



Emerging Environmental/Energy Technologies and Fire Safety

Alison Linburg, MEEA

Sean DeCrane, UL

Mark McKinnon, UL

Michelle Britt, ICC

Beth Tubbs, ICC



Michelle Britt

Director of Energy Programs at the International Code Council. She has more than 15 years of experience impacting building energy use and broader sustainability. She has served national, state and local governments; industry; and non-profits across the U.S. and the Pacific.

Her broad background in land use and transportation planning, and environmental impact analysis brings a holistic approach to her work in building energy. Previously, she was a partner with the Britt/Makela Group and a Senior Research Scientist with the Pacific Northwest National Laboratory. She holds a bachelor's degree in environmental studies and a master's degree in architecture.



Beth Tubbs, PE, FSFPE

Senior Staff Engineer with the International Code Council (ICC) Codes and Standards Development. Active involvement in a wide variety of activities including code development and support and representing ICC in various committees both on a national and international level.

Staff secretariat to the *International Fire Code* and the *International Existing Building Code*. Currently lead staff on the ICC Fire Code Action Committee which has been dealing with topics such as exterior wall finishes/cladding and energy storage systems.

Fellow of the Society of Fire Protection Engineers (SFPE) and member of the Board of Directors for the Society. She holds a professional fire protection engineering license in the Commonwealth of Massachusetts and State of California.

Goal

Better understand the needs and policy drivers
from an environmental/energy perspective

&

Address the fire safety needs for successful
implementation of emerging energy
technologies

Overview

- Explore emerging technologies and environmental drivers
- Present a fire incident to highlight fire safety needs
- Briefly review I-Code energy safety related provisions
- Discuss the need for successful and safe implementation of energy technologies



Alison Lindburg

Alison Lindburg is the Building Energy Policy Manager at MEEA, where she works to improve energy efficiency in buildings in the Midwest via energy codes and market transformation strategies such as energy benchmarking. Prior to MEEA, Alison was the director of the Buildings policy program at the Minnesota non-profit organization Fresh Energy, and also served on the Board of Directors for the U.S. Green Building Council of Minnesota and the Technical Advisory Committee of the GreenStar residential remodeling standard. Previously Alison was a program director for Minnesota non-profit Dovetail Partners, working in rural areas to promote sustainability and local economic development through green building demonstration projects, community education and contractor training. Prior to Dovetail, Alison worked for a Twin-Cities urban development firm, where she helped write and implement its green building program. Alison has a B.A. in Architecture with a focus on sustainable design, and a minor in Spanish from the University of Minnesota, Twin Cities.



Sean DeCrane

Sean DeCrane retired as a 25+ year veteran of the Cleveland Division of Fire. He served in various roles including the Director of Training and Chief of Operations retiring as a Battalion Chief. Sean is currently the Manager of Industry Relations for the Underwriters Laboratories Building Life Safety, Security and Technologies Division. He is responsible for engaging with various industry organizations with a focus on the international fire service including Asia, Australia, Europe and the United Kingdom.

Sean has been involved in the research at Underwriters Laboratories and the National Institute of Standards and Technology. He served on the UL Fire Council and is a member of the UL Fire Fighter Safety Research Institute's Advisory Board.

Chief DeCrane also represented the International Association of Fire Fighters in the International Code Council process and has served on the 2009, 2012, 2015 and 2018 Fire Code Developing Committee and as Chair for 2015 and 2018. Sean served on the NFPA 1 Technical Advisory Panel, NFPA Research Foundation on Tall Wood Buildings and is serving as the Chair of the Fire Test Work Group for the ICC Tall Wood Building Ad Hoc Committee.

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Mark McKinnon

Mark McKinnon has an M.S. in Fire Protection Engineering and a Ph.D. in Mechanical Engineering from the University of Maryland. His research at the University of Maryland focused on the development of a generalized methodology to characterize composite materials for pyrolysis models as well as the development and instrumentation of a bench-scale gasification apparatus to study pyrolysis.

Mark joined UL FSRI in May 2019 from the consulting world, where his work involved fire modeling, performance-based design, fire-related litigation, environmental regulation consulting, material flammability testing, and experimental design. At UL FSRI, Dr. McKinnon has focused on fire model validation, fire fighter line of duty injury investigations and property determination for fire models.

#ICCLEARNLIVE



Energy Storage Solutions – Emerging Issues Discussion

ICC Learn Live
November 9-13, 2020



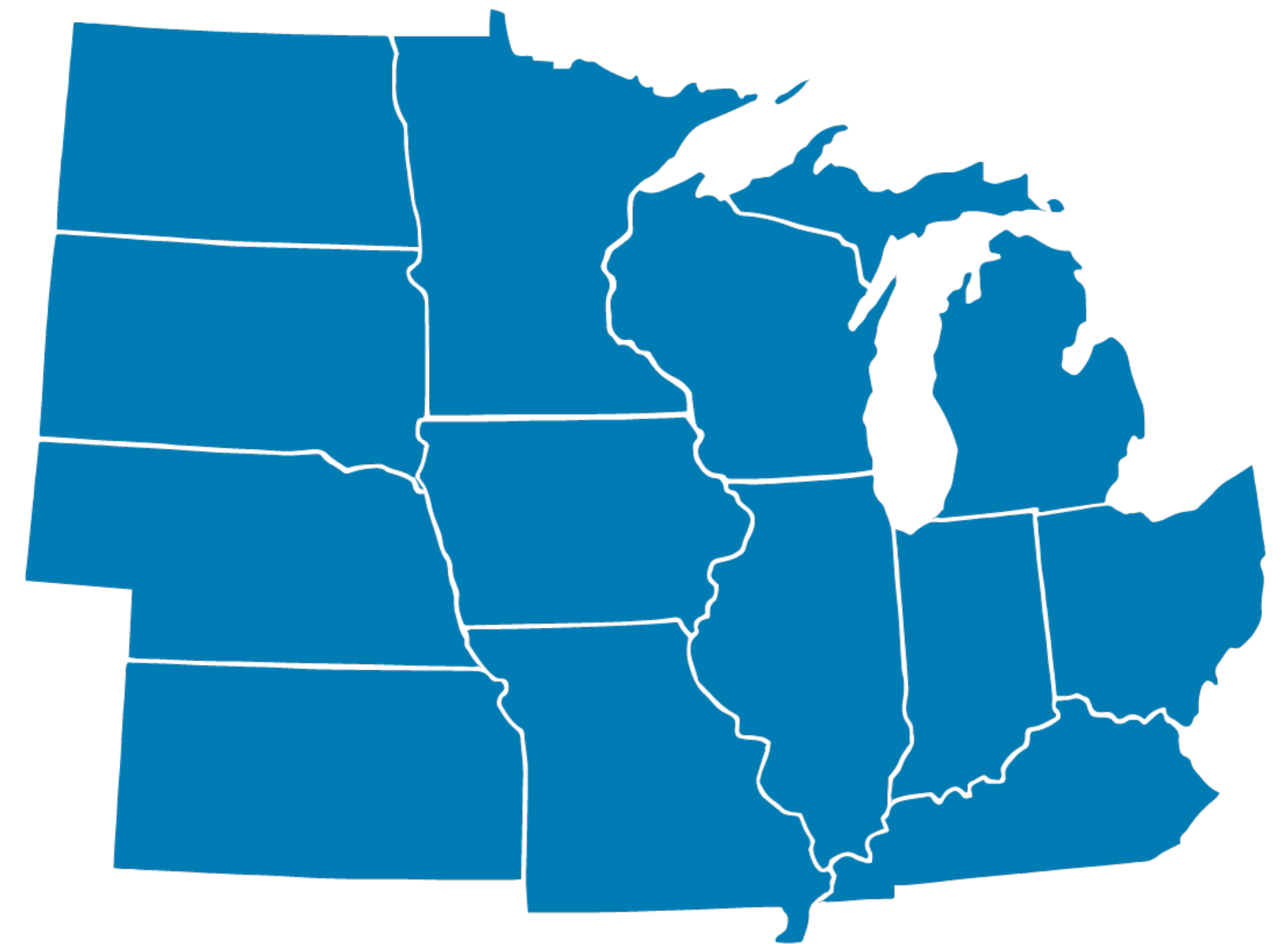
About MEEA

The Trusted Source on Energy Efficiency

We are a nonprofit membership organization with 160+ members, including:

- Utilities
- Research institutions
- State and local governments
- Energy efficiency-related businesses

As the key resource and champion for energy efficiency in the Midwest, MEEA helps a diverse range of stakeholders understand and implement cost-effective energy efficiency strategies that provide economic and environmental benefits.





Alison Lindburg

Building Policy Manager, MEEA

- Works to improve energy efficiency in buildings in the Midwest via energy codes and other energy policies.
- BA in Architecture with a focus on sustainable design, and a minor in Spanish from the University of Minnesota, Twin Cities.
- Has been in building industry for almost 20 years; working on codes and standards for 15 years.
- Past experience as mixed-use commercial project manager, single family general contractor, contractor trainer and educator, and codes and standards technical consultant
- Current member of the Governing Committee for the International Code Council's Sustainability Membership Council

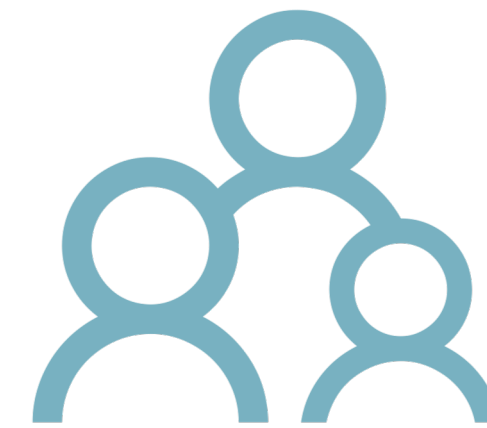


Energy Storage Solutions

Emerging Issues Discussion



Drivers



Policies and Actions



Opportunities for Engagement

Drivers

Increased Energy Storage



Sustainability



Climate Goals and Policies



Grid Resilience



Weather Events/Natural Disasters

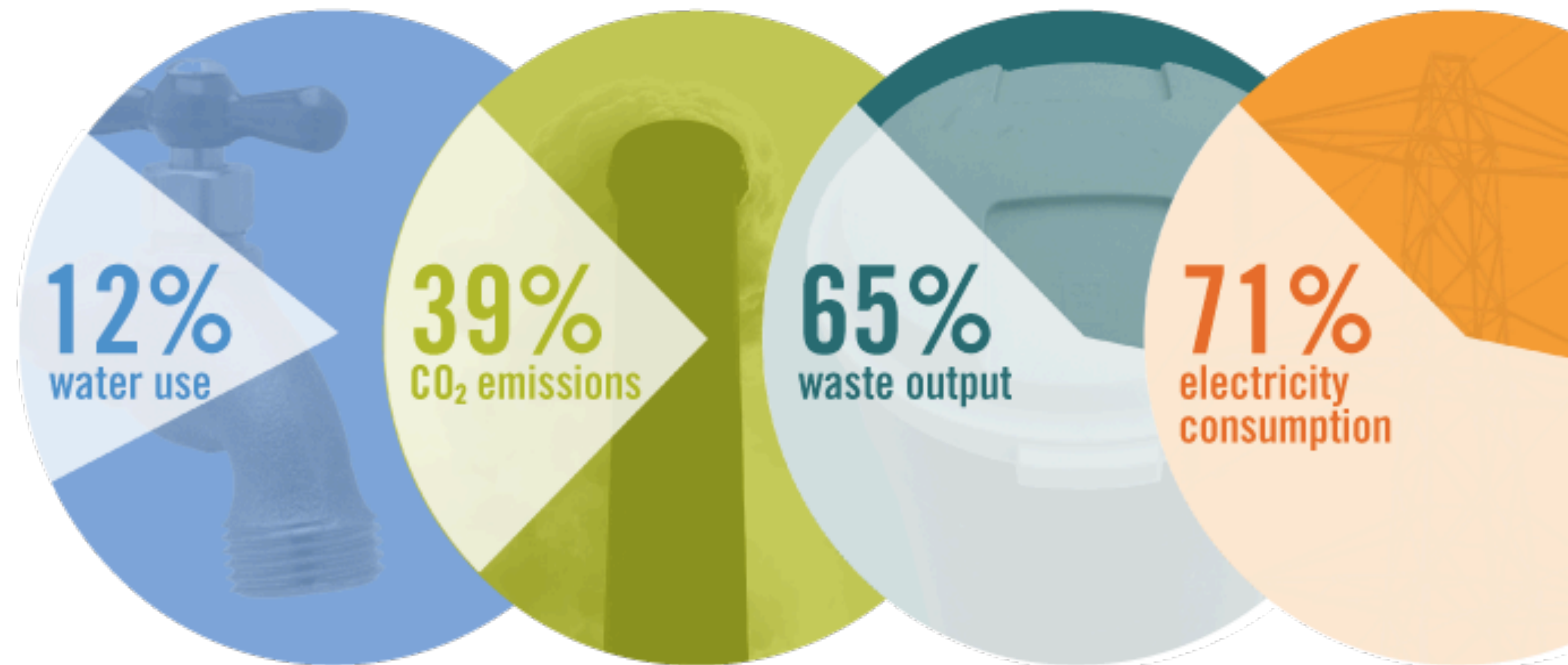


Individual Preference

National Implications by Buildings

US buildings account for major portions of total impact on natural environments

Incremental sustainable improvements will have lasting impacts on global climates and promote safety and resilience



Drivers

Climate Goals



With the US federal government leaving the Paris Climate agreement, state and local jurisdictions have taken the lead on driving sustainable solutions to meeting climate goals.

Policies and Actions

Increased Energy Storage

Code Adoption &
Development

Stretch Codes and
Green Standards

Renewable Energy
Portfolio
Standards; more
renewables

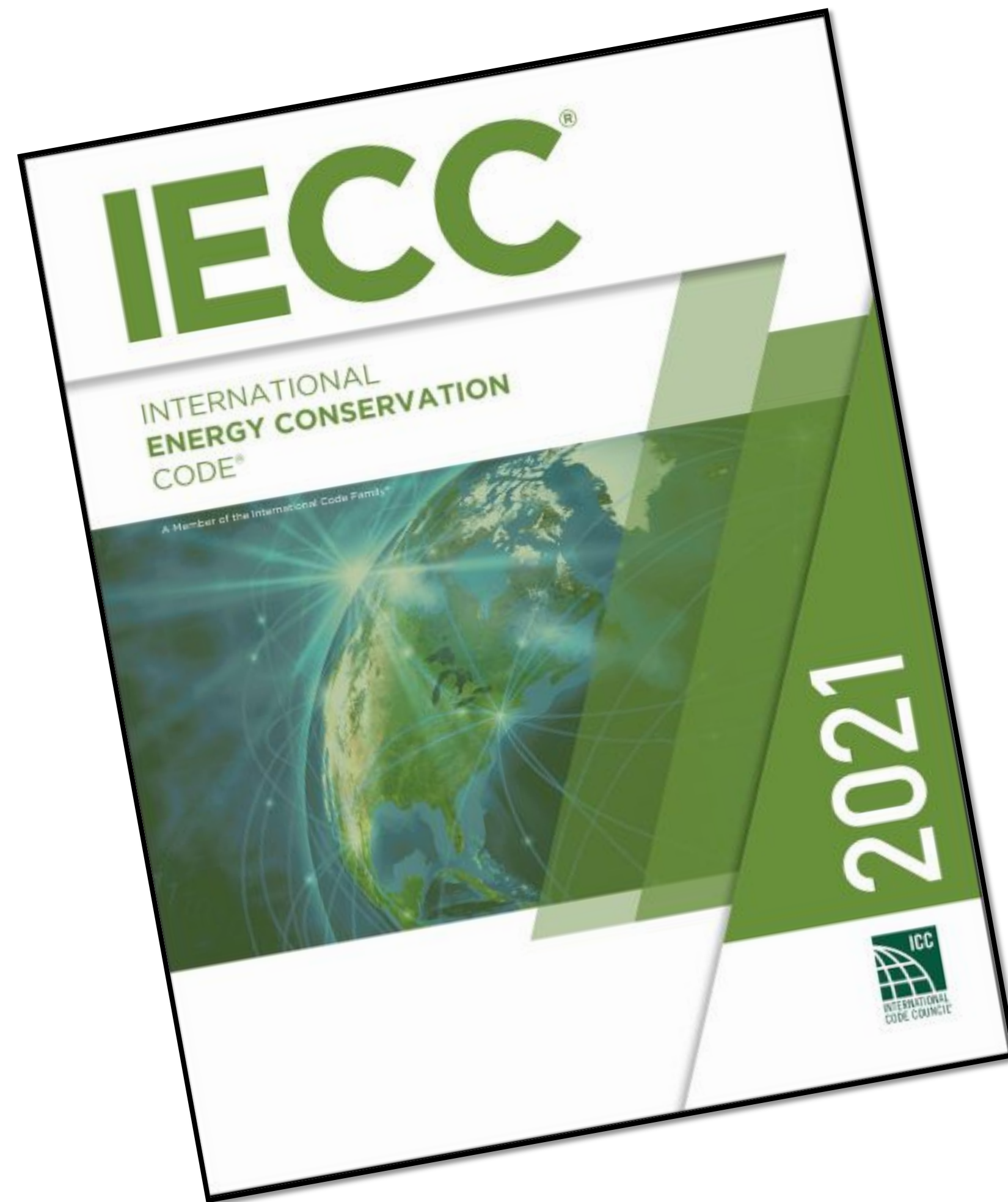
Building
Performance
Standards

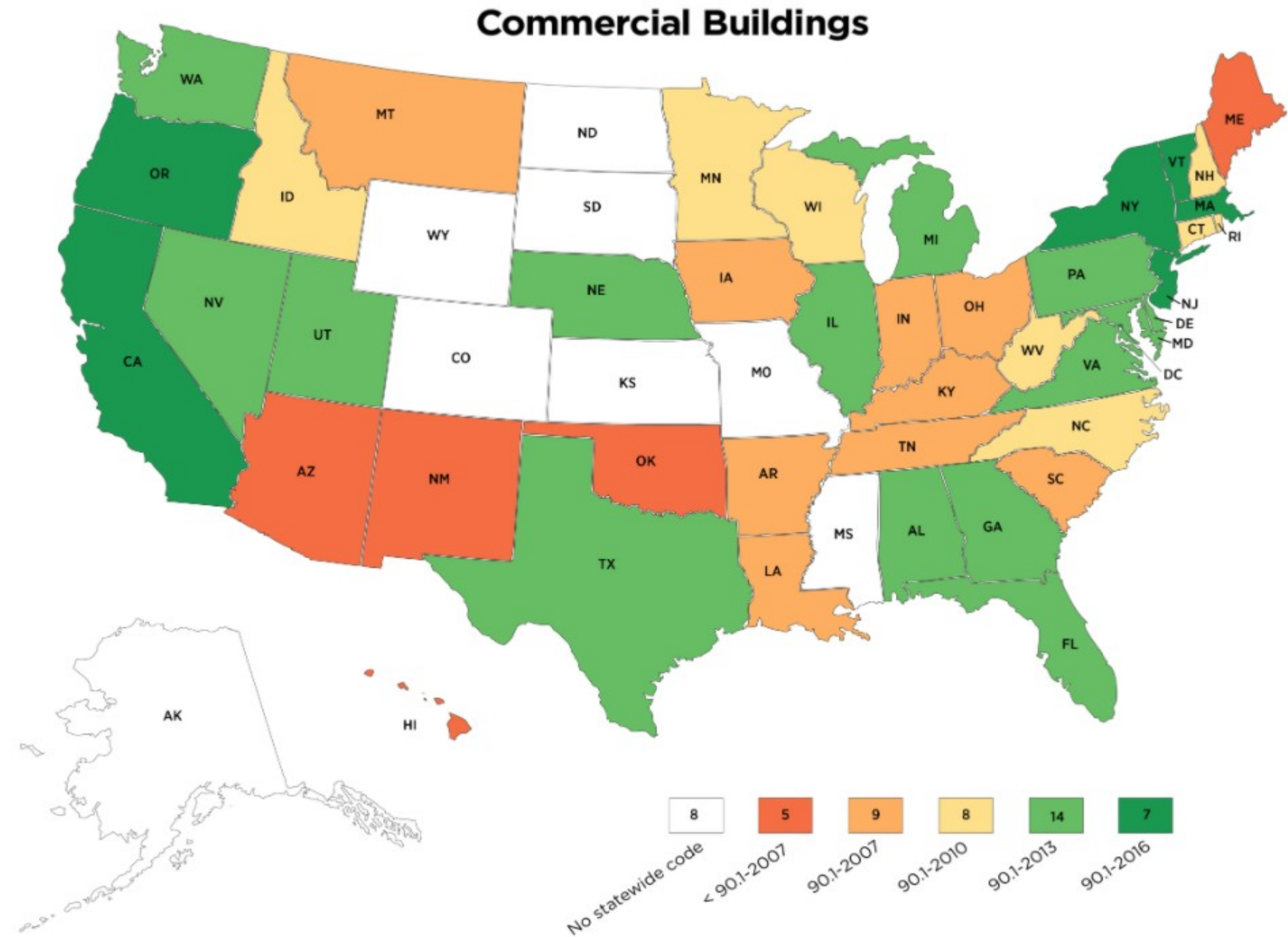
Increased
Electrification
Efforts

Increased Grid
Resiliency Efforts

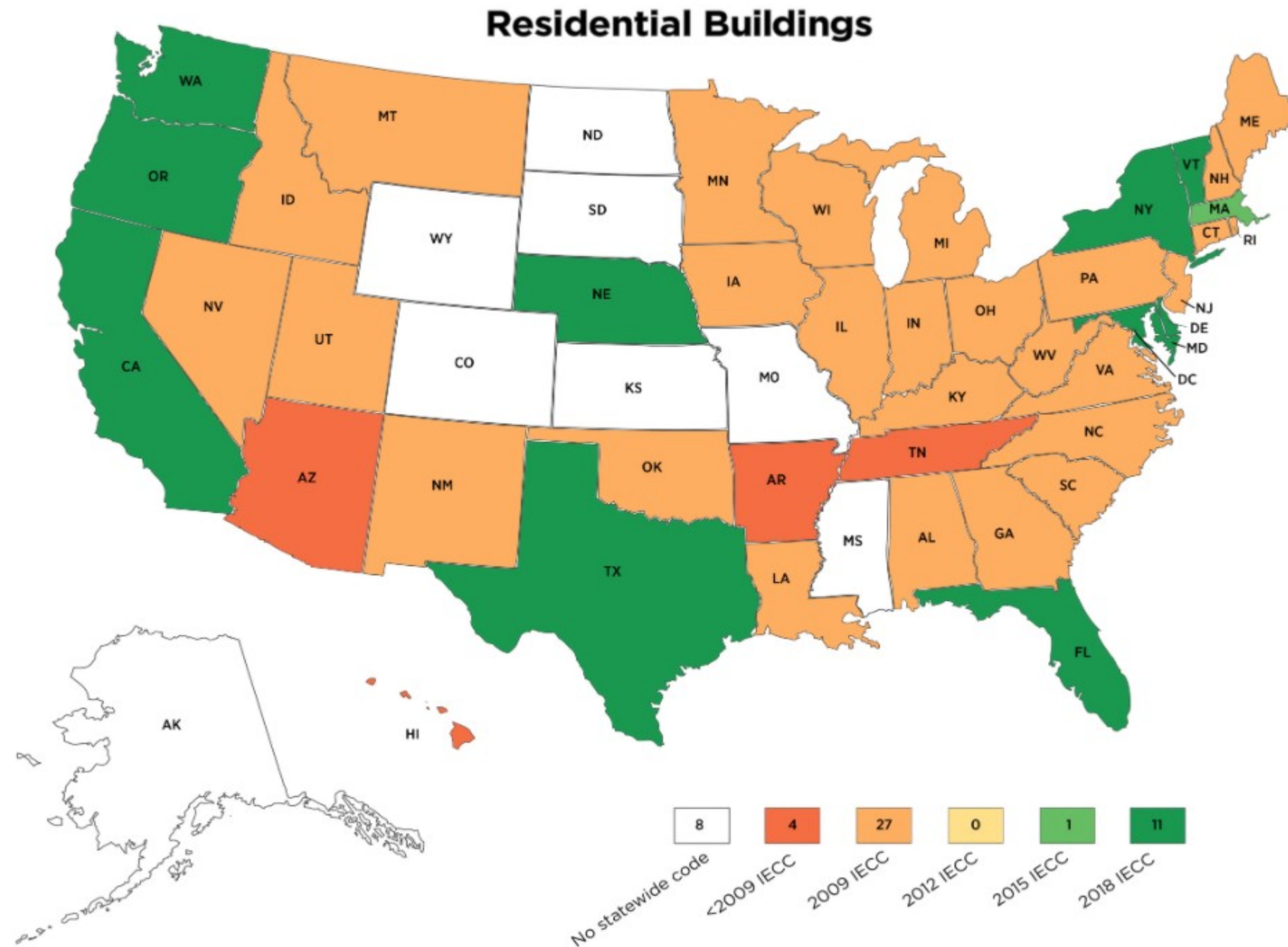
Policies and Actions

Increased Energy Storage





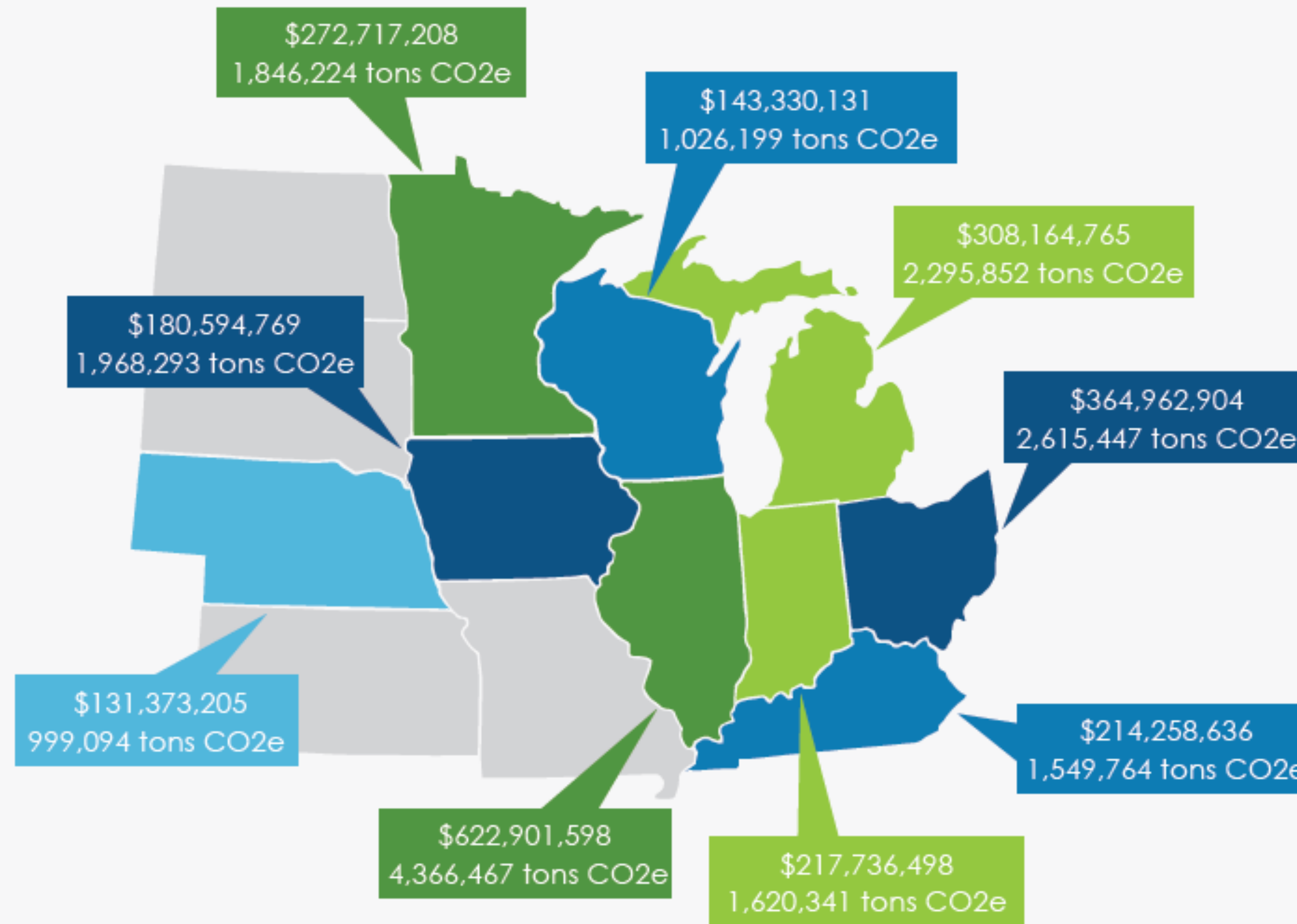
Map showing energy equivalent of commercial energy code adoption.
Source: US Dept of Energy



Map showing energy equivalent of residential energy code adoption.
Source: US Dept of Energy

Building Energy Code Impacts in the Midwest

Cumulative Savings 2009-2018



Thanks to building energy codes, Midwest states saved:

Consumer Energy Savings
\$2,456,039,714

Total Energy Savings (MMBTU)
156,963,199

Total CO₂e Savings (Tons)
18,287,683

That's enough savings to:

Pay for **63,628** students
to attend 4 years of college



Build **18,893** miles
of new bike lanes



Buy **35,086** Tesla
Model S electric cars



In CO₂ equivalent, that's like:



Powering
1,792,732 homes



Installing **4,202**
new wind turbines



Removing **3,552,529**
cars from the road

Efficiency Improvements of IECC: Historic and Projected

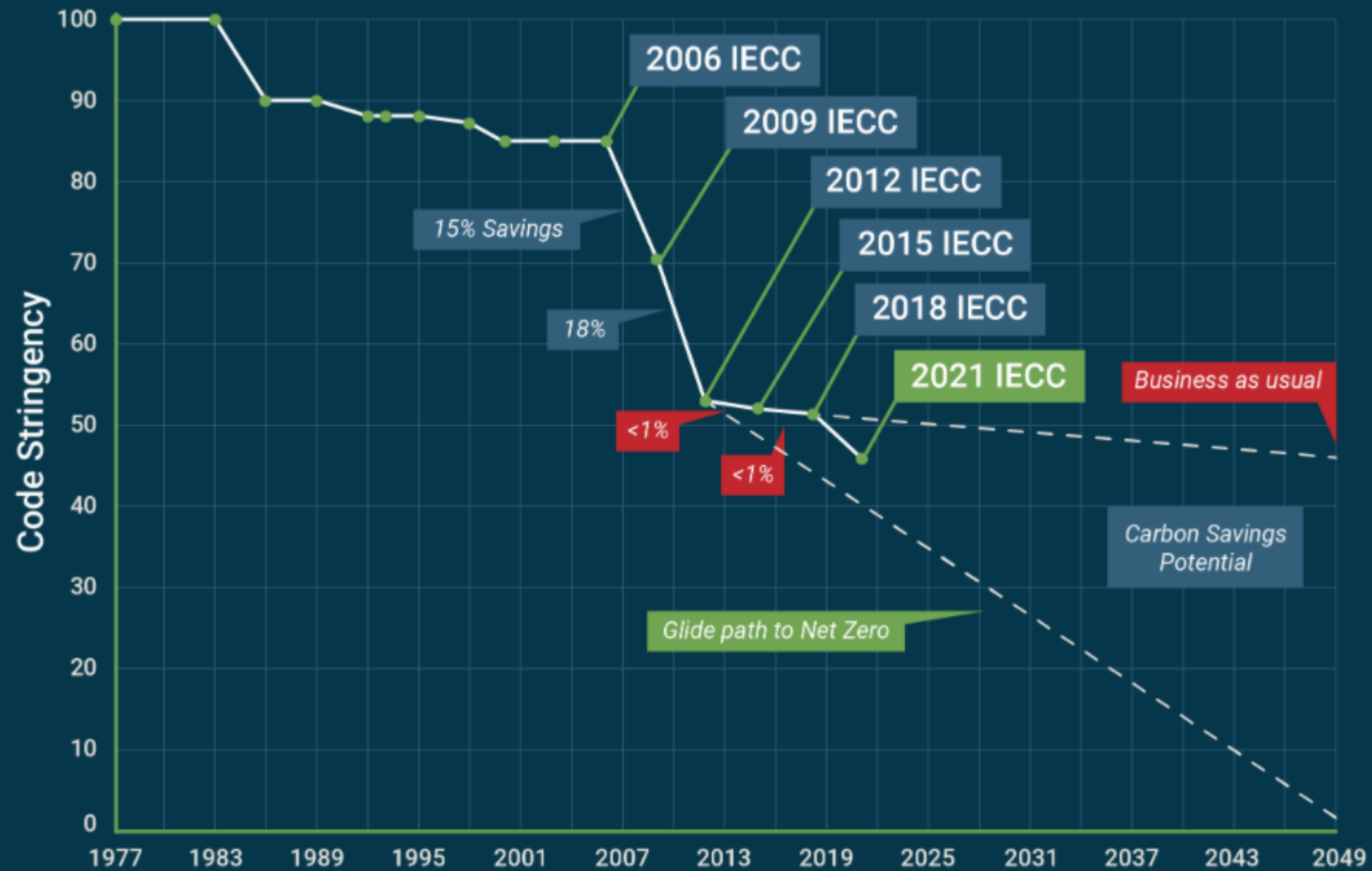


Image Source: Energy Efficient Codes Coalition

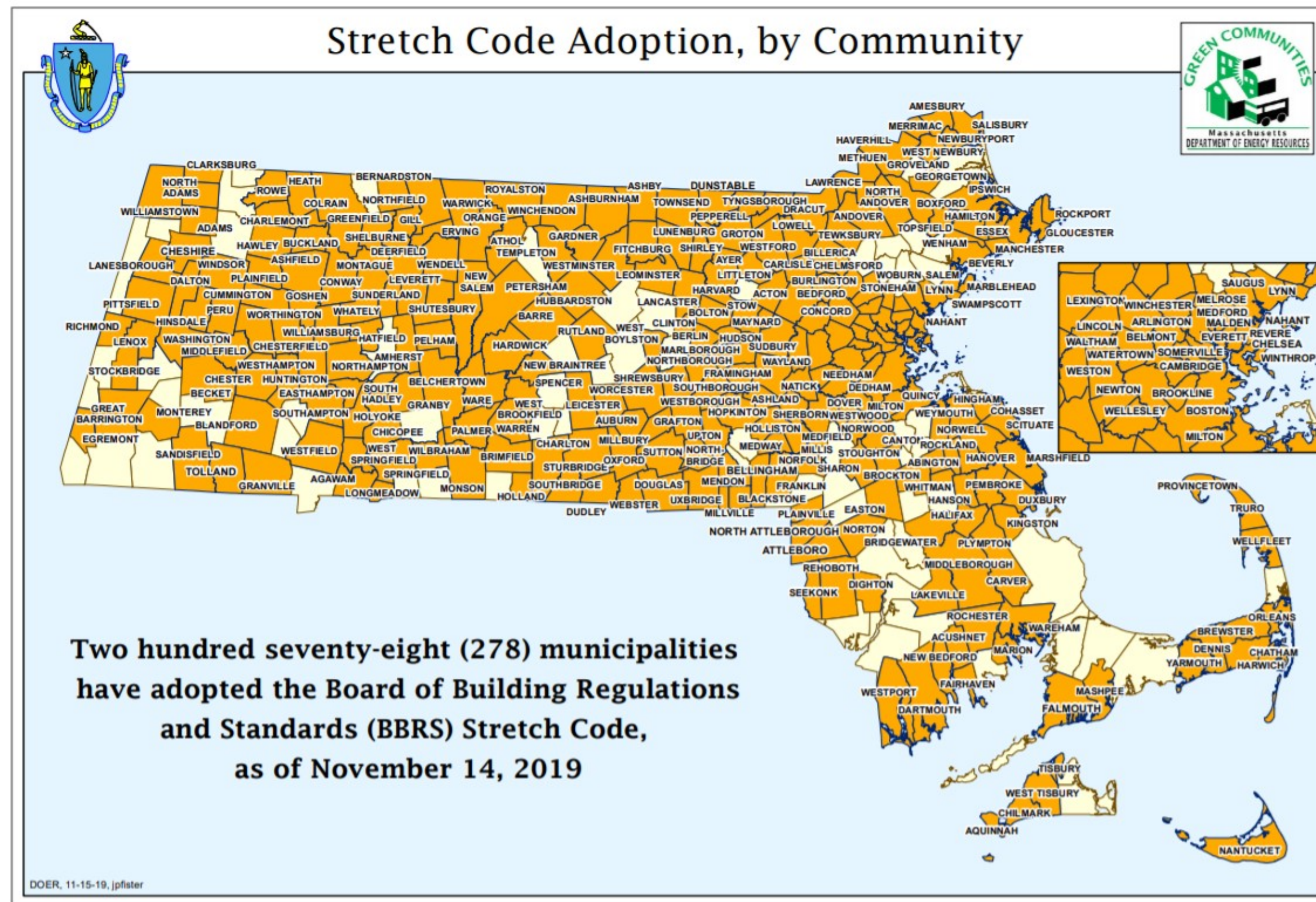
Stretch Codes

What and Why

A stretch code, also known as a “reach code”, is a locally mandated code or alternative compliance path that defines a higher level of energy efficiency or sustainability than the adopted base code. A good way to envision a stretch code is as the future base code.

- Gives municipalities who want the ability to take meaningful action on energy use and climate change an alternative mandatory compliance path that promotes energy efficiency beyond the available code options,
- Provides significant cost savings for residents and businesses,
- Implement cutting-edge technologies and processes, and
- Help gain market acceptance of the adoption of more energy efficient codes or sustainability practices in the future.

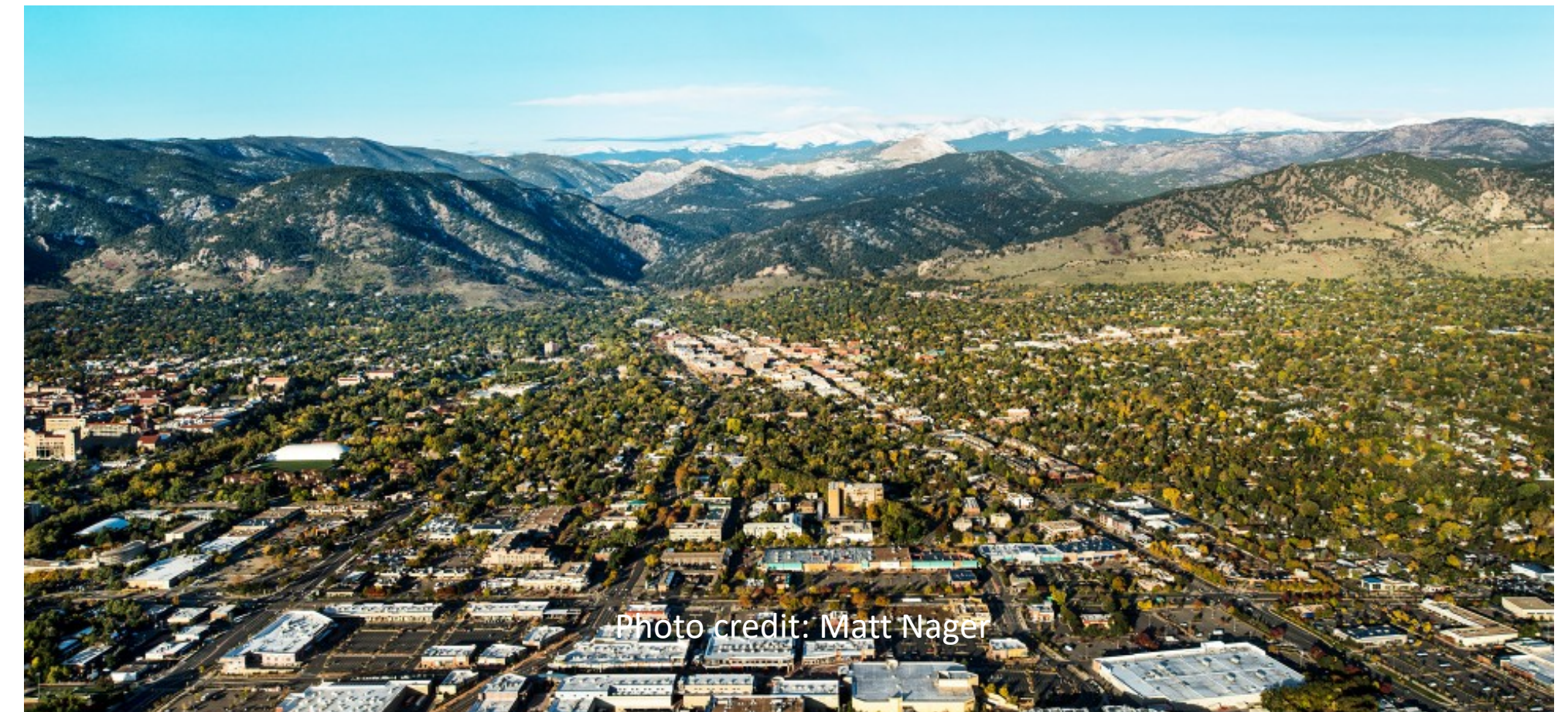
Stretch Energy Code - Massachusetts



- 2009 - First state to adopt an above-code policy using an informative appendix to its state code.
- New residential construction must achieve a HERS rating of 55
- The updated stretch code also applies to new commercial buildings over 100,000 square feet.
- As of Nov 2019, 278 jurisdictions have adopted the stretch code – more than half of the state by population.

Sustainable Code Example – Boulder, CO

- Baseline: IECC 2018/ASHRAE 90.1-2016
- Efficiency: 20% better than model code
- Residential: sliding scale of ERI/HERS 50 or better; > 3,000 sq. ft. houses are required to be Net Zero Energy (NZE)
- Commercial: At least 5% of building energy use must be supplied by on-site renewables
- Previous additional "green points" of EV-ready and PV-ready are now required by code for res & com.
- Pilot: outcome-based code



The City of Boulder has set a goal of reaching net zero energy (NZE) construction through building and energy codes by 2031

What is a BPS?

Building Performance Standards

Building Performance Standard ordinances are a municipal tool to equitably reduce energy costs in **existing** buildings while creating jobs in the efficient and clean energy economy.

- Set **energy** use or **carbon** (ghg) emissions thresholds for commercial buildings within a jurisdiction.
- Property owners report actual energy consumption of their buildings on a set cadence (e.g. biennial) or upon certain triggers (e.g. sale or lease of property).

Building Performance Standards

- Washington, DC.
- New York City
- St. Louis, MO
- Boulder, CO
- Washington state



Building Performance Standard

Washington, D.C.

- “Clean Energy DC”
- Went into effect 3-22-19
- 2021: Privately-owned buildings 50,000 square feet and District-owned properties 10,000 and above
- 2027: Privately-owned buildings between 25,000 and 49,999 sq. ft.
- 2033: Privately-owned buildings between 10,000 and 24,999 sq. ft.
- 5 years to comply with targets

Building Performance Standard

New York City

- “Climate Mobilization Act”
- Enacted 5/19/19
- Carbon intensity limits
- 2024-2029: 20% highest GHG intensity buildings
- 2030-2034: 75% highest GHG intensity buildings
- Intensity limits will fall in 2030, 2035, 2040 and by 2050

Opportunities for Engagement

Policy mandate or
normal state
adoption process

Municipal policy
adoption

Training and
stakeholder
engagement

Codes/Standards
development
process

Criteria to meet
project goals or
public funding
goals

Compliance and
implementation

Questions?

Contact

Alison Lindburg

alindburg@mwalliance.org



Case Study – Fire Safety Concerns

Surprise, AZ ESS Incident

November 12, 2020 | ICC Emerging Environmental and Energy Technologies and Fire Safety



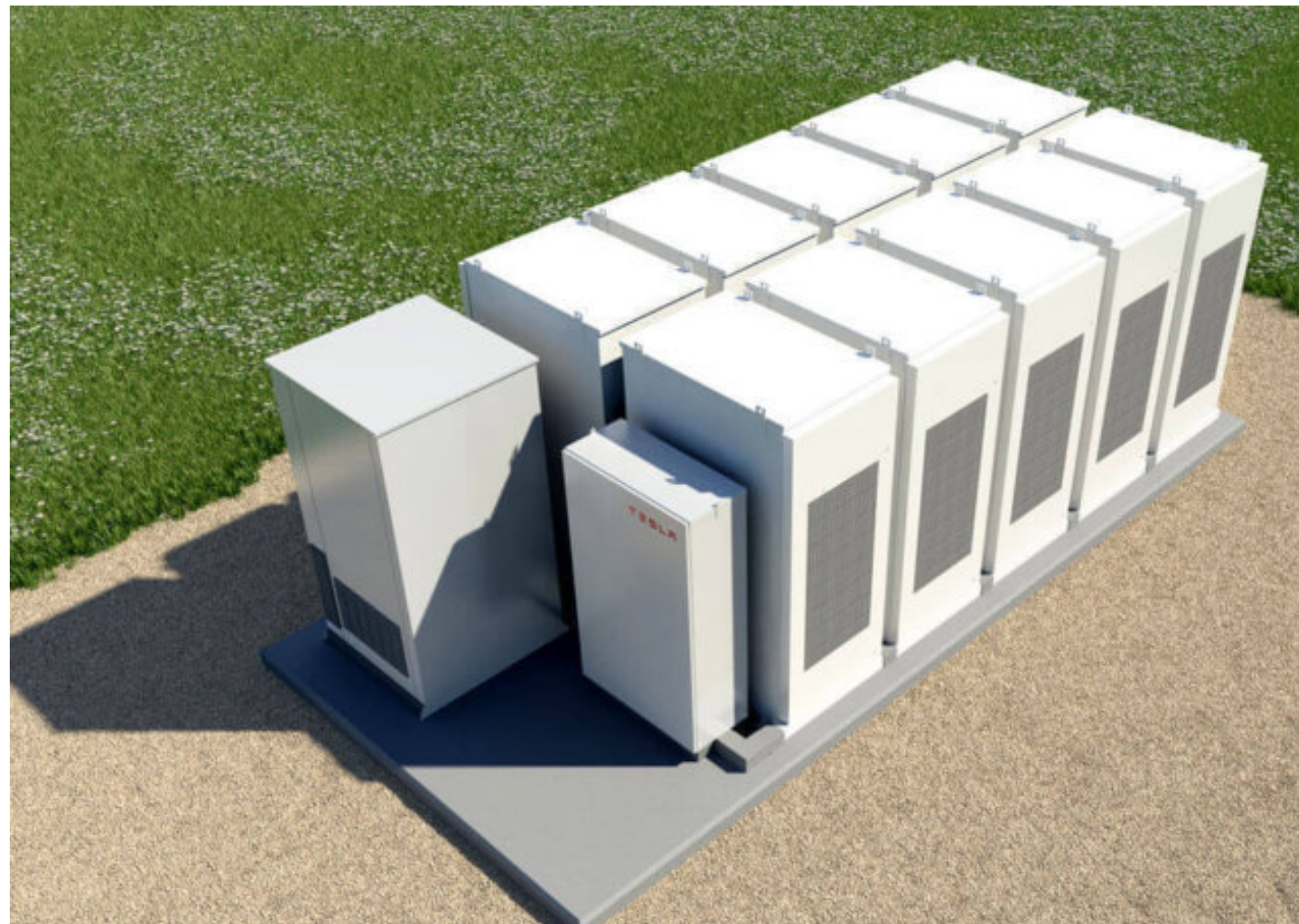
WHY ENERGY STORAGE?



- Grid Balancing and Load Leveling
- Increase Reliability
- Economic Incentives

LITHIUM-ION BATTERIES

- Excellent Energy Density
- The Current Battery of Choice
- Batteries and Systems are Readily Available
- Approximately 90% of ESS Market is Li-ion



Surprise, AZ ESS Incident



Background

2 MW/2.16 MWh Lithium-Ion Battery ESS

- Average home in AZ consumes 1 MWh/month
- ESS owned by local electric utility (APS)
- Batteries manufactured by LG Chem
- ESS designed by integrator (Fluence)
- ESS maintained by contractors to the integrator (Sturgeon)

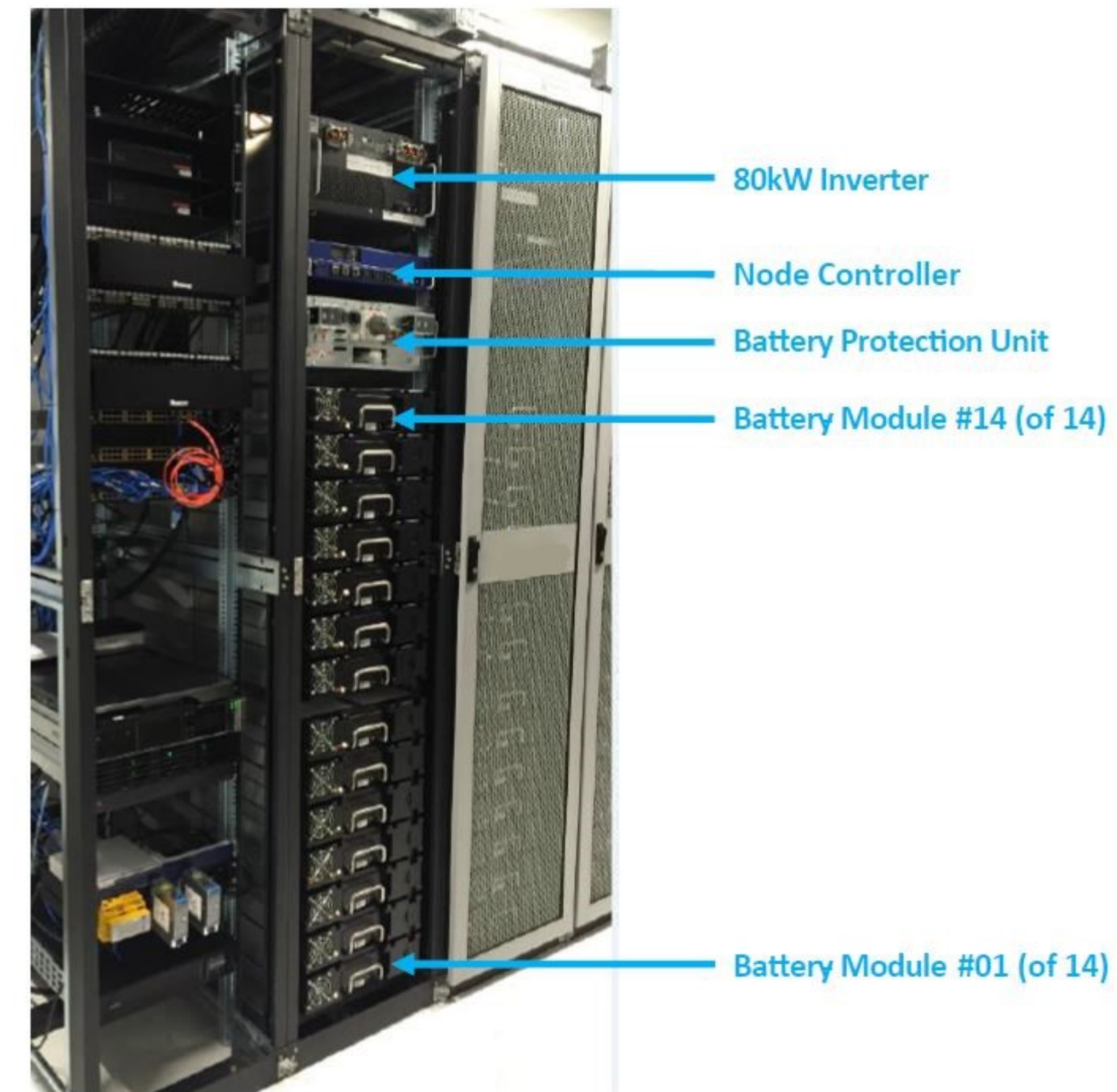
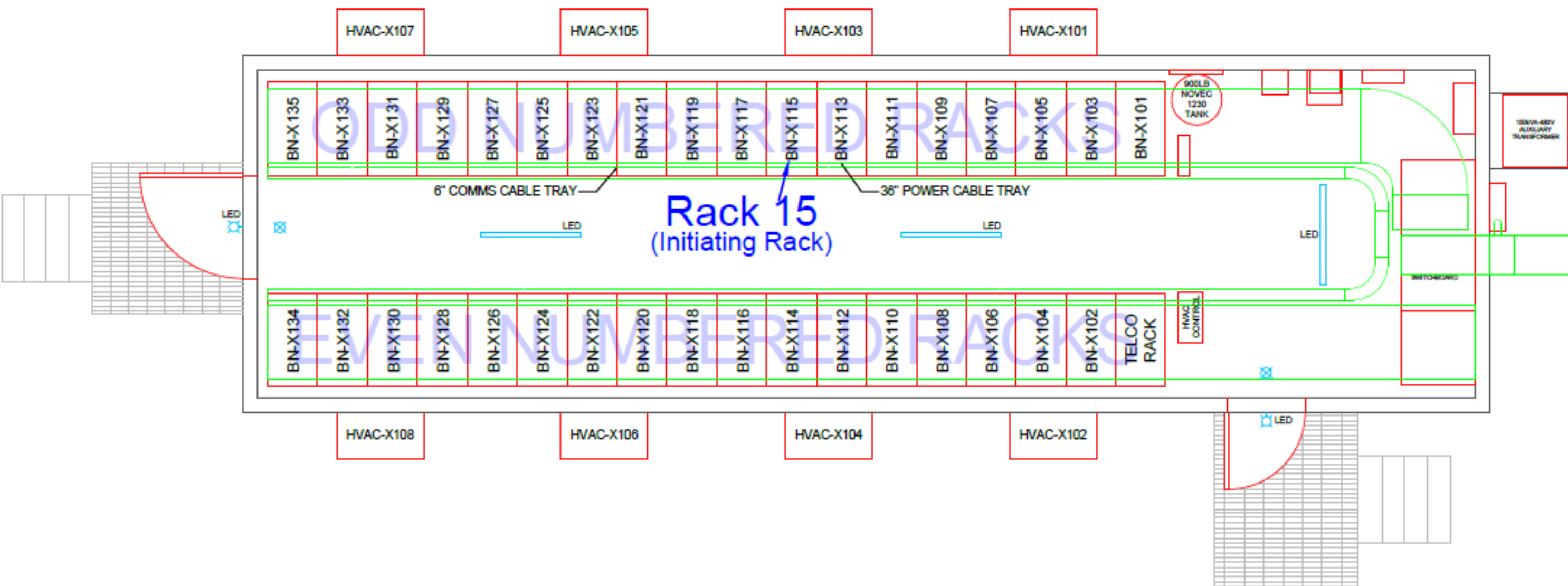
Four firefighters (Peoria HAZMAT team) seriously injured

Four firefighters (Surprise E304) held overnight for suspected exposure to HCN



Energy Storage System

- 27 Racks of battery modules
- 14 modules per rack
- 28 lithium-ion NMC pouch cells per module (2P14S)
- 10,584 cells total
- 8 HVAC Units ($75^{\circ}\text{F} \pm 5^{\circ}\text{F}$)
- VESDA smoke detector system
- Novec 1230 total flooding clean agent suppression

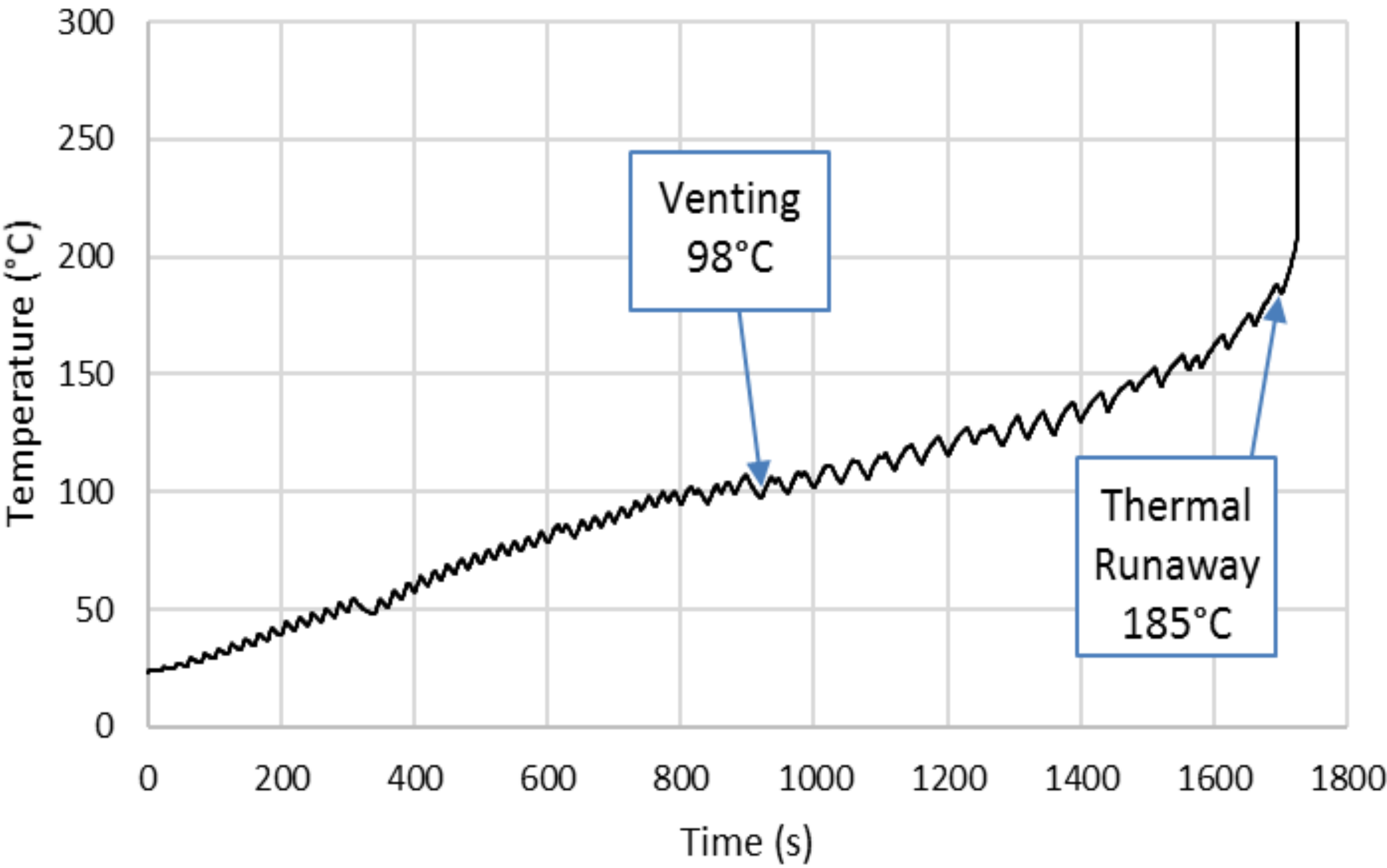


CELL LEVEL MOCKUP TEST



CELL LEVEL MOCKUP TEST

Example of generic li-ion cell heated to thermal runaway.
Cell venting and thermal runaway temperature are documented.



Gas	Composition (Vol %)
CO	36.2
CO ₂	22.1
H ₂	31.7
Hydrocarbons	~10%

Lower Flammability Limit: ~8.5%
Burning Velocity: 35 cm/sec





16:54:30 – Minimum battery cell voltage in Rack 15 began to decrease

16:54:44 – Air temperature measurements started to rapidly increase

16:55:20 – VESDA smoke detector registered an alarm condition

- All breakers and contactors opened

16:55:38 – Air temperature measurements peaked at 121.6°F

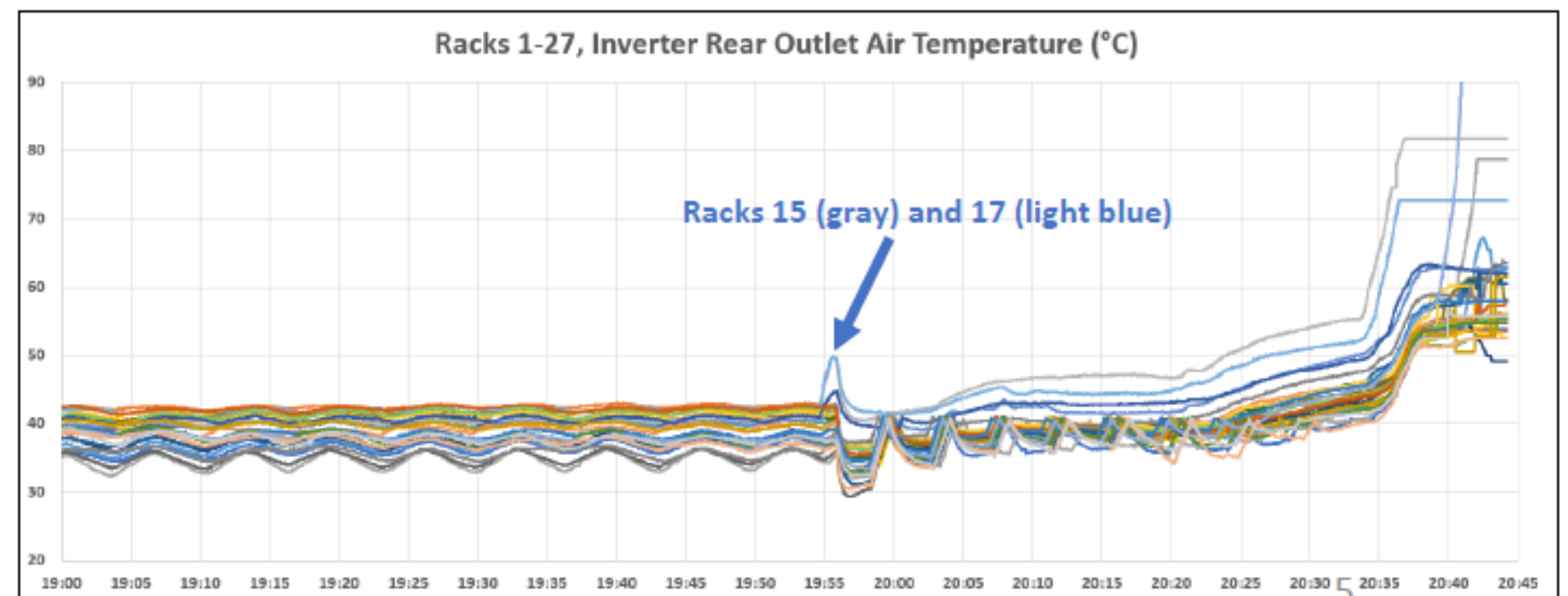
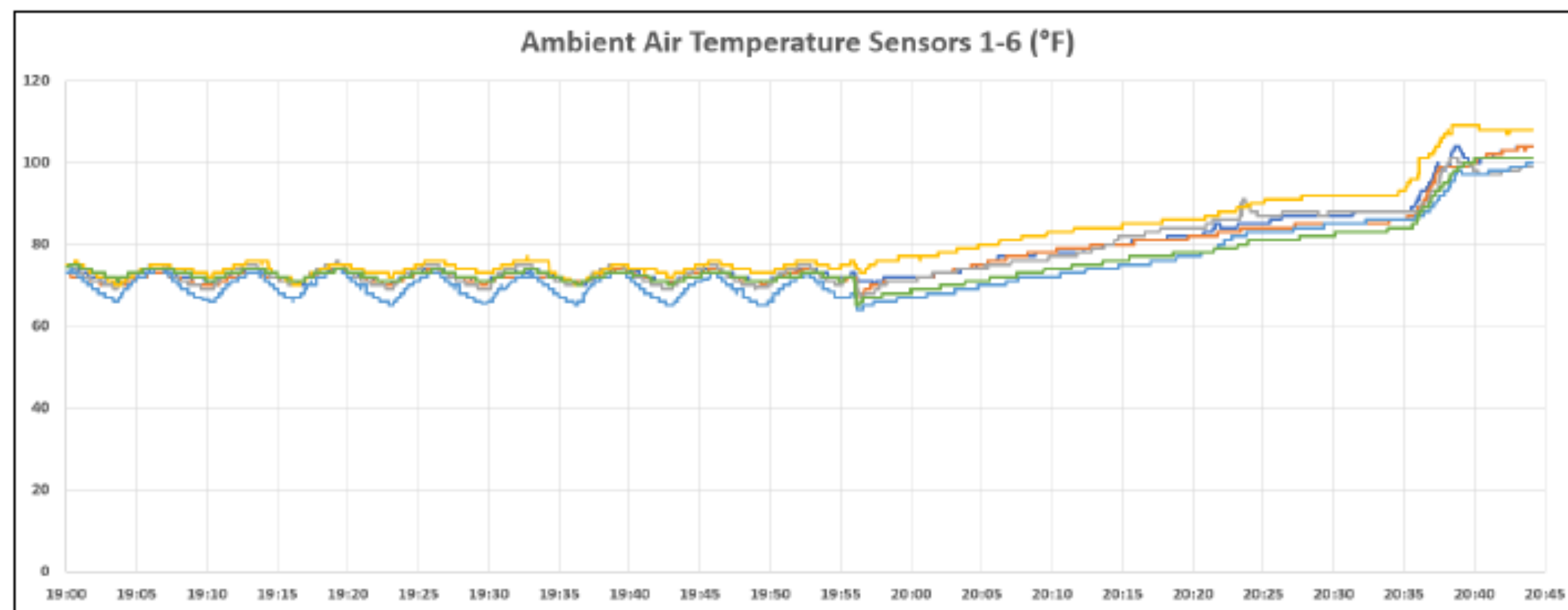
16:55:50 – Suppression system discharged

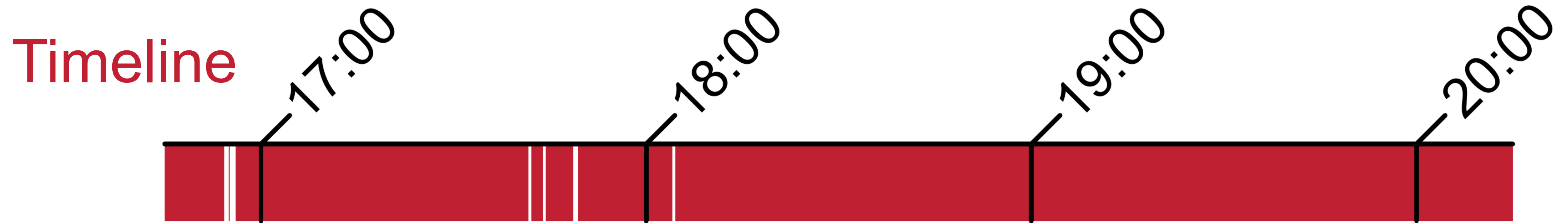


17:41:54 – Phoenix Metro dispatch received a call for smoke and a bad smell near an electric substation and Surprise FD E304, BR304, and T304 were dispatched

17:44:08 – All communication from the ESS was lost

- Air and module temperatures reported prior to 17:44:08

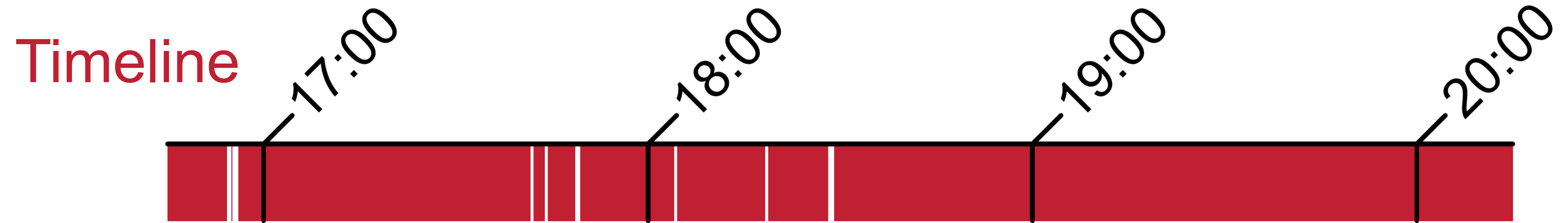




17:48:52 – 17:49:12 – Surprise FD E304, BR304, and T304 arrived on the scene

18:04:21 – E304 Capt elevated to HAZMAT operation – Peoria FD E193 HAZMAT team dispatched to call.

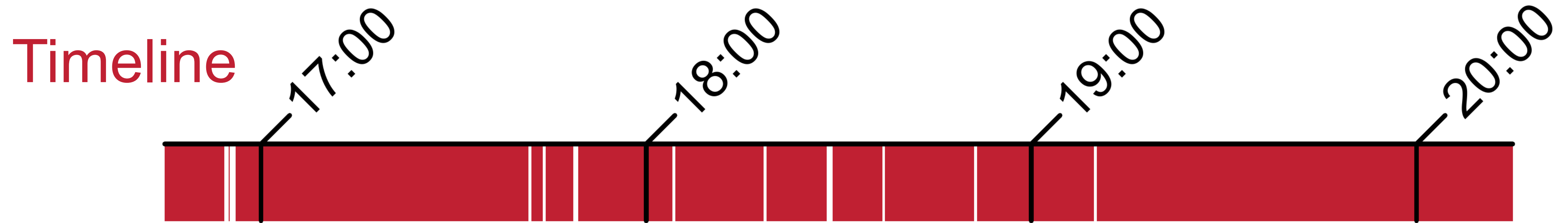




18:18:30 – Surprise BC 301 arrived on the scene

18:28:21 – Peoria FD E193 and HM193 arrived on the scene



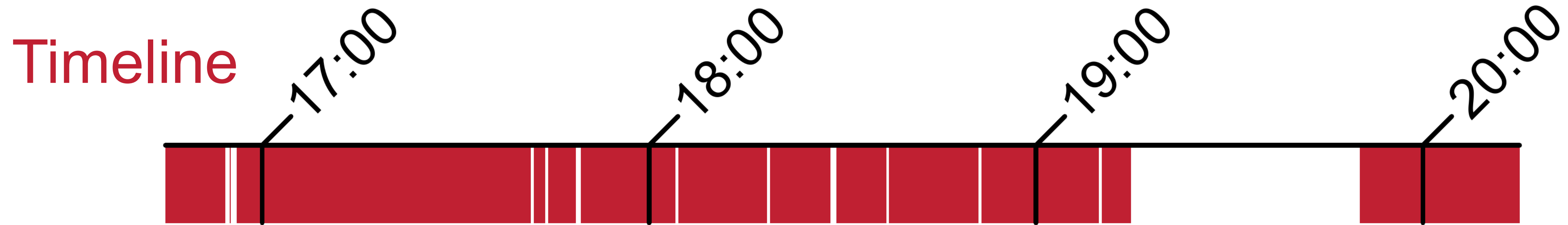


18:37:00 – HAZMAT team conducted 360-degree size-up and defined hot zone

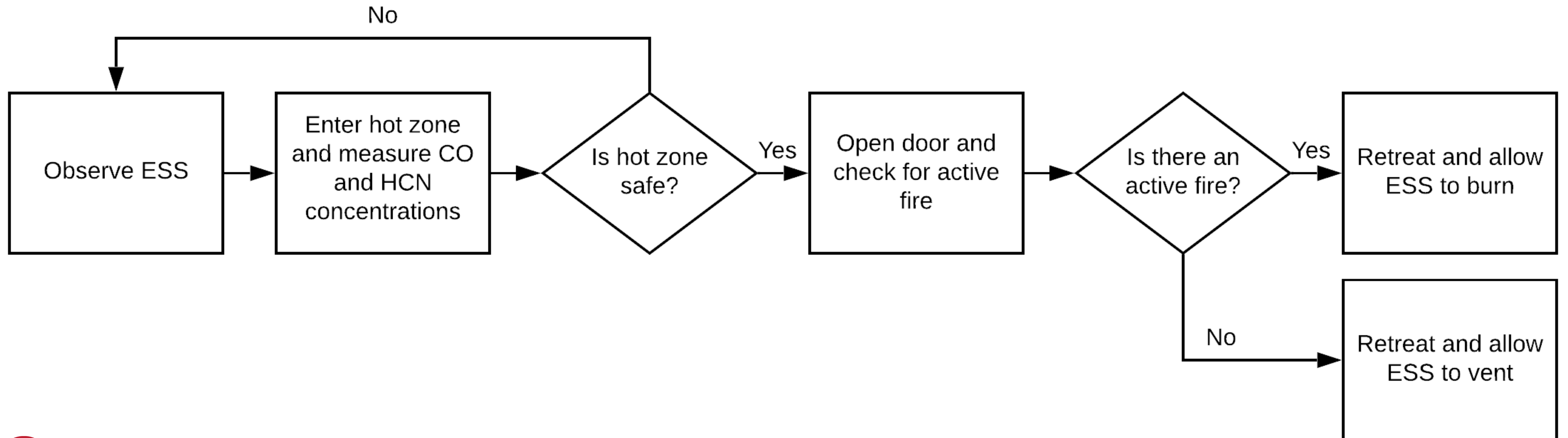
18:51:21 – HAZMAT team made second entry into hot zone

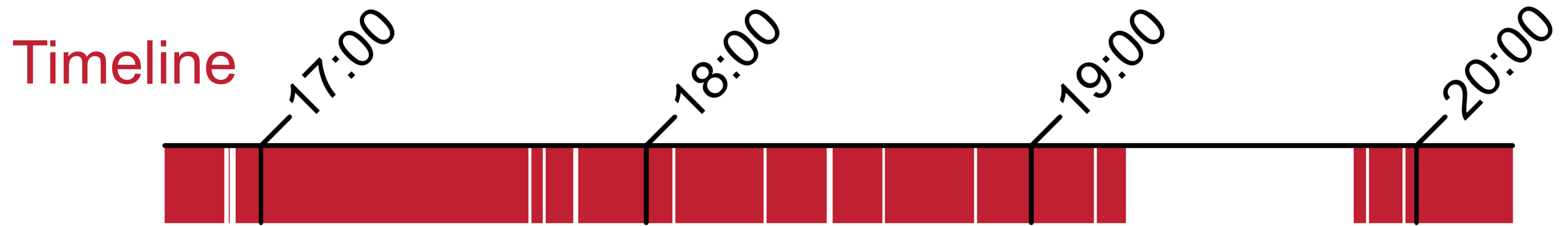
19:10:00 – HAZMAT team made third entry into hot zone





19:15 – 19:50 – HAZMAT team conferenced with senior fire department officers and developed a plan to render the ESS and hot zone safe





19:50 – The visible gas/vapor mixture was no longer leaking out of the ESS

19:52:24 – HAZMAT team made final entry into the fenced area around the ESS

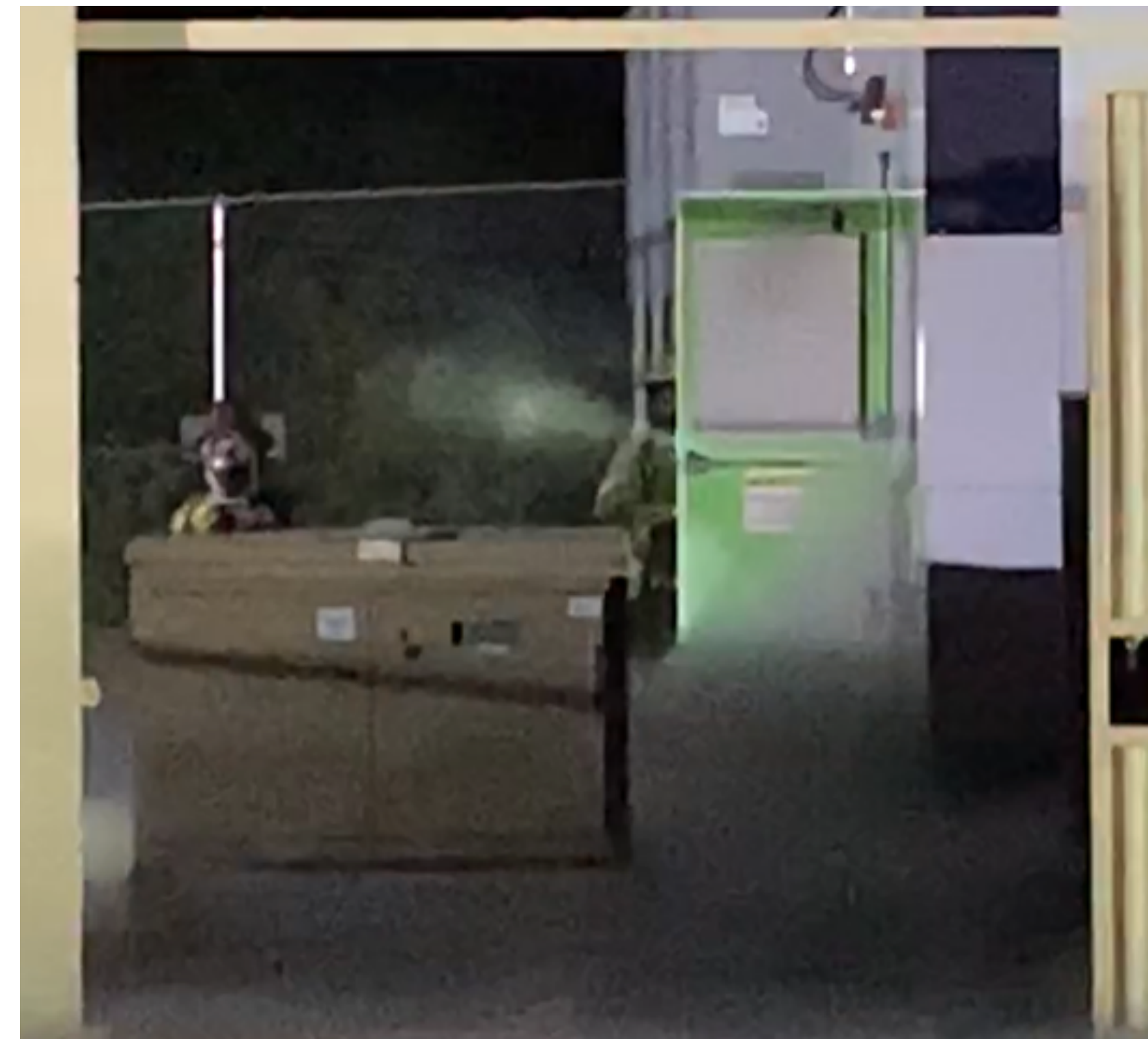
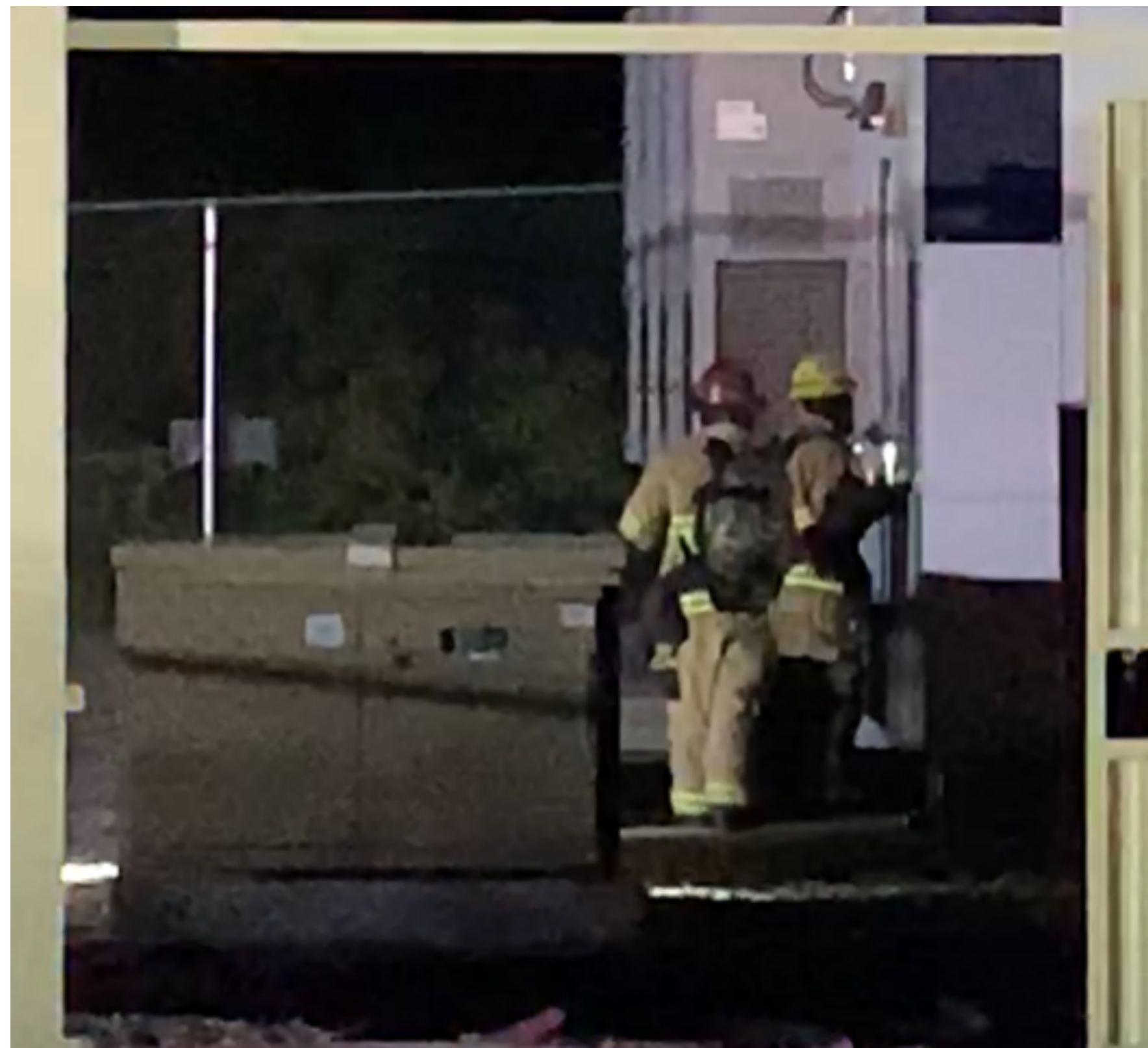
19:58:03 – HAZMAT team pulled hoseline to ESS to prepare to open door





20:00:54 – HAZMAT team opened the door to the ESS

20:03:49 – Mayday call





Contributing Factors

- The ESS did not include sensors that provided information about the presence of flammable gases.
- There was no way for the HAZMAT team to monitor toxic gas concentrations, LEL, or any other conditions inside the ESS from a physically secure location.

Recommendations

- Lithium-ion ESSs should incorporate gas monitoring that may be accessed remotely.
- Research that includes multi-scale testing should be conducted to evaluate the effectiveness and limitations of stationary gas monitoring systems for lithium-ion battery ESSs.



Contributing Factors

- The emergency response plan was not provided to the responding fire service personnel prior to the incident.
- The emergency response plan that was provided was inadequate.

Recommendations

- Owners and operators of ESS should developed an emergency operations plan in conjunction with local fire service personnel and the AHJ and hold a comprehensive understanding of the hazards associated with lithium-ion battery technology.
- Signage that identifies the contents of an ESS should be required on all ESS installations to alert fire responders to the potential hazards associated with the installation.



Contributing Factors

- The ESS did not have deflagration venting panels (NFPA 68) or adequate ventilation to prevent accumulation of flammable gases (NFPA 69).
- The total flooding clean agent suppression system likely contributed to the deflagration.

Recommendations

- Lithium-ion battery ESSs should incorporate adequate explosion prevention protection as required by consensus standards in coordination with the emergency operations plan.
- Research that includes full-scale testing should be conducted to determine the most effective fire suppression and explosion prevention systems for lithium-ion battery ESSs.



UL 9540A TEST STANDARD

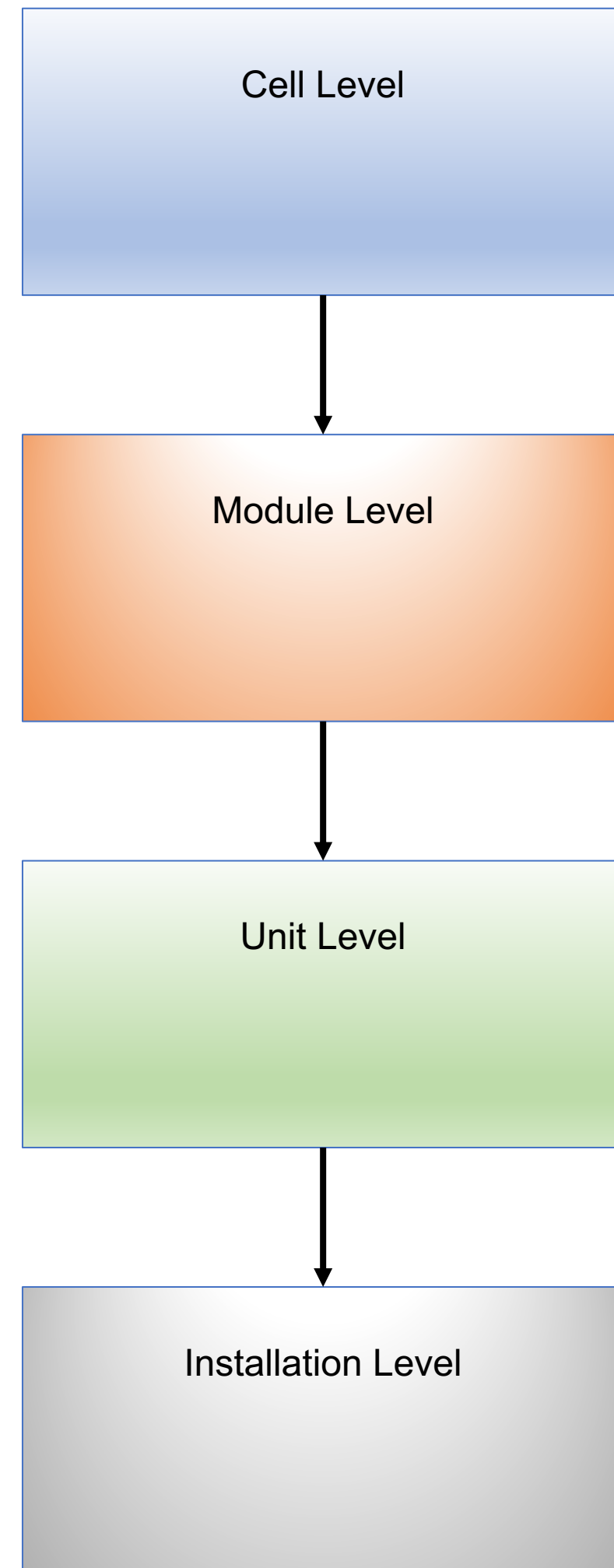
Scope

Evaluate fire characteristics of a battery energy storage system that undergoes thermal runaway. Data generated will be used to determine the fire and explosion protection required for an installation of a battery energy storage system.

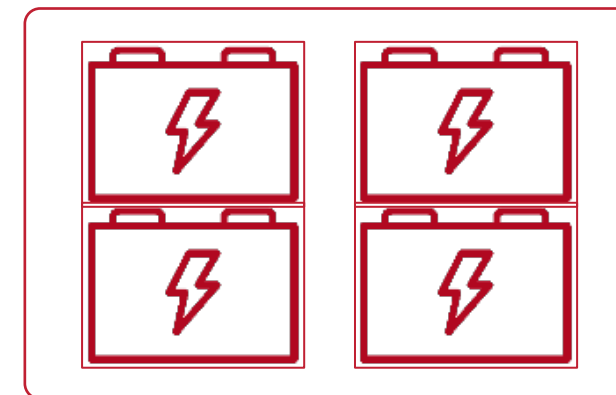
Match Fire Protection of Installation to
Performance of BESS



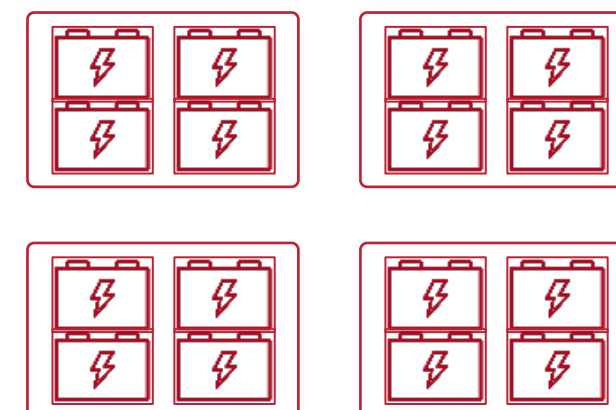
UL 9540A TEST METHODOLOGY



- Whether cell can exhibit thermal runaway
- Thermal runaway characteristics
- Gas composition



- Propensity for propagation of thermal runaway
- Heat and gas release rates
- Deflagration hazards

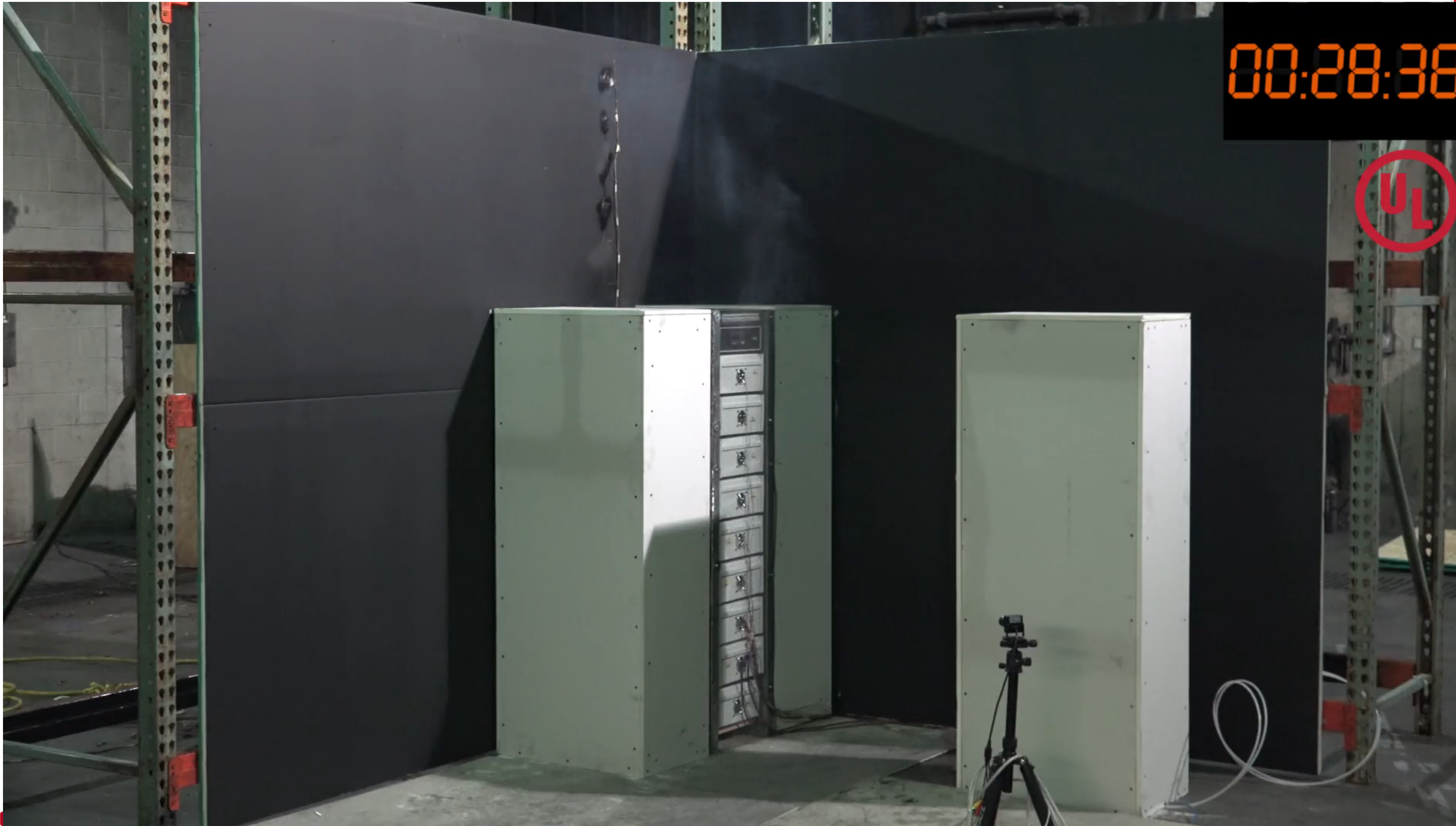
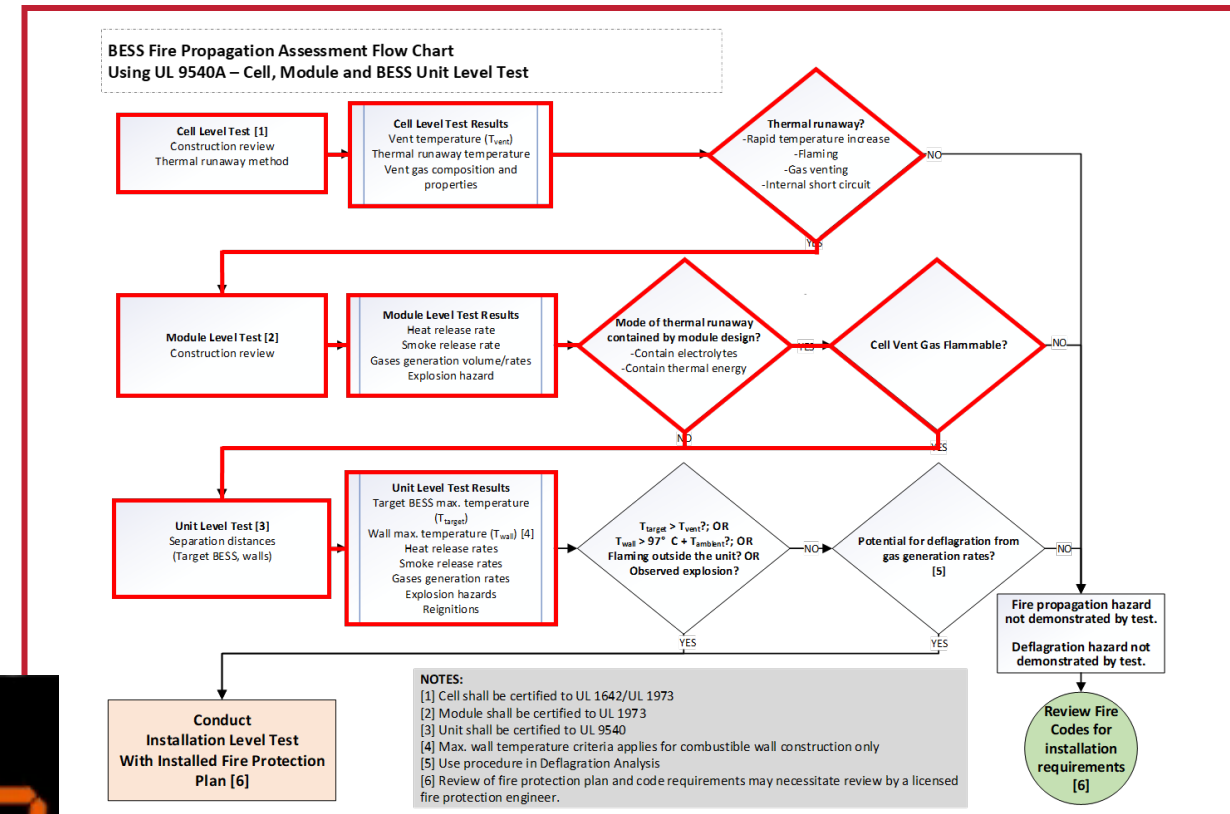


- Evaluation of fire spread
- Heat and gas release rates (severity/duration)
- Deflagration hazards
- Re-ignition hazards



- Effectiveness of fire protection system(s) to mitigate fire propagation
- Deflagration hazards
- Re-ignition hazards

UNIT LEVEL TEST



2021 IFC New Requirements (1207.2)

Commissioning, decommissioning, operation and maintenance

Commissioning required for new ESS, retrofit ESS, or ESS returning to service

Approved commissioning plan required that includes a decommissioning plan

Large scale fire test

Shall be conducted in accordance with UL 9540A





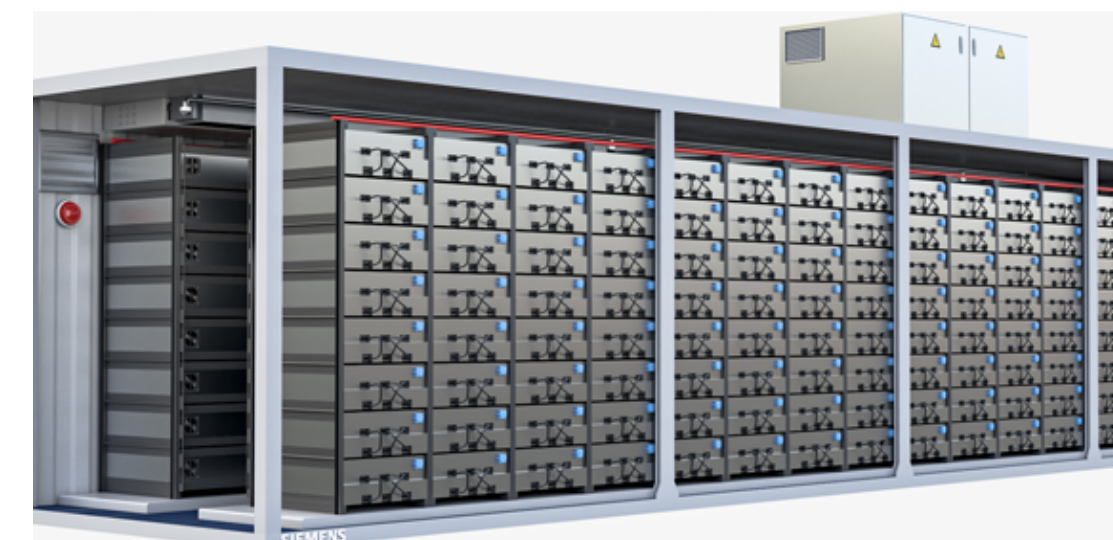
www.ulfirefightersafety.org

Questions?



How are the I-Codes Addressing Safety

- Focus of I-Codes on emerging Energy needs (2021 Sections)
 - Energy Storage Systems (IFC Section 1207 & IRC R328)
 - Stationary Fuel Cells (IFC Section 1206 & R330)
 - PV technologies (IFC Section 1205 & IRC R324)
 - Combustible exterior wall requirements (IBC Ch 14 and Ch 26)



#ICCLEARNLIVE

Panel Discussion

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Thank you for participating!

