Fire hazards and risk mitigation strategies of alternative energy solutions

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Fire & Risk Alliance, LLC.
Workshop Schedule – Day 2

9:45 am to 10:45 am - Introductions and small group work
10:45 am to 11:00 am - Break
11:00 am to 12:00 pm - Small group work continues
12:00 pm to 1:00 pm - Lunch
1:00 pm - reconvene in the main lecture room
1:00 pm to 2:00 pm - Workshop facilitators present findings (of their small groups)
Workshop / Group Activities (Day 2)

1 hour - Introductions and small group work
  Facilitator introduces the “contemporary issue”
  Attendee introductions
  Case and Ecosystem discussion

15 min - Break

1 hour - Small group work continues
  Facilitator records small group recommendations

1 hour - Lunch
Workshop / Group Goals (Day 2)

Introduce yourself to each other
  (Current job, location, role(s) within the NFPA Ecosystem, why interested in this topic)
Discuss the contemporary issue
Identify challenges / recent failures
Identify what elements of the NFPA Ecosystem may have been lacking (under-represented) in recent failures
Identify ways the NFPA Ecosystem may help in the future
What is Alternative Energy?
Alternative Energy
Wind Energy

- Wind turbines operate on a simple principle. The energy in the wind turns two or three propeller-like blades around a rotor. The rotor is connected to the main shaft, which spins a generator to create electricity.
Tidal Energy

• Tidal Stream Generator
  Makes use of the kinetic energy of moving water to power turbines, in a similar way to wind turbines that use wind to power turbines.

• Tidal Barrage
  Tidal barrages make use of the potential energy in the difference in height between high and low tides.
Wave Energy

• Ocean waves contain tremendous energy potential.
• Wave power devices extract energy from the surface motion of ocean waves or from pressure fluctuations below the surface.
Geothermal Energy

• (geo = earth and thermal = heat), geothermal energy comes from heat produced by the Earth.
Biofuels

• The two most common types of biofuels are ethanol and biodiesel.
Solar Energy
What’s the Common Thread?
Energy Storage Not New
Energy Storage Technologies

**Chemical**
- Ammonia
- Hydrogen
- Drop-in Fuels
- Methanol
- Synthetic Fuels Gas
- Synthetic Natural Gas

**Electrochemical**
- Classic Batteries
  - Lead-Acid
  - Li-Polymer
  - Na-NiCl2
  - Na-Cd

- Li-ion
  - Li-S
  - Na-Ion
  - Na-S

- Flow Batteries
  - Vanadium Red-Ox
  - Zn-Br

- Flow Batteries
  - Zn-Fe

**Electrical**
- Supercapacitors
- Superconducting Magnetoc Energy Storage (SMES)

**Mechanical**
- Compressed Air
- Flywheels
- Gravity
- Liquid Air
- Pumped Hydro
- Column Stack
BESS Information: Cell→System

- **Cell**
  - Cell-level integration
  - Cell testing and screening
- **Module**
  - Module-level integration
  - Module testing
- **Unit**
  - Unit-level integration
  - Unit testing
- **Lithium Battery System**
  - Includes BMS, detection, suppression
Hazards

• Fire
• Explosion
• Stranded Energy
Thermal Runaway

- Short circuit inside battery
- Electrolyte gases released (80-150°C)
- Battery separator breaks down
- Temperature increases uncontrollably

Thermal Runaway: Fire/ explosion

Temperature Increases
Anatomy of an Event

<table>
<thead>
<tr>
<th>Cell Failure</th>
<th>Venting</th>
<th>Immediate Ignition</th>
<th>Fire Extinction</th>
<th>Venting until Flammable Mixture</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes Possible Explosion Hazard</td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td>Yes</td>
<td>No</td>
<td>No Fire Extinguished</td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes Ongoing Fire</td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td>Yes</td>
<td>No</td>
<td>No Fire burns out</td>
</tr>
<tr>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes Possible Explosion Hazard</td>
</tr>
<tr>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No Gas dissipates</td>
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</table>
MOORABOOL
FIRE DESTROYS LITHIUM BATTERY
THE VICTORIAN BIG BATTERY PROVIDES 'CRUCIAL' ENERGY STORAGE
Challenges

• Inconsistent code adoption and varied interpretations/requirements
• Poorly written contracts & design
• Products not tested to latest standards (design cycles initiated prior to standard issuance)
• “One size fits all (most)” doesn’t necessarily work if price is critical
• Lack of understanding/risks of systems by manufacturers, integrators, developers, FD, and yes, even FPE’s
• Competing interests (supplier, owner/operator, AHJ, etc.)
• Appropriate design of safety systems
Types of Installations

- Dedicated Use Building
- Outdoors Near Exposures
- Non-Dedicated Use Building
- Outdoors Remote
BESS Roadmap & FPE Roles

- Jurisdiction
  - Applicable codes & standards

- Facility Siting
  - Setbacks
  - Arrangement

- Indoor vs. Outdoor
  - Outdoor, remote vs near exposures

- Technology Chosen
  - Chemistry
  - Vendor
  - Arrangement

- Protections Required
  - Detection
  - Alarm
  - Suppression
  - Active Ventilation (purge or NFPA 69)
  - Deflagration Venting (NFPA 68)
Unit ESS Testing with Suppression Agent

<table>
<thead>
<tr>
<th>Test Time</th>
<th>Event (ID)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0:00:00 (0s)</td>
<td>Test Start</td>
</tr>
<tr>
<td>0:40:00 (2400s)</td>
<td>Cell Failure Event</td>
</tr>
<tr>
<td>0:42:22 (2556s)</td>
<td>Thermal Runaway (E0)</td>
</tr>
<tr>
<td>0:43:12 (2592s)</td>
<td>Smoke Alarm (E1)</td>
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<tr>
<td>0:43:18 (2598s)</td>
<td>Release Event</td>
</tr>
<tr>
<td>0:44:45 (2685s)</td>
<td>Smoke Alarm (E2)</td>
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<tr>
<td>0:45:26 (2726s)</td>
<td>FSS Discharge (E3)</td>
</tr>
<tr>
<td>0:50:15 (3015s)</td>
<td>Ventilation (E4)*</td>
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<tr>
<td>0:51:54 (3114s)</td>
<td>Deflagration (E5)</td>
</tr>
<tr>
<td>0:54:02 (3242s)</td>
<td>Test End</td>
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</tbody>
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![Graph showing O2 Concentration over time](image)