Fire Risk of Emerging Technologies

Steve Kerber, PhD, PE
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World Fire Congress
May 8, 2024
Balancing Sustainability and Fire Resiliency
All powered devices are candidates for lithium-ion electrification.
Many challenges throughout the life cycle
Global trend of lithium-ion battery incidents

Source: Google Maps, UL Solutions R&D (Veronica Kimmerly)
Lithium-ion battery thermal runaway incidents

Source: UL Solutions R&D (Veronica Kimmerly)
North America’s biggest challenge

Most injury and fatality incidents involve consumer products*

Most consumer products incidents involve e-mobility devices

*EV data inflated by fatalities as a result of crash
# Bureau of Fire Investigation

## Lithium Ion Fire Stats

(As of 12/31/2023)

<table>
<thead>
<tr>
<th>Year</th>
<th>Investigations</th>
<th>Injuries</th>
<th>Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019</td>
<td>30</td>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>2020</td>
<td>44</td>
<td>23</td>
<td>0</td>
</tr>
<tr>
<td>2021</td>
<td>104</td>
<td>79</td>
<td>4</td>
</tr>
<tr>
<td>2022</td>
<td>220</td>
<td>147</td>
<td>6</td>
</tr>
<tr>
<td>2023</td>
<td>267</td>
<td>150</td>
<td>18</td>
</tr>
</tbody>
</table>
Moving target

• New fuels, new chemistries, new boxes
• Determining which hazards extend outside scope of first response
• Staff development to the new fire environment
• Codes and standards are slow, technology is fast
• Developing best practices for extinguishment and gear cleaning
• Impact on building systems and evolutions
• Community actions to eliminate secondary incidents
• Public messaging and the fire service role goes beyond operations
• DIY impacts
Addressing the challenge today and into the future.
Fire Risk of Emerging Technologies

Steve Kerber, PhD, PE
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Energy transition in the built environment: Dutch facts and figures for AFV and PV

Dr. Nils Rosmuller
Applied Professor, Energy and Transportation Safety
1. The built environment

The term "built environment" refers to human-made conditions and is often used in architecture, landscape architecture, urban planning ...

These curated spaces provide the setting for human activity and were created to fulfil human desires and needs.

Buildings, public infrastructure, industries and agriculture
1. The built environment

High-rise buildings

Warehouses, barns

Car parks

Infrastructure

Industries

A rainbow bike road in Utrecht, Netherlands. Photo Credit: Dutch Cycling Embassy
2. The Energy Transition

- Sustainability
- Clean/‘green’ fuels
- Electrification
- Hydrogen
- Geo, bio, wind, solar…
- Nuclear
3a) Dutch F&F: Alternative-fueled vehicles (AFV)

- Database (The Netherlands)
- Start: 1 January 2021
- Alternative (clean(er)) Fuels:
  - BEV, (P)HEV, FCEV, CNG, LNG
- Type of vehicles:
  - Everything with 4+ wheels
- Fire brigade on the incident scene
- Data collection: Questionnaire
Fuel type passenger cars (% in 2023)

- 78.2% Benzine
- 9.8% Diesel
- 1.1% LPG
- 7.0% Hybride
- 3.7% EV
- 0.1% CNG/LNG/Biobrandstof/Waterstof/Onbekend

Development passenger cars per fuel type (% in 2023)

- EV
- Gasoline
- LPG
- CNG
- Diesel

EVs in The Netherlands in 2023

- Passenger cars: Aantal: 464,508, Aandeel: 5.2%
- Small commercial veh.: Aantal: 27,056, Aandeel: 2.6%
- Trucks: Aantal: 789, Aandeel: 0.5%
Number of AFV-Incidents

<table>
<thead>
<tr>
<th>Year</th>
<th>Accidents</th>
<th>Fire</th>
</tr>
</thead>
<tbody>
<tr>
<td>2021 (N=221)</td>
<td>159</td>
<td>62</td>
</tr>
<tr>
<td>2022 (N=306)</td>
<td>189</td>
<td>117</td>
</tr>
<tr>
<td>2023 (N=316)</td>
<td>164</td>
<td>152</td>
</tr>
</tbody>
</table>
Incident Characteristics
(in absolute numbers)
3a) Key lessons: AFVs

- **Incidents** (fire and accidents): Despite the +30% EV, the absolute incident number (fire and accident) remains the same (2021-2023)

- **Fires**
  - In case of fire → EV at charger in about 25%-35%
  - Battery in about 35% in thermal runaway

- **Accidents**
  - Substantial increase in deploying the submerging container
  - Battery hardly in thermal runaway

- **Serious fire fighter issues**
  - TR, copious amounts of water, contaminated cooling water, explosions, HF
3b) Solar energy
3b) F&F Solar system fires in NL
(TNO and ECN, 2019)

- 24 fires in 2018
- 20 private houses
- 4 others
- 80-90% in-roof systems
- Causes:
  - 70% installation error
  - 10% junction box
  - 20% heat development
3b) Building fires involving solar panels

Deposition of sharp-edged, (non-toxic) solar cell fragments → danger to human, animals, and crop (NIPV (2020, 2021) and RIVM (2022))
3b) Building fires involving solar panels

More advanced data collection method since the end of 2022.

- 349 building fires involving PV
  - 361: no deposition
  - 33: deposition

- Deposition characteristics:
  - buildings with fire load and 100s of PV panels
  - solar cell fragments
  - distance: several kilometers
3b) Key lessons PV-panels

- Solar panels complicate firefighting:
  - Deposition of sharp-edged pieces
  - ‘Umbrella effect’ in case of fire suppression
  - Electrocution risks
4) Key message ET in built environment

- Energy transition (ET) affects life safety of citizens and firefighters due to ‘new’ fire risks in the built environment, complicating fire suppression.

- Designers, OEM's, spatial planners have to take their responsibility for safety.

- Communicate with the FRS, rather than passing the responsibility for safety to them (suppressing the accident consequences).

- Maximum effort on prevention and legislation to better ‘guarantee’ safety.
Energy transition in the built environment: Dutch facts and figures for AFV and PV

Dr. Nils Rosmuller
Applied Professor, Energy and Transportation Safety
Lithium-Ion Battery/Electric Vehicle Fire Incidents Around the United States

Michael G. Abraham, PE
Bureau of Alcohol, Tobacco, Firearms, and Explosives
Fire Research Laboratory
• ATF is the primary agency investigating fires affecting interstate or foreign commerce.

• ATF has approximately 110 Certified Fire Investigators nationwide.

• Two-year, full-time training program involving fire scene examinations, in-person training, and a research project.

• IAAI CFI certification
ATF National Response Team (NRT) & International Response Team (IRT)

- Mission to investigate large fire and explosion incidents anywhere in the U.S.
- 15 full-time Special Agents, 115 part-time Special Agents, Fire Protection and Electrical Engineers, Chemists, Accelerant Detection Canines, etc.
- Over 900 callouts nationwide since 1978.
- 43 International callouts to countries in Europe, Africa, Asia, and South America.
ATF Fire Research Laboratory (FRL)

- Support fire investigations and the resolution of fire-related crimes for Federal, State, Local, and International Authorities
- On-scene Support and Evidence Examinations
- Full-Scale Testing
- Research, Training, and Education
Spokane, WA - 2018 Tesla Model 3 Battery
Neptune, New Jersey
Neptune, New Jersey
Neptune, New Jersey
Los Angeles, CA
Los Angeles, CA
Vape Failure Fatalities

St. Petersburg, FL

Chewelah, WA
New Orleans, LA - Oil Tanker Bridge Fire
Boston Metro Area, MA
Palo Alto, CA
New York City – Ford Fusion Hybrid
Pittsburgh, PA - Tesla Model X

Fire occurred in February  ●  Joint Scene Exam in April  ●  Vehicle Removed & Transported
  ●  Three hours later…
World Fire Congress

2024 | UNITED STATES

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Fire Risk of Emerging Technologies

Adam Barowy
UL FSRI
Intentional E-Scooter Overcharge: Living Room

Overcharge Time: 01:39:23

Living Room Low
Entry
Living Room High
Hallway
Living Room Infrared
Living Room Windows

World Fire Congress 2024 | UNITED STATES
Impact of Residential Automatic Fire Sprinklers
TAKE CHARGE OF BATTERY SAFETY
What can you do to “Take C.H.A.R.G.E. of Battery Safety”?

Choose certified products.

Handle with care.

Always stay alert for warning signs.

Recycle devices and batteries properly.

Get out quickly if there’s a fire.

Educate others on safe practices.

www.batteryfiresafety.org
EV Research at FSRI

1. Are hazards changing with a transition to electric vehicles (EVs)? If so, how?

2. What fire control strategies can fire fighters use to mitigate demonstrated hazards?

Courtesy: Boston Fire Department (MA)
EV Fire Measurements & Methodologies

1. Heat Release Rate
2. Water contamination
3. Heat Flux
4. Occupational Exposures
   1. Gases, Vapors, and Particulates
   2. PPE Contamination
   3. PPE Decontamination
Fire Risk of Emerging Technologies

Adam Baroway
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EV Battery Fires

SCDF’s Current Response, Challenges, and Areas for Further Work

DC Ling Young Ern
Deputy Commissioner
(Operations & Resilience)
Singapore Civil Defence Force
SG EV Landscape

Singapore aims to achieve net zero emissions by 2050

SG Green Plan

Energy Reset

2025 – New Registration of Diesel Cars to cease, HDB towns to be charger equipped
2030 – Car/Taxi Registration to be cleaner energy models, 60,000 island chargers
2040 – All vehicles to run on clean energy
Risks Identified

**Thermal Runaway**
Phenomenon in which the Lithium-ion cell enters an uncontrolled, self-heating state of propagation.

**Off Gassing**
Occurs during thermal runaway and involves production of smoke, usually grey or white in color, that issues from the battery.

**Vapour Cloud Explosion**
EV batteries undergoing thermal runaway will release toxic/flammable gases due to the combustion of electrolytes.
EV Fires – Recent Cases in Singapore

Case 1: Sembawang Wharves (Jul 23)
Fire involved a battery module stored in the storage compartment of a Porsche Taycan. Fire was extinguished with a water jet.

Case 2: Kaki Bukit (Jan 24)
Premises was a workshop housing three vehicles: a Porsche Taycan (fire involved the battery pack) and 2 hybrids. Fire was extinguished within 15 mins with a water jet.
LTA and SCDF established the EV Battery Safety Taskforce (EBST) in August 2023 to develop matters related to strengthening Singapore’s response to EV incidents. The EBST specifically looks at:

- Enhancing incident response framework to support Singapore’s transition to EVs
- Building good public understanding on EV batteries and associated risks
- Promoting knowledge sharing among agencies in area of EV batteries
- Reviewing sufficiency of existing capabilities, infrastructure, and regulations to manage EV incidents
Fire Safety Provisions for EV Charging

Indoor & Outdoor Chargers – 60,000 by 2030

• Each EV charging station shall have an e-stop button within 15m.

• Regulated under the Fire Code (Clause 10.4.2) and national EV charging standard (Technical Reference 25).
SCDF’s EV Firefighting Tools

Vehicle Fire Blanket
SCDF recently introduced vehicle fire blankets to **slow fire spread and any release of toxic gases**, to buy time while a water jet is prepared.

Water Injection

Piercing: Recently operationalised tool with a hardened lance that **pneumatically pierces the EV battery compartment** to flood it with water.

Ultra High Pressure (UHPS) cutting: Latest generation of fire engine will be equipped with **UHPS extinguishing tools to inject water into EV battery compartment**; further trials will be conducted upon delivery in end 24.
EV Fire Test

• An EV fire test was conducted on 11 April 2024
  • Validated SCDF’s EV firefighting response plan
  • Deployment of vehicle fire blanket in tandem with water jet and battery fire extinguishing system
Vehicle batteries for electric buses and heavy goods vehicles are mounted in areas other than the vehicle floor.

Accessing the batteries and applying water effectively will be a challenge.
State-of-Charge is a good means of estimating reignition risk

However, EV instruments display battery related information, but this is often damaged during the incident. Better tools needed to help responders quantify reignition risk.

Quarantine of damaged EVs

More research needed on cost effective means of quarantining EVs, if required. For example, to enable safe containment within the vehicle workshop. Difficult in Singapore due to limited space!
Conclusion

1. Science & Technology Advancements:
   • Safer, superior EV battery & car designs
   • Lower incidence of EV fires worldwide compared to ICE vehicles

2. Unique Challenges for Emergency Services:
   • EV fires present distinct challenges
   • Rare occurrences can skew public perception

3. Confidence Building for a Greener Future:
   • SCDF and partner agencies building robust capabilities
   • Establishing an ecosystem for comprehensive preparedness

4. Research Opportunities:
   • Focus on EV battery fire mitigation approaches
   • Aim to enhance global response effectiveness
EV Battery Fires
SCDF’s Current Response, Challenges, and Areas for Further Work

Ling Young Ern
Deputy Commissioner (Future Technology & Public Safety)
Singapore Civil Defence Force