Battery Energy Storage System (BESS) Fire Safety

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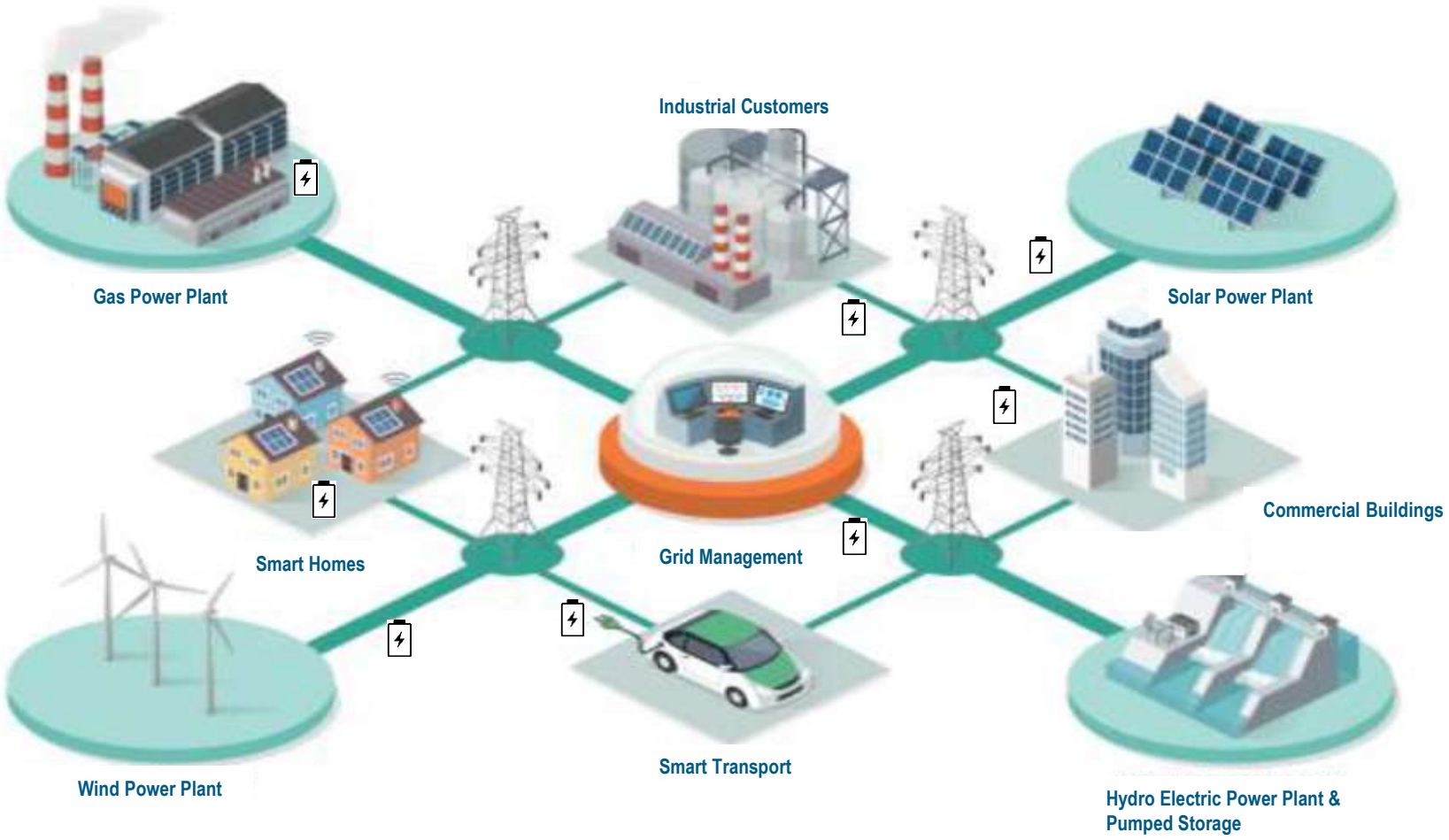
DUKE ENERGY®

Customer Delivery

Old Grid

Smart Grid


Industrial Customers
Gas Power Plant
Solar Power Plant
Smart Homes
Grid Management
Commercial Buildings
Wind Power Plant
Smart Transport
Hydro Electric Power Plant &
Pumped Storage

Long-Term Strategy

Emissions from Generation: Long-Term Outlook

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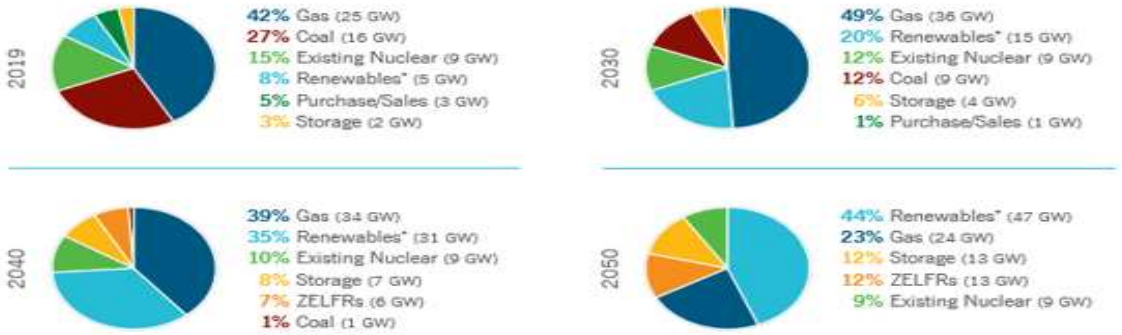
Regulated Project Development
Policy Change
Technology Education
Stakeholder Engagement
Think Customer
Internal Strategy Alignment



10x Renewables Deployments

6x Energy Storage Deployments

Duke Energy 2020 Climate Report

Battery Storage Terminology

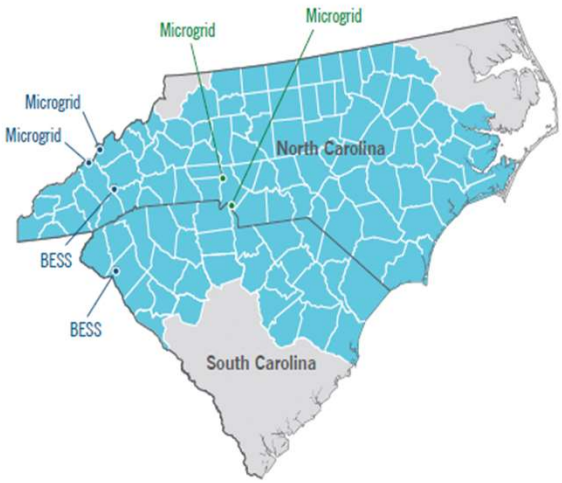
BESS: Battery Energy Storage System

Microgrid: A self-sufficient energy system that serves a discrete geographic footprint. The energy system pairs a generation source and an energy storage source.

Duke Energy BESS Projects

Regulated Battery Energy Storage Sites

Carolinas

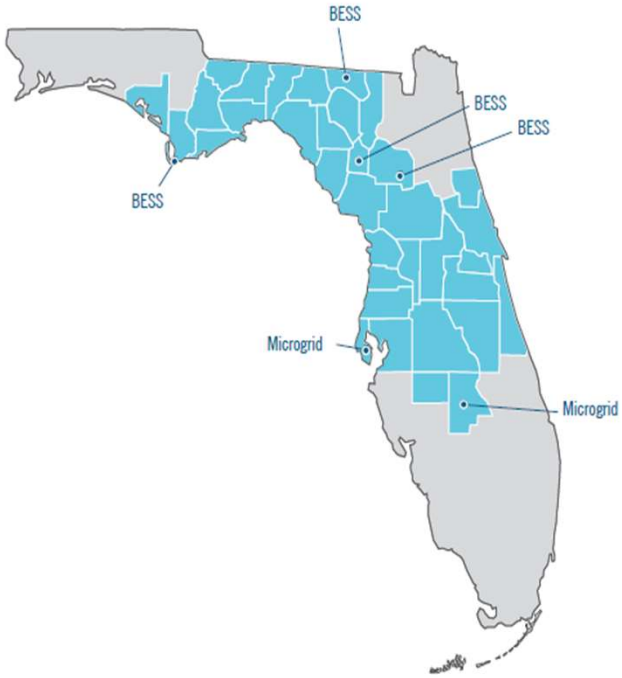


Duke Energy Service Territories

Legend: ● Regulated Battery Energy Storage Site
● Research and Demonstration Microgrid Site

Midwest

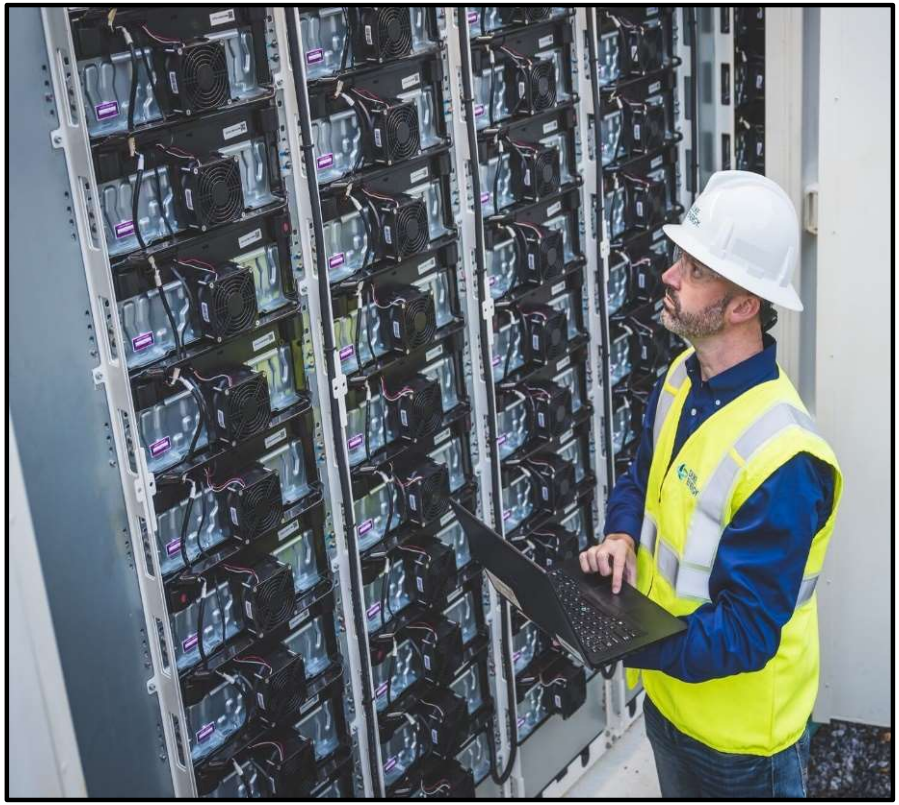
Florida

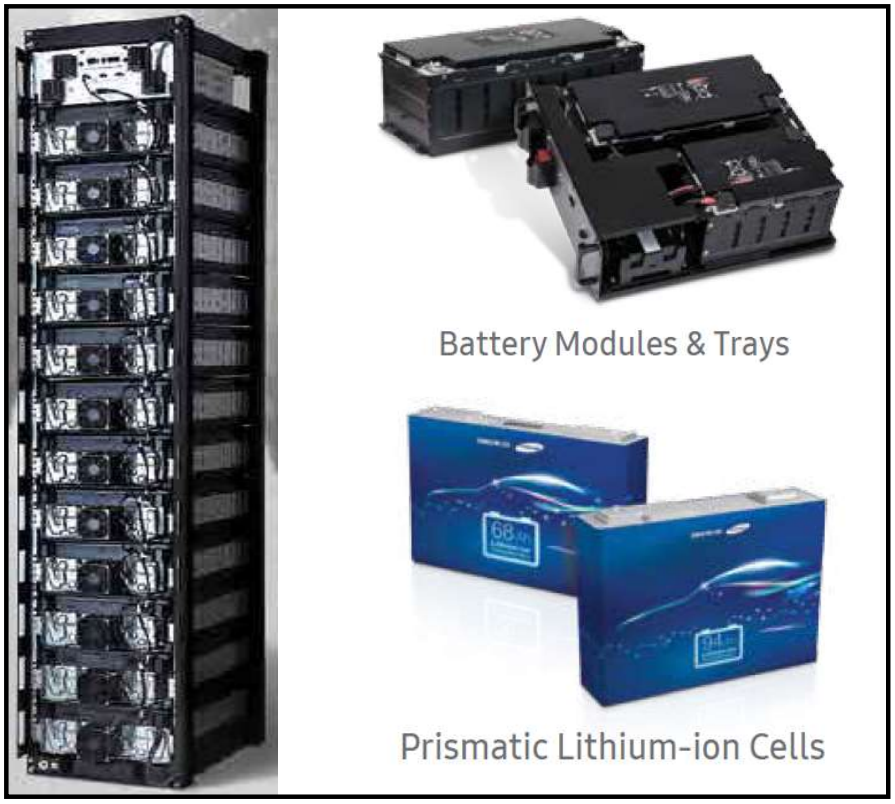


Typical BESS Site Layout

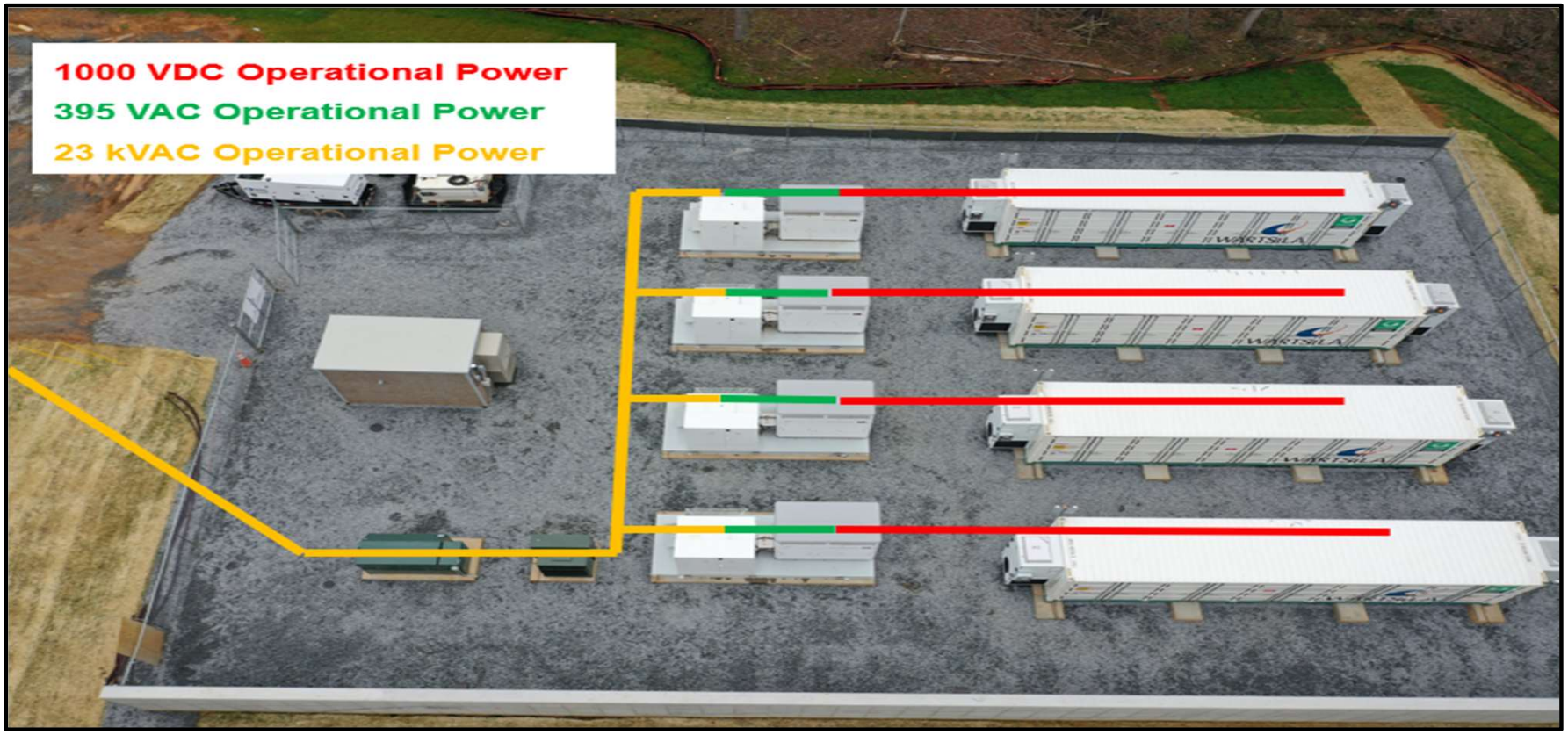
Typical Microgrid Footprint

Typical BESS Battery Layout





Typical Site Voltages

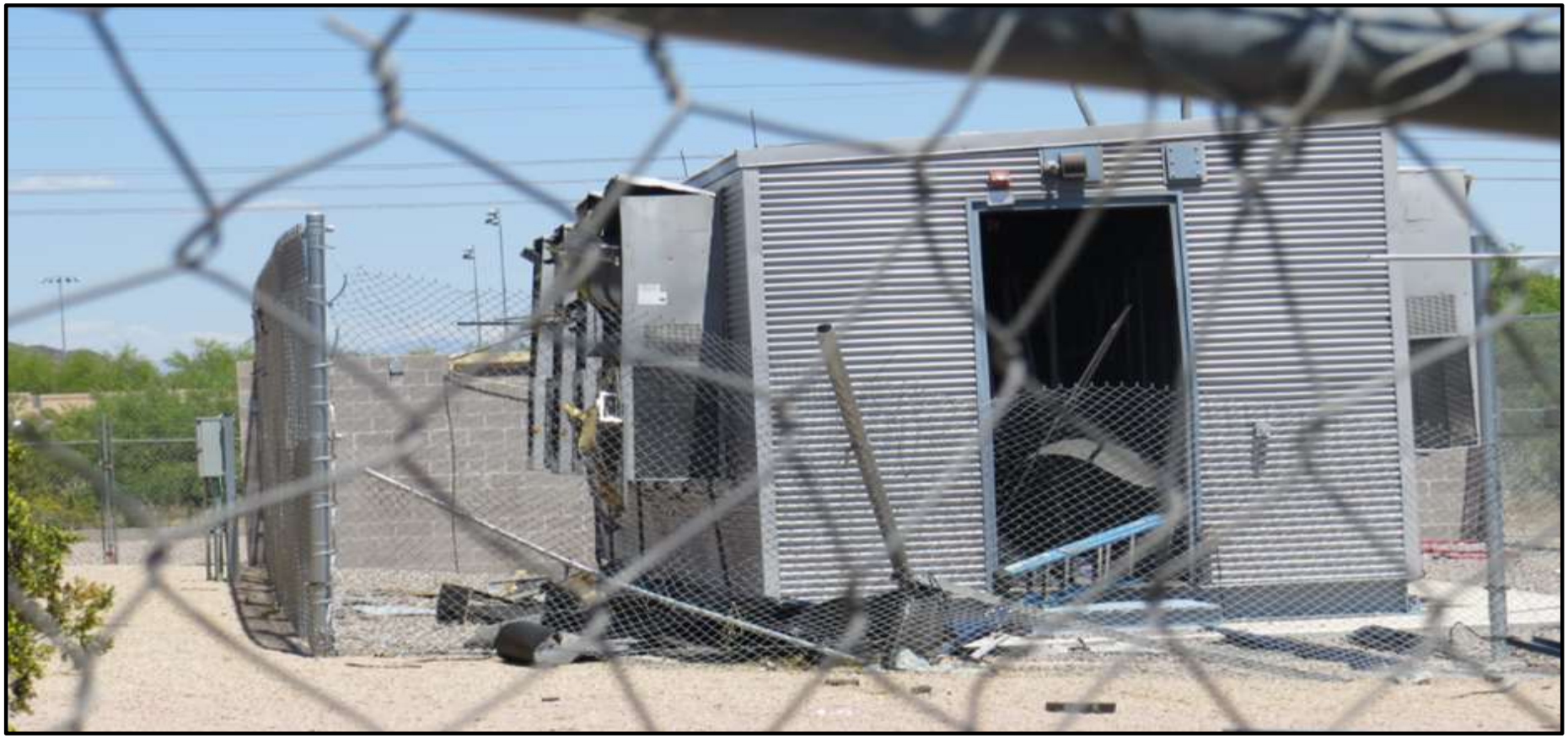


Hazards of Li-ion Batteries

- A malfunction takes place – Overheating, overcharging or short circuit
- Off-Gas Generation – Damaged cell relieves pressure venting hydrogen, carbon monoxide, carbon dioxide and other hydrocarbons
- Hydrogen: Lower Explosive Limit (LEL) is 4% and Upper Explosive Limit (UEL) is 75%
  - Hydrogen can reach LEL quickly and can possibly reach UEL
- Smoke Generation – Smoke is emitted prior to an actual flame
- Thermal Runaway – Chemical reactions or shorts inside the battery that continue until there are no reactive agents left
  - Once the cell goes into thermal runaway, there is no way to stop the reaction. Also, fire re-ignition is possible
- Explosion Risk – Even if thermal runaway is avoided, the enclosure could contain high amounts of hydrogen
- Possibility of an electrical fire inside the container

Industry Events – McMicken, USA

Event Date: April 19, 2019



McMicken – Lessons Learned

- Thermal runaway can cascade very easily.
- Clean agent suppression systems do not stop thermal runaway.
- Ventilation is key to reducing gas concentrations below flammable ranges.
- Owners need a precise BESS entry procedure for emergency response and need to train on this procedure.
- First responder training is crucial to ensure everyone’s safety.

Industry Events – Carnegie Rd BESS, UK

Event Date: September 15, 2020

Carnegie Rd BESS – Lessons Learned

- Single cell failure on a cell that was at end of life.
- Container had a suppression system, but it never activated.
- Remote activation of the suppression system was not available.
- Container had no pressure relief.
- Firefighters were trained not to enter the fence, however, they had a difficult time getting water directly on the fire.
- Volume of water needed to attack fire was underestimated (6 hours to get fire under control).

Industry Events – Victorian Big Battery, AU

Event Date: July 30, 2021

Victorian Big Battery – Lessons Learned

- Event occurred during commissioning of the site.
- Liquid cooling leak caused a short circuit.
- Short circuit caused an electrical fire, which eventually led to a thermal runaway.
- SCADA systems were disabled and did not alert operators to the incident.
- The BESS unit was switched to off-line; this led to battery cooling and battery protection systems being shut down.

BESS Fire Safety Approach

- Duke Energy started construction on our first commercial BESS sites in early 2019
- All-stop on construction after the McMicken incident to review safety systems
- Utilize the EPRI BESS Fire Safety event tracker for industry events
- Post-event review to determine root cause and if changes need to made in our fire safety design criteria

Container Safety Systems

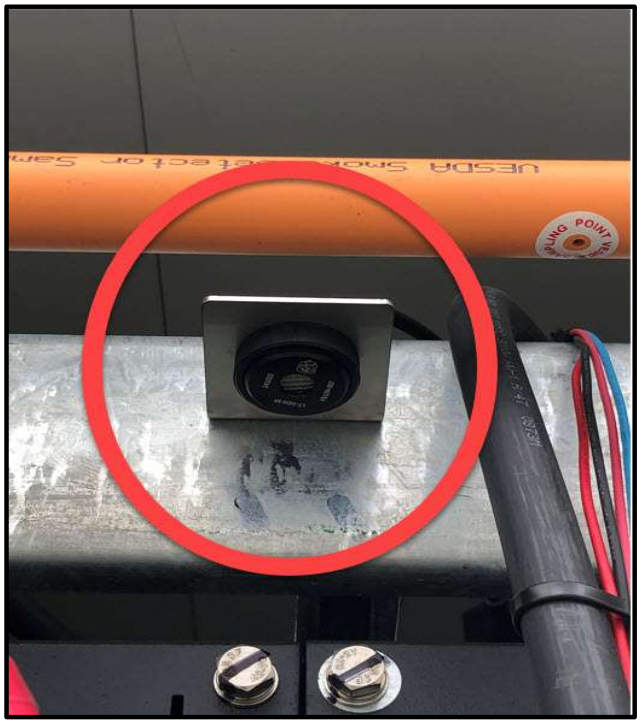
All ISO containers have the following:

- Exterior strobes and audible alarms
- Li-Ion Tamer system for early gas detection
- Fire alarm control panel
- Smoke and thermal detectors
- Fire suppression system (dry chemical)
- Gas detection system
- Gas ventilation activated by high gas alarm
- Deflagration panels to direct any blast upward
- Container flooding system

Warning Strobes

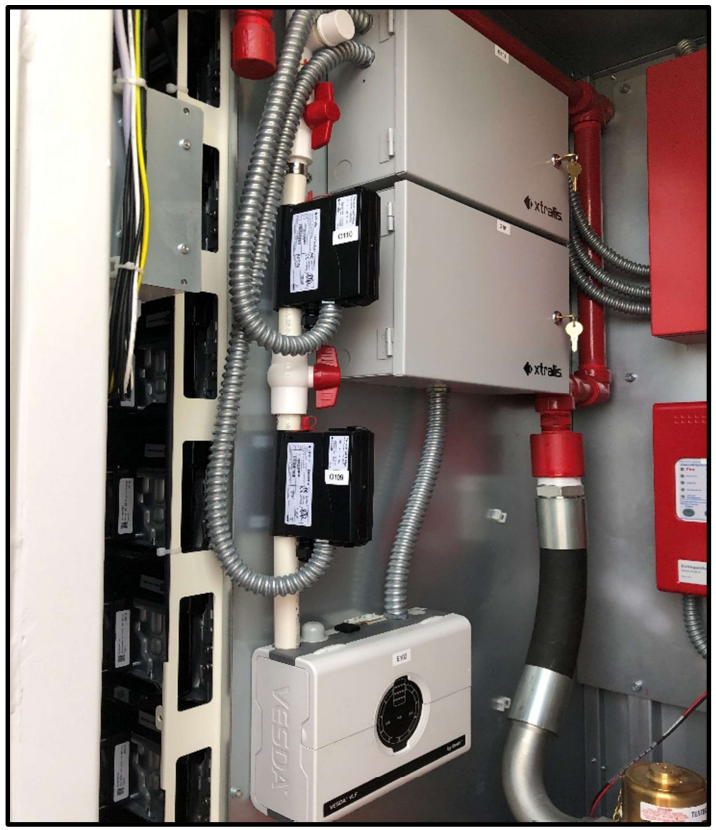
Li-Ion Tamer


LI-ION TAMER®
Honeywell
LI-ION TAMER #2
LI-ION TAMER®
Honeywell
LI-ION TAMER #1



Fire Suppression

Gas Detection



Gas Ventilation

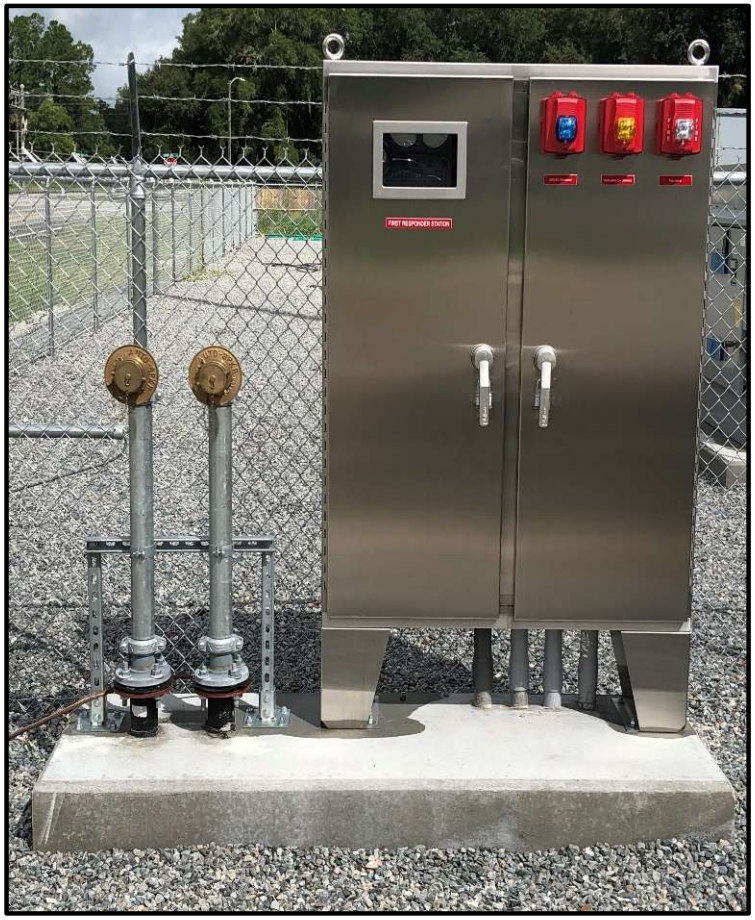
Deflagration Panels

Container Flooding

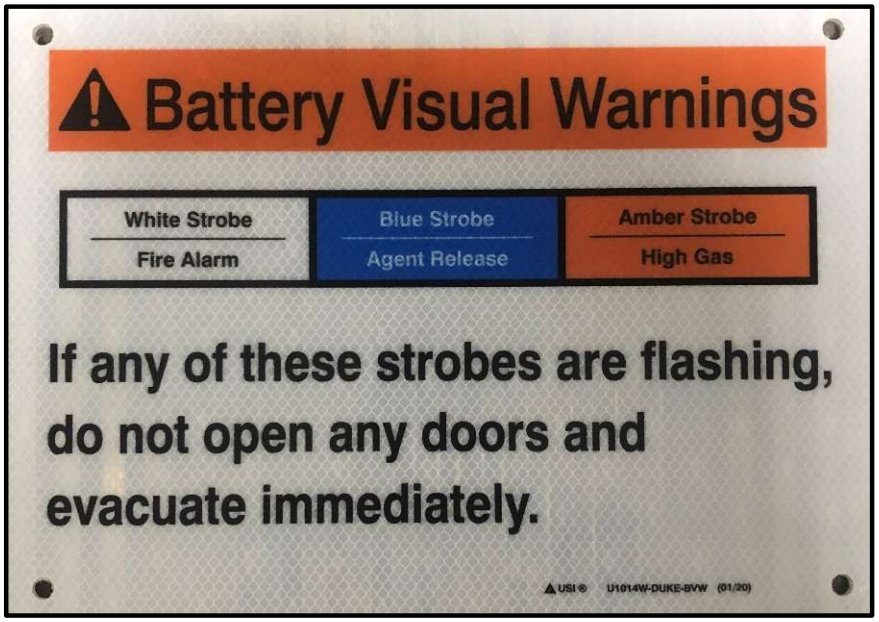
Site Safety Systems

- Site Fencing
  - 1 psi minimum at fence line based on blast analysis
- First Responders Station
  - Exterior strobes
  - Main fire alarm panel
  - Fire suppression pull station
  - Emergency stop pushbutton
  - Emergency ventilation pushbutton
  - Dry pipe hook-ups for container flooding

Site Safety Systems



Site Signage



First Responders Message

- 911 message incorporated into the county 911 CAD system

- Message Details:
  - Warning: You are responding to a Duke Energy large-scale battery storage facility
  - Code for the First Responders Stations is XXXX
  - Contact the Distributed Generation Operation Center at 1-800-726-6736 for assistance in determining immediate dangers
  - Site will remain energized even when disconnected from the grid
  - DO NOT ENTER THE SITE FENCE FOR FIRE RESPONSE

First Responders Brochure

- What is a battery energy storage system
- Hazards of Li-Ion batteries
- Upon arrival instructions
- Unique challenges
- Warning strobes descriptions
- Contact information

Emergency Action Plans

First Responder Training

First Responder Training

- On-site training with the local fire departments who respond to our site
- Initial Training:
  - Introduction of Duke Energy Battery Energy Storage
  - Review First Responder Safety brochure and BESS fire safety strategy
  - Discuss SDS, ERP & EAP
  - Tour site
- In-depth Training:
  - Review SDS sheets, EAP & Hazard Risk Mitigation Plan
  - 911 message and site signage
  - First Responders Station equipment training
  - Full site tour with hands-on discussion of site safety systems
- Yearly Refresher Training

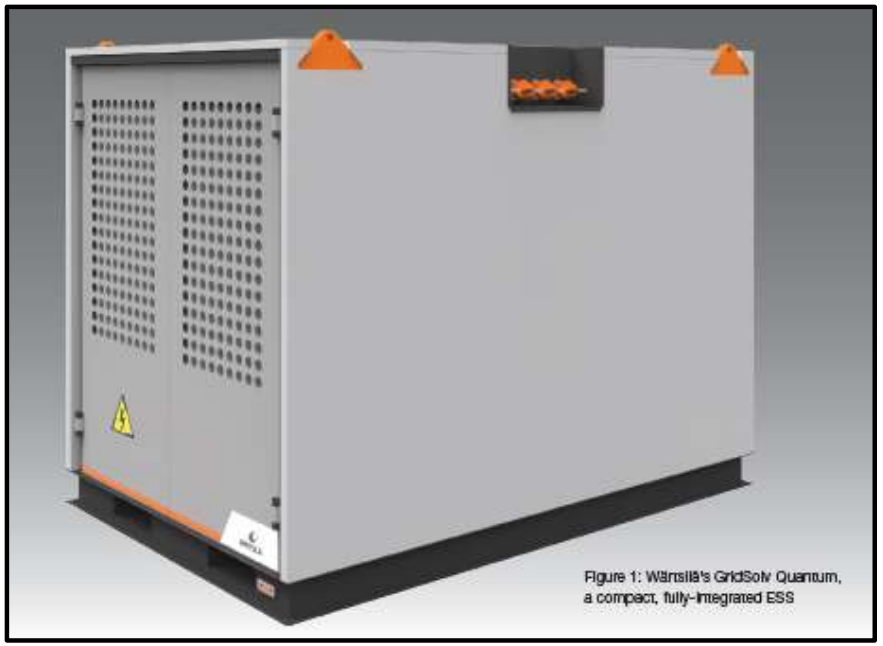
New Technology

- Design move from large containers to small containers placed in “pods”
- Chemistry shift from NMC to LFP
- Liquid/Air HVAC in each unit
- Fire suppression in each unit
- Smaller pod contains less batteries and available “free space” for gas build-up
- UL9540 testing & listing required

New Designs

New Designs

CATL “Rack”



Wartsila Quantum “Cube”

New Designs - Challenges

- Loss of ability to customize to Duke Energy's fire safety specifications
- Liquid cooling and the containment of Glycol
- Fire control networking and ensuring it meets NFPA 72
- Lack of off gas detection – early indicator
- Some designs have no container flooding option
- Alarm level: pod versus container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