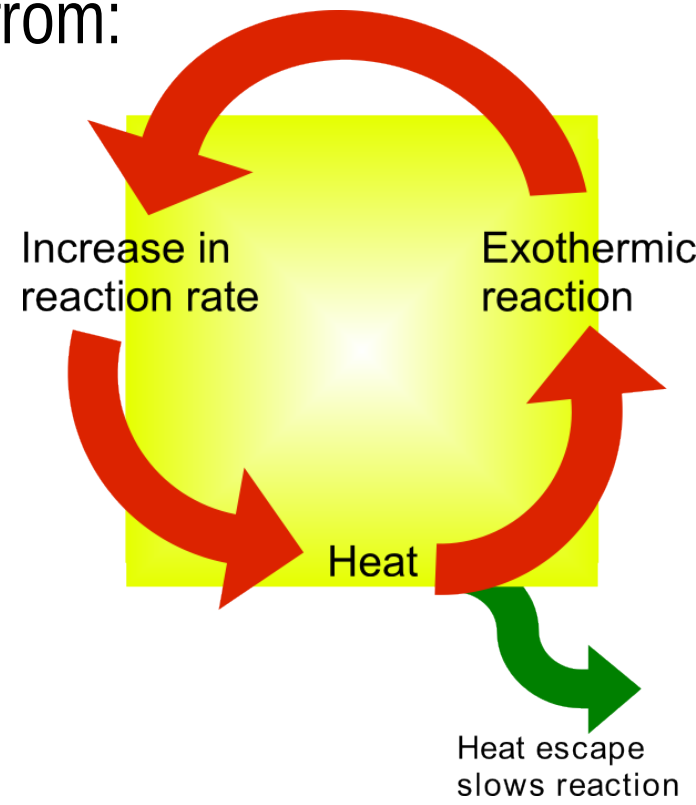
The current battery of choice

Batteries and systems are readily available

Li-ion Battery Safety Considerations

Overheating and cell rupture is possible from:

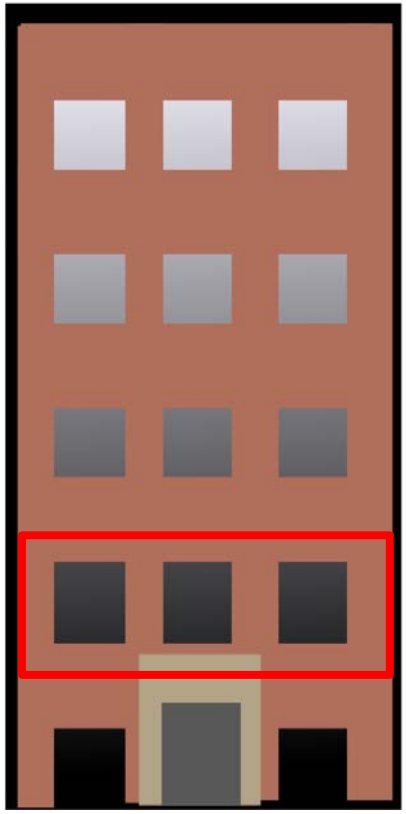
- Overcharging
- Short circuits
- Manufacturing defects



Thermal runaway in one battery will readily spread to adjacent cells

Li-ion Batteries – Abnormal Charging

Fire Code Battery System Requirements



Since 1997 (lead-acid) battery systems allowed in incidental use areas

1 or 2 hour fire-rated separations

Hazmat requirements exempted

Spill control, ventilation, smoke detection

Battery quantities unlimited

Location in building not regulated

Standby & emergency power, UPS use

Current codes do not adequately protect newer battery technologies

Addressing New Potential Hazards

How can you address ESS hazards not covered by the code?

Large quantities of Lithium-ion batteries

New battery and other ESS technologies

Proven effective protection methods not yet available

What do fire and emergency services need to know to respond to incidents

Proposed Battery System Requirements

NFPA 1 TC approved new battery system requirements

Proposal F95-16 for the IFC/IBC and RB171-16 for the IRC were approved at ICC Public Comment Hearings

Intent - Both 2018 fire codes will include similar requirements

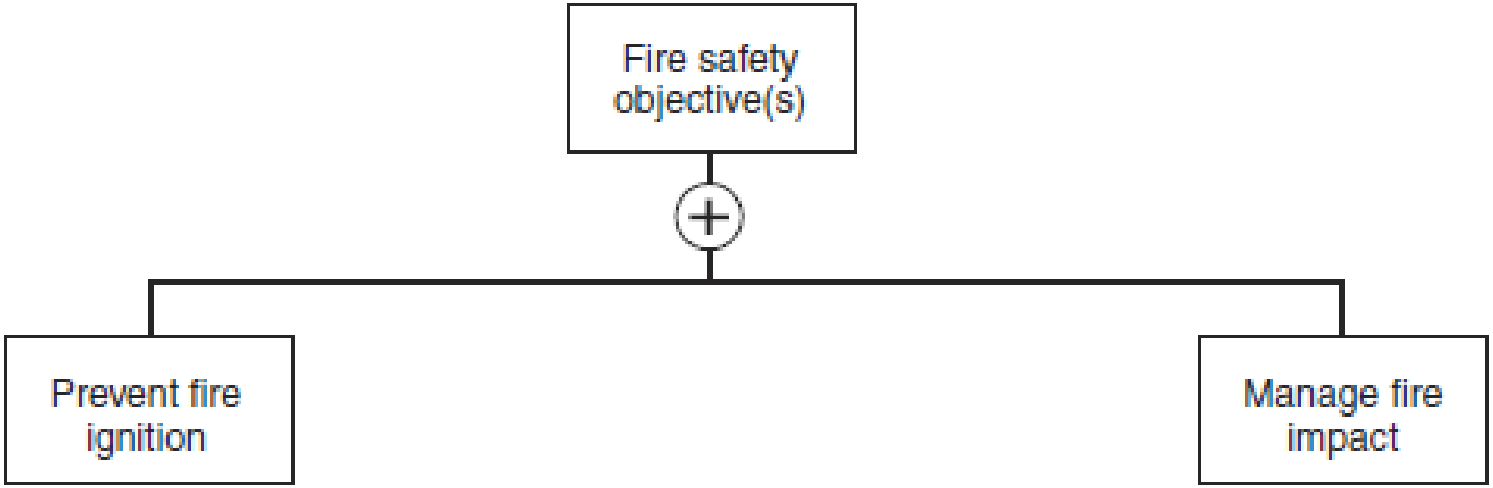
NFPA 855 TC recently formed to develop an ESS standard

Considerations behind the IFC Code Proposals

- Section 608 addresses lead acid battery system hazards
- Covers lithium batteries but doesn't effectively address associated hazards
- Does not regulate other battery technologies – outside of scope of Section 608
- Societal needs for ESS installations
- Recognition that additional research, large scale testing and standards are needed to address unknowns

Concepts for Protecting Energy Systems

NFPA 550: Guide to the Fire Safety Concepts Tree



Listed batteries and equipment
BMS and compatible equipment
Proper installation
Ventilation, as needed

Fire-resistive separation
Suppression and control
Array spacing and MAQs
Location in building or on property
Signage

IFC Proposal - Threshold Limits

Current threshold

50 gallons electrolyte for lead-acid, Ni-Cad, VRLA

1,000 pounds for lithium-ion and lithium metal polymer

Other technologies not covered

Use - Standby and emergency power or UPS

2018 threshold

Lead acid, Ni-Cad - 70 KWh

Lithium, sodium all types - 20 KWh

Flow batteries - 20 KWh

Other battery technologies 10 KWh

Use - No limitations

2018 IFC – General

Installation permits

Construction documents

Hazard mitigation analysis (HMA) shall be provided for:

1. Battery technologies not specifically covered
2. Multiple battery technologies in a room with a potential for adverse interactions

3. When allowed as a basis for increasing MAQs

2018 IFC – General

The HMA will evaluate the consequences of failure modes

- Thermal runaway in a single battery array
- Failure of the energy management system
- Failure of ventilation system
- Voltage surges on the primary
- Short circuits on the load side of the batteries
- Failure of the smoke or gas detection, fire suppression

The fire code official is authorized to approve the hazardous mitigation analysis based on the HMA.

The HMA is a tool to address unknowns with new technologies

2018 IFC – General

Seismic and structural design per IBC Chapter 16
Vehicle impact protection
Combustible storage not allowed in battery rooms, cabinets
Testing, maintenance and repairs per the manufacturer's instructions

Location and Construction

Current IFC

No restrictions on location in a building or on the property

2018 IFC

Battery room floor < 75 feet above the lowest level of fire department vehicle access, and < 30 feet below the lowest level of exit discharge

Exception: Installations on noncombustible rooftops > 75 feet that do not obstruct fire department rooftop operations when approved by the fire code official.

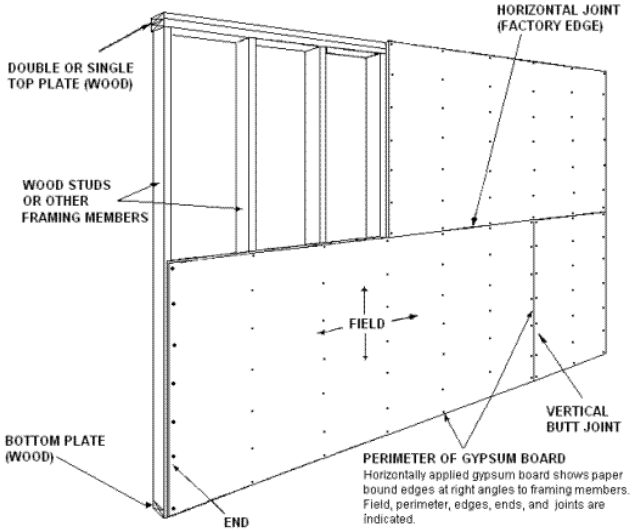
Fire-Resistive Separations

Current IFC

Battery room must be separated from other areas of the building in accordance with Section 509.1 of the International Building (1 or 2 hours depending on adjacent occupancy)

2018 IFC

No changes, still allowed in incidental use areas



New Stationary Storage Battery Concepts

Pre-packaged stationary storage battery system
Pre-engineered stationary storage battery system

Battery Arrangements

Current IFC

No restrictions on battery arrangements within the room

IFC 2018

- Storage batteries, prepackaged , and pre-engineered battery systems must be segregated into arrays not exceeding 50 KWh each
- Each battery array must be spaced three feet from other stationary battery arrays and from walls in the storage room

  Exceptions:

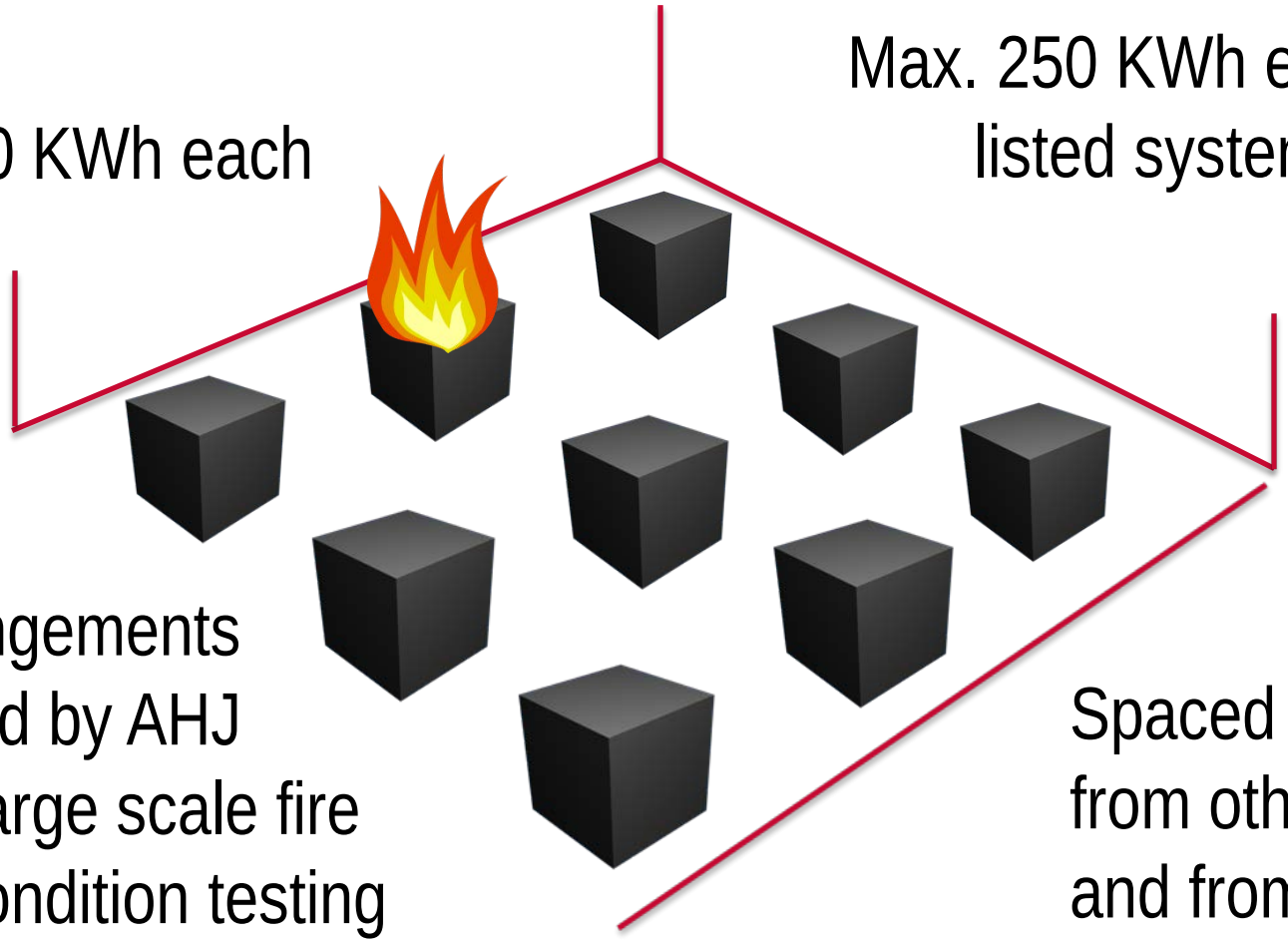
  1.Lead acid batteries arrays

  2. Listed pre-engineered and prepackaged battery systems may be 250 KWh

New Battery Array Concepts

Max. 50 KWh each

Max. 250 KWh each for listed systems



Other arrangements as approved by AHJ based on large scale fire and fault condition testing

Spaced min. 3 ft. from other arrays and from walls

Maximum Allowable Quantities

Current IFC

No restrictions on the quantity of batteries in an incidental use area

2018 IFC

MAQ for an incidental use area within buildings is 600 KWh

- 100 KWh for technologies not covered by the code
- No limit for lead acid battery systems

Fire areas containing battery systems above the MAQ shall comply with Group H requirements

Exception: When approved, larger quantities allowed based on HMA and large scale fire and fault condition testing by an approved testing laboratory.

2018 IFC - Outdoor Installations

Installations in outdoor enclosures or containers which can be occupied are treated as battery storage rooms

Exception: Battery arrays in noncombustible containers are not required to be spaced three feet from the container walls.

Outdoor battery systems must be separated 5 feet from lot lines, public ways, buildings and other exposure hazards

2018 IFC Batteries and Equipment

Storage batteries (except lead-acid) must be UL 1973 listed

Prepackaged/pre-engineered systems must be UL 9540 listed

Battery chargers must be listed and compatible with the battery chemistry and the manufacturer's charging specifications

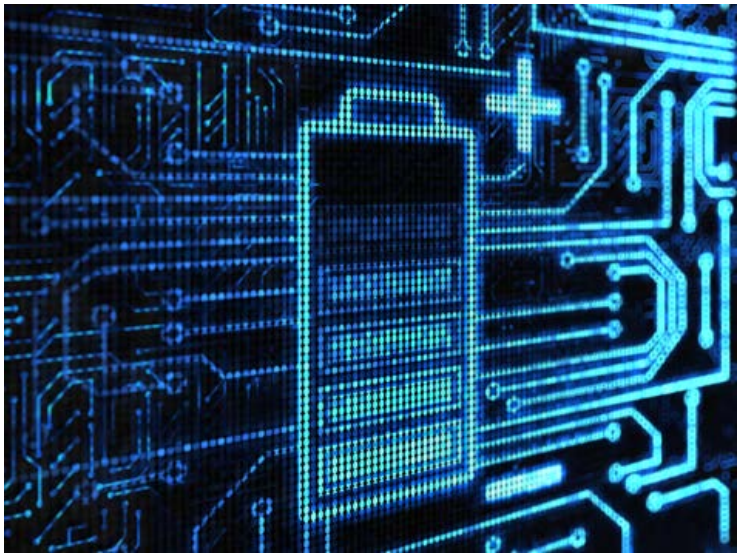
Inverters must be listed and suitable for utility interactive system use if operating in parallel with the electrical grid

Vented batteries must include flame-arresting safety caps

2018 IFC - Battery {Energy} Management Systems

An approved BMS must be provided to monitor and balance cell voltages, currents and temperatures within the manufacturer's specifications.

The BMS must transmit an alarm to an approved location if hazardous temperatures or other conditions such as short circuits, overvoltage or undervoltage are detected.



Battery Room Protection

Automatic smoke detection system per Section 907.2.

Signage on or near battery room doors:

- Cautionary markings to identify hazards with specific batteries (corrosives, water reactive, hydrogen gas, Li-ion batteries, etc.)

2018 IFC - Battery Specific Protection

Systems that release toxic/highly toxic gases during charging, discharging and normal use must comply with Chapter 60

Exhaust ventilation is required for system that produce combustible gases during normal use

Spill control and neutralization required for systems with liquid electrolytes

Fire Suppression Systems

Current IFC

Not required

2018 IFC

Battery rooms need a NFPA 13 system

Commodity classifications per Chapter 5 of NFPA 13.

If the storage batteries are not addressed in Chapter 5 of NFPA 13, the fire official can approve the system based on full scale fire and fault condition testing

Fire Suppression Systems - Discussion

How to protect battery rooms and exposures if no sprinklers are listed for use with battery systems?

Hilden Germany Warehouse Fire

32 tons of cylindrical Li-ion batteries were reportedly involved

600 KWh of Li-ion batteries (MAQ) in an incidental use area ~ 7 tons

New IFC Chapter 12 – Energy Systems

Consolidates new and existing energy related requirements

1201-02 General and definitions

1203 Emergency and standby power systems

1204 Solar photovoltaic power systems

1205 Fuel cell energy systems (New)

1206 Electrical energy storage systems

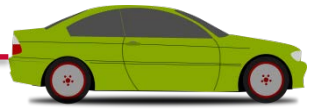
- 1206.1 Scope
- 1206.2 Stationary storage battery systems
- 1206.3 Electrical capacitor energy systems (New)

Consumer Considerations

The “Smart grid” enables consumers to enhance their electric utilization with consumer storage systems

Residential ESS

Li-ion Battery System



Electric Vehicle

Solar or off-peak demand utility power charges the battery system

Utility Interactive Inverter

Electrical Panel

Residential Storage Battery Systems

- Lithium-ion with BMS
- One manufacturer has 6.4 KWh unit ~$3000
- Will provide power for a typical home overnight, but probably not A/C
- Multiple systems can be provided to increase capacity

2018 IRC Battery Systems (RB171-16)

Applies to battery systems > 1KWh

Battery systems must be listed to UL 9540

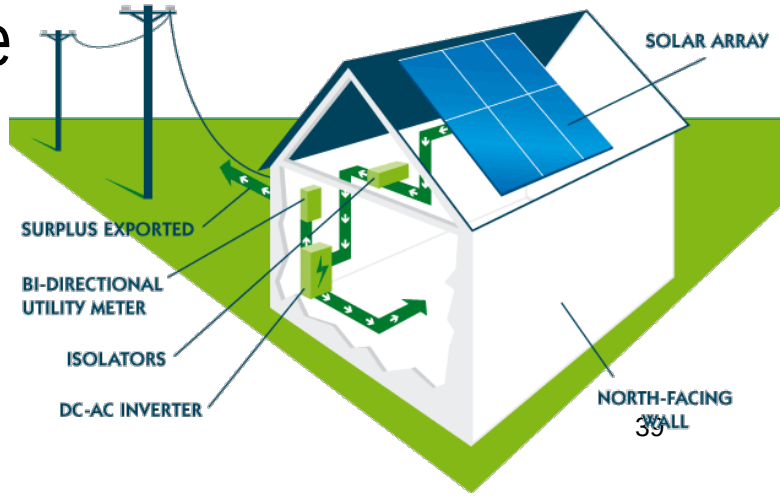
Installed per the manufacturer's instructions

Cannot be installed within habitable space of a dwelling unit

Electrical installation same as residential PV systems

Ventilation required if charging produces hydrogen gas

Vehicle impact protection, if applicable



Repurposing EV Battery Systems

Used Li-ion EV battery systems that no longer provide a sufficient driving range will be replaced in the vehicle, but still retain significant capacity that may be used in non-EV applications

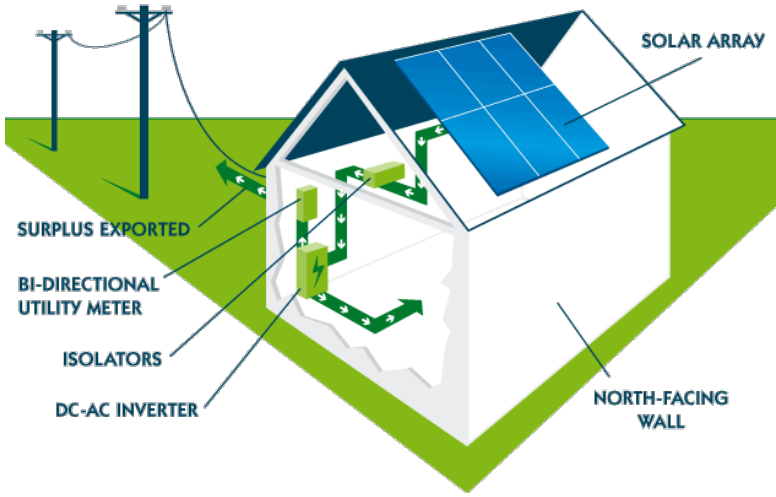
These batteries can be used to capture surplus renewable energy during times of low demand for use during higher demand time periods.

UL 1974 being developed to verify safety methodology

2018 IRC Battery System Reqiurements

Repurposed Batteries

Where approved, repurposed unlisted battery systems from electric vehicles are allowed to be installed outdoors or in detached sheds ≥ five feet from exterior walls, property lines and public ways.



Take Aways – Modern Battery Storage Systems

What do code authorities need to know?

Resiliency and cost savings are driving demand for new energy solutions

Installations may be coming to your jurisdiction soon

Hazards associated with various energy technologies

Prudent to share information with administrators, faculty and emergency responders

New code requirements cover traditional, new and future technologies

Discussion