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ESIC Energy Storage Safety Incident Gathering and Reporting List

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ABSTRACT

Recent energy storage fire safety incidents have highlighted gaps in the collection and dissemination of data following an incident. The Energy Storage Integration Council (ESIC) facilitated the development of an incident information gathering and reporting list to facilitate uniform and robust gathering that enables improved post-incident evaluation. The topics provided here can help to frame appropriate questions and develop a template for database entries that would further support the identification of common failure modes and characteristics of the incident. This list can be used by system owners, first responders, and integrators to support incident root cause analysis and ultimately lead to guidance that could eliminate or reduce the impact of such incidents in the future.

Keywords
Energy storage
ESIC
Safety

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OVERVIEW

Background and Scope

The Energy Storage Integration Council (ESIC) relaunched the Safety Task Force following a series of energy storage fire-related incidents that highlighted industry gaps and challenges related to safety. One of the challenges identified by the task force was the lack of publicly available data associated with the incidents that would support root cause analysis and lead to guidance that could eliminate such incidents in the future. An incident information gathering and reporting list was developed to facilitate uniform and robust gathering that enables improved post incident evaluation.

This list can be used by system owners, first responders, and integrators to support the evaluation of individual incidents. The topics provided here can help to frame appropriate questions and develop a template for database entries that would further support the identification of common failure modes and characteristics of the incident. This could then benefit first responders by informing improved design and operational practices. Application of a structured root cause analysis process coordinated among a multidisciplinary incident review team assembled with the stakeholders mentioned above can help to most effectively reach defendable recommendations.

An alternative to developing a database would be to create and publish an annex that could be applied with existing resources, such as NFPA 901 Standard Classifications for Incident Reporting and Fire Protection Data, National Fire Incident Reporting System (NFIRS), and U.S. General Services Administration Fire Incident Report (GSA53), as such those existing programs, forms, and existing support infrastructure could be used as a foundation for much of the information that is considered relevant to an ESS related incident. The list is intended to be exhaustive – many fields may not apply to a single incident or may not be answerable given the state of an investigation.

Approach

The information list was compiled after conducting a literature search and review that identified existing resources (e.g. guidelines, papers, standards, programs, etc.) that are focused on gathering and reporting information about safety-related incidents in the built environment and secure copies for review. It is noted that no resources were identified that specifically addressed energy storage systems, but the task force provided the input to tailor to stationary energy storage applications. Then a review existing energy storage system safety incident reports was conducted to gather additional information that was relevant to reporting and evaluating each of those incidents. The list of resources identified in the literature search is in the Bibliography.

Organization

The information is organized in a logical manner starting with general information about the ESS project, through details about the ESS itself and installation and then ends with information associated with an incident. The initial information can and should be gathered for any ESS project and is likely readily available from project specifications, permits, construction drawings

and inspection and commissioning reports. Within each section the relevant items are broken down further as needed in order to secure additional detail. Where the item was derived from one of the above referenced sources the citation is provided in ( )'s.

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SAFETY INCIDENT INFORMATION LIST

1. Project Information
    a. Location
        i. Street type and number, city and zip code (USPS Publication 65)
        ii. State, territory, possession or CA province (NFPA 901 Section 4.1.1, 4.1.2 or 4.1.3)
        iii. Geographical coordinates (NFPA 901 Section 5.9.2)
        iv. UTM Coordinates (NFPA 901 Section 5.9.3)
    b. Property use(s)
        i. General (NFPA 901 Section 6.5 and NFIRS)
        ii. Specific (NFPA 901 Section 6.6)
    c. Property owner (NFPA 901 Section 5.11 and NFIRS)
    d. Property management code (NFPA 901 Section 6.8)
    e. Name of the business, tenant or occupant of the space/building associated with the ESS (NFPA 901 Section 5.10 and NFIRS)
    f. Type of building/facility associated with the ESS
        i. Building occupancy class (use group) of the building/facility
        ii. Construction type(s) (NFIRS) of the building/facility
        iii. Number of stories (NFIRS)
            1. Above and including grade
            2. Below grade
2. Description of the energy storage system(s) (NFPA 901 Section 8.4.2 in part)
    a. Number of separate energy storage systems
    b. If more than one and they are NOT identical provide a description of each system
    c. Application(s) for the system (e.g. peak shaving, renewables integration, frequency regulation, etc.)
    d. Technology type
        i. Thermal
        ii. Mechanical
        iii. Electrochemical
            1. Electrochemical chemistry
    e. System manufacturer (if a complete tested and listed system)

f. System integrator (if an assembly of components)
    i. Cell manufacturer
    ii. Module manufacturer
    iii. BMS manufacturer
    iv. PCS manufacturer
    v. SCADA/DAS provider
g. System information
    i. Model designation
    ii. Serial number
    iii. Year of manufacture
    iv. Brand or trade name
    v. Version of the product design
    vi. Software version
    vii. Firmware upgrades
    viii. Current and voltage ratings
        1. DC rating
        2. AC ESS rating
        3. PCC rating
    ix. Capacity energy storage system (kW or MW and kWh or MWh)
    x. Third party testing entity and test standard(s) used
    xi. Third party listing agency and reference standard(s)
    xii. Continuity of the system(s) (stationary, mobile, portable) (NFPA 901 Section 8.4.5)
    xiii. Fire suppression system(s) type (make/model or description if supplied as a component of the system)
    xiv. Description of thermal management system (if supplied with the system)
h. Method of storing operating data
i. Data intended to be available in the event of complete damage to the system
j. Does the system(s) manufacturer provide customer service to the system(s)
k. Availability of operations, maintenance and repair log

3. Description of the energy storage system installation
    a. System integration location
        i. Factory
        ii. On site
    b. System installer or integrator

c. System operator
d. Date(s) installed
e. Date(s) commissioned
f. Citation for commissioning procedures used
g. Responsible authority having jurisdiction AHJ(s)
h. Date(s) inspected (MN DPS)
i. Safety violations found during inspection (MN DPS)
j. Location of the system
    i. Location in relation to grade (stories above or below or at grade)
    ii. Location in, on or adjacent to buildings, landscape features, or structures)
    iii. Location in relation to other energy storage systems
    iv. Location on site in relation to property lines, buildings/facilities, roads/parking, access and egress to the site
    v. Location in relation to the power grid/energy sources connected to the system(s)
k. If located indoors or enclosed
    i. Use of the space/room and number of occupants in the space/room associated with the system(s)
    ii. Area of the space or room in which the system(s) is installed
    iii. Interior finish associated with the space or room in which the system(s) is installed (NFPA 901 Section 7.6.2)
l. Characteristics of the building/facility containing or adjacent to the system
    i. Roof covering of building or enclosure associated with the system (NFPA 901 Section 7.8.2)
    ii. Perimeter access for fire-fighting operations (NFPA 901 Section 7.10)
    iii. Type of construction where the system is installed (NFPA 901 Section 7.4.1)
    iv. Method of construction associated with the system installation (NFPA 901 Section 7.4.2)
    v. Power source to the building/facility (NFPA 901 Section 8.4.4)
    vi. Electrical service condition (NFPA 901 Section 7.11)
    vii. Flammable or combustible liquid use (NFPA 901 Section 7.14.2)
    viii. Automatic detector information (type, power supply) (NFPA 901 Section 10.3.2 and 10.3.3)
    ix. Ventilation system capacities (include heating and A/C if applicable)
    x. Characteristics of the ESS project site
    xi. Obstacles to rescue and fire control (NFPA 90.1 Section 7.15)

xii. Access requirements (key, code, escort, etc.)

xiii. Transmission features from alarm to fire department (NFPA 901 Section 10.4.1)

xiv. Availability, type and coverage of automatic extinguishing system (NFPA 901 Section 10.5.1)

xv. Availability and type and coverage of manual extinguishing system (NFPA 901 Section 10.5.2)

4. Data associated with or relevant to the incident
    a. Incident number (NFPA 901 Section 5.3)
    b. Date (NFIRS)
    c. Day of the week (NFPA Section 5.8 designation)
    d. Status of building/facility at the time of the incident (MN DPS)
    e. If occupied were occupants evacuated and or relocated (GSA)
    f. Weather conditions (NFPA 901 Section 9.6.1)
    g. Other environmental conditions
    h. Alarm time (NFIRS)
    i. Alarm codes or type (from BMS or on-site system controller)
    j. Arrival time of first responders (NFIRS)
    k. Duration of the incident
    l. Length of time since the system was initially placed in service (NFIRS)
    m. Length of time between the incident and when the system was last serviced
    n. Specific location of incident on the property or in the building/facility
    o. Incident response
        i. Number of fire service personnel responding (NFIRS)
        ii. Number of engines responding (NFIRS)
        iii. Number of aerial apparatus responding (NFIRS)
        iv. Number of other vehicles responding (NFIRS)
    p. Events leading up to the incident (NFPA 901 Section 9.7)
    q. Circumstances associated with the incident
        i. Area of fire origin (NFIRS)
        ii. Type of situation found (NFIRS)
        iii. Equipment involved in ignition (NFIRS)
        iv. Form of heat of ignition (NFIRS)
        v. Type of material ignited (NFIRS)
        vi. Form of material ignited (NFIRS)

r. Description of the incident
    i. Video and/or photos during and/or after the incident
    ii. Witness statements
    iii. Ignition factor (NFIRS)
    iv. Method of detection associated with the incident (NFPA 901 Section 9.5.1)
        1. Performance of fire detection equipment (NFPA 901 Section 10.3.4)
        2. Reason for any fire detection equipment failure (NFPA 901 Section 10.3.5)
    v. Was fire alarm notification made to the fire department
        1. Method of alarm (NFPA 901 Section 9.5.2)
        2. Number of alarms (NFPA 901 Section 5.6 and NFIRS)
    vi. Method of extinguishment (NFIRS)
        1. Performance of automatic extinguishing systems (NFPA 901 Section 10.5.1)
        2. Water supply type and flow (NFPA 901 Section 10.6)
        3. Reason for extinguishing system failure (NFPA 901 Section 10.5.1)
        4. Performance of manual extinguishing systems (NFPA 901 Section 10.5.2)
        5. Reason for extinguishing system failure (NFPA 901 Section 10.5.2)
        6. Status of enclosure/room ventilation
    vii. Identification of area of origin of the incident (NFPA 901 Section 8.3.2)
    viii. Identification of equipment involved in the incident (NFPA 901 Section 8.4.3)
    ix. Capacity of the affected energy storage systems(s) (kW or MW and kWh or MWh)
    x. Point of origin
    xi. Item(s) ignited (NFPA 901 Section 8.6.1)
    xii. Heat source causing ignition (NFPA 901 Section 8.5.1)
    xiii. Ignition (NFPA 901 Section 8.7)
        1. Cause
        2. Physical factors contributing to ignition
        3. Human factors contributing to ignition
    xiv. Level of origin of the incident if above grade (NFPA 901 Section 8.8 and NFIRS)
    xv. Occupant(s) of the room or space of origin (NFPA 901 Section 8.9)
    xvi. Performance of fire spread limitation features (NFPA 901 Section 10.7)
    xvii. Performance of exit systems (NFPA 901 Section 10.8)

xviii. Safety-related occurrences associated with the incident
    1. Arcing
    2. Explosions
    3. Fire
    4. Smoke
    5. Release of toxic gases and type
    6. Release of toxic liquids and type

s. Incident growth and spread
    i. Contributing factors (NFPA 901 Section 9.2.1)
    ii. Flame development (NFPA 901 Section 9.3)
        1. Materials involved (NFPA 901 Section 9.3.1)
        2. Factors contributing to flame travel (NFPA 901 Section 9.3.2)
    iii. Smoke development (NFPA 901 Section 9.4)
        1. Materials involved (NFPA 901 Section 9.4.1)
        2. Avenue of smoke travel (NFPA 901 Section 9.4.2)
        3. Extent of smoke spread (NFPA 901 Section 9.4.3)

t. Staff/occupant actions
    i. Did staff or occupants call 911 (MN DPS)
    ii. Did staff or occupants active fire alarm system (MN DPS)
    iii. Did staff or occupants attempt extinguishment (MN DPS)

u. Fire department intervention
    i. Incident type (NFPA 901 Section 11.3)
    ii. Condition of fire on arrival (NFPA 901 Section 11.4)
    iii. Type of action taken (NFPA 901 Section 11.5 and NFIRS)
    iv. Fire suppression factors (NFPA 901 Section 11.6)
    v. Method of extinguishment (NFPA 901 Section 11.7)
    vi. Type of emergency response resources used (NFPA 901 Section 11.8)
    vii. Outside fire service assistance (NFPA 901 Section 11.9)

v. Events immediately following the incident (NFPA 901 Section 9.7)

5. Post Incident Forensics and Analysis
    a. Origin of the incident (MN DPS)
    b. Causes of the incident (MN DPS)
        i. Primary
        ii. Secondary

c. Video and/or photos before, during, and after the incident
d. Cell failures
e. Containment of the incident within the system
f. If not contained within the system what other areas, spaces, systems, etc. were impacted
g. Fire ratings associated with walls, floors and ceilings/roofs associated with the area/room of origin (MN DPS)
h. Fire detection equipment performance (NFIRS)
i. Fire suppression system performance (NFIRS)
j. Property and human loss attributable to the incident (NFPA 901 Chapter 13)
    i. Number of fatalities, injuries, persons assisted, persons rescued (NFPA 901 Section 13.3 and NFIRS)
    ii. Monetary loss (NFPA 901 Section 13.3.7 and NFIRS))
    iii. Extent of damage (NFPA 901 Section 13.4)
        1. To the system
        2. Were any assemblies breached (MN DPS)
        3. Were pipe, duct and similar penetrations sealed (MN DPS)
        4. Was HVAC system involved in the incident (MN DPS)
        5. Damage to equipment, materials, etc.
        6. Extent of flame damage (NFIRS)
        7. Extent of smoke and heat damage (NFIRS)
k. Hazardous materials release or potential release (NFPA 901 Chapter 16)
    i. Identification (NFPA 901 Section 16.4)
    ii. Actions taken (NFPA 901 Section 16.4.8)
    iii. Container to hold hazardous materials (NFPA 901 Section 16.5)
    iv. Release information (NFPA 901 Section 16.6)
    v. Disposition of the incident (NFPA 901 Section 16.8)
l. Existence of any building, fire, electrical, etc. code violations or deficiencies identified (MN DPS)
m. BMS information - What information was available from the system, before / during the incident?
n. How did the system behave before and during the event (e.g. opened contactors, shut off inverter, etc.) time-stamped or sequenced
o. Operating mode at the time immediately prior to the incident
p. Duty cycle of the system and number of cycles the system has gone through
q. Availability of maintenance records and their degree of completeness

6. Analysis of the Incident
    a. Incident Result
        i. Impact to human safety
        ii. Impact to asset performance
        iii. Impact to project economics
    b. Causes of the incident
        i. Primary cause
        ii. Secondary causes (addressing the ‘5 whys’)
    c. Other contributing factors
    d. Recommendations to reduce the severity, reduce the probability, or eliminate the probability of the incident in future scenarios

3
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This bibliography includes all the resources identified and reviewed in the literature search. The five resources in bold contained relevant information and were referenced in the Safety Incident Information list.

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