Large EV Battery Market, Challenges and Standards

Priya Tabaddor

Underwriters Laboratories Inc.

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Introduction – History Of UL

- 1894 founded by William H. Merrill

- Opens Underwriters Electrical Bureau, the Electrical Bureau of the National Board of Fire Underwriters in Monroe Street in Chicago, Ill., USA

- First test is conducted on March 24, 1894 on a non-combustible insulation material for Mr. Shields

- Independent, not-for-profit company with reputation in electrical and fire, safety testing

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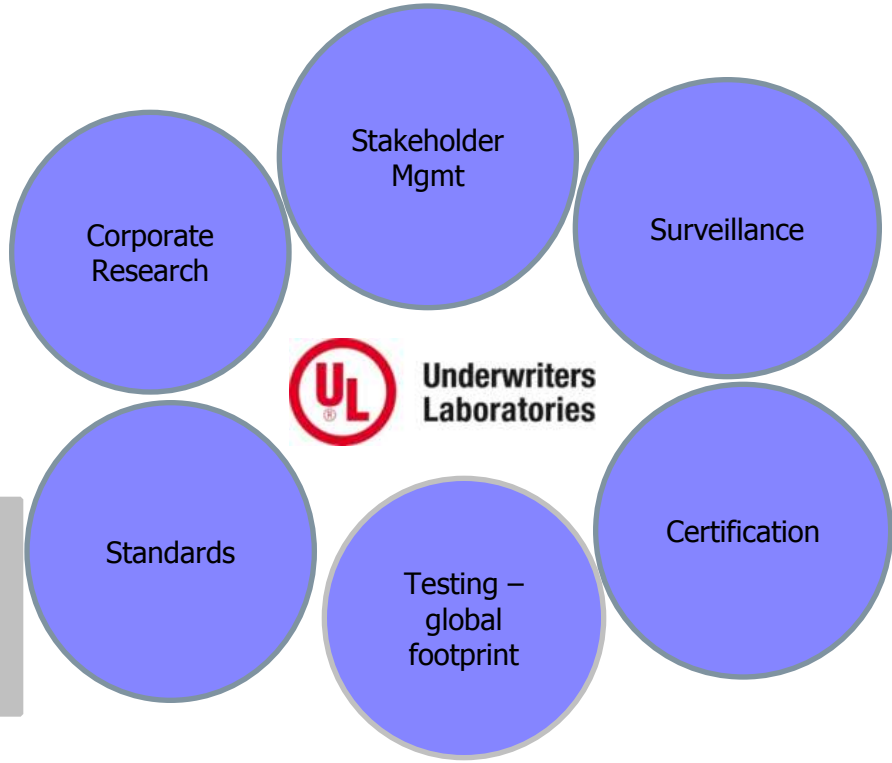
UL Introduction

Authorities Having Jurisdiction
Regulatory services
Insurance community
Governmental affairs
Supply chain

Hazard assessment
Failure analysis
Chemical & electrical analysis
Modeling
R&D partnerships



Ensures ongoing conformity
Supply chain integrity
Anti-counterfeiting

Defining requirements
ANSI SDO
Consensus –STP
ISO, IEC participation

Code enforcement
Independence
Risk management

Labs accredited by ANSI
ISO 17025

UL By the Numbers

2008 records

Number of product evaluations conducted by UL

93,762

Number of countries where UL customers are located

98

Number of facilities in the UL family of companies

64

Number of UL Marks appearing on products

20 billion**

Number of UL and ULC Standards

1,362

※More than 60% of UL Standards are adopted as National Standard by ANSI.

Number of manufacturers producing UL certified products

72,302

**** Note that only Underwriters Labs is authorized to issue the UL Mark**

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EV Industry Drivers

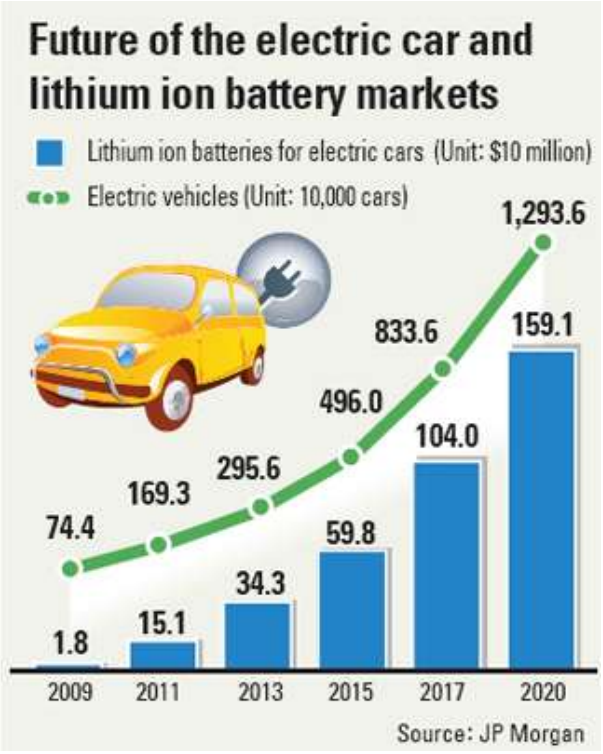
EV Industry and Energy Storage - Macroeconomic Drivers

Main technology & demand drivers for large batteries and EVs

- Volatile gas prices spur demand and promote market
- Government policies promote growth
- Consumers driven by need to reduce carbon footprint/emissions

EV/PHEV and large battery development

- New governmental incentives globally are projected to enhance EV adoption and technology development
  - US DOE spending $25B over 3 years to promote EV technology
- Energy Independence and Security Act (EISA) of 2007 mandates a 40% increase in fuel economy standards for automobiles and light trucks 2020
  - EV industry expects 3-5M vehicles on the road **globally** with rechargeable batteries on the road by 2020[1]
  - LEV industry (scooters & bikes with rechargeable batteries) projected for growth in Asia and parts of Europe expects 100M+ units on the road by 2020.[2]



1. http://www.greencarcongress.com/
2. EBWR Electric Bikes Worldwide report, 2007

LEV Market Assessment

- Lead acid batteries used and Li-ion technology is in increasing focus
- Extended range feasible but battery prices may be prohibitive
- 20.8 million electric bikes were sold worldwide in 2007, projected to approach 100M units by 2020[1.]
- Taiwan and China represent the fastest growing market segment globally for LEVs
  - China electric bike sales: 12M in 2005 vs. 17M in 2007[1]
- eBikes represent the fastest-growing bicycle category within the U.S and Europe
  - U.S. eBike sales are projected to hit 220,000 units in 2009, a two-year increase of 83% from 2007 [1]
  - eBike sales in Europe expected to hit 750,000 units in 2009 a three-fold increase over 2007[1]

Recent developments

- Taiwan Ministry of Economic Affairs (MOEA) announced a subsidy for purchase of a certified e-scooter using plug-in, detachable lithium-ion battery pack from 2009 to 2013
- Taiwan's Pihsiang Energy Technology Co. Ltd. (PHET®) has license to manufacture, market and distribute C-coated Li-ion Phosphate batteries to LEV market
- China BAK Battery, Inc. –selected by the PRC's Ministry of Science and Technology to receive a grant of $3.1 for commercialization of high-power lithium-phosphate cells for LEV/EV applications

1. EBWR Electric Bikes Worldwide report, 2008

Large Batteries Scope – A Global Industry

China - expected to be one of the largest EV/HEV/PHEV markets globally driven by:
•Increasing awareness about pollution and global warming
•Government subsidies with support reaching 2billion RMB through 2010
•Extensive research and development activity within Chinese auto industry
• BYD's new HEV, known as the F3DM, started selling in China in Dec 2008 with new models planned for US in 2010

U.S.A. - GM to launch the much anticipated Chevy Volt in Fall 2010
• Ford has announced new hybrid models planned for launch in 2011-2012

Europe -

• BMW to launch EVs –Rolls Royce, Mini and BMW models by 2015
• Daimler has purchased a 10% stake in Tesla Motors
• Fiat (in partnership with Chrysler) plans extended range electric vehicles by late 2010

Japan - expects to lead the EV industry with new designs slated for full production by 2012
•METI (Ministry of Economy, Trade & Industry) created a strategic study group for rechargeable batteries system in May 2009 to enhance competitiveness of Japanese industry
•Japanese Govt. offering substantial incentives to EV buyers (43% in subsidies and no tax is owed)
•Nissan: LEAF available in 2010 with mass production in 2012. Nissan collaborating with infrastructure developers to enable proliferation in market. Battery in LEAF to be leased.
• Mitsubishi: iMEV available in early 2010 can run 160 km on full charge
• Toyota: Next generation of Prius PHEV to be equipped with solar panels

Asia –
•Reva and Tata Motors developing EV designs targeted for sales locally & in the US
•Taiwanese government offering subsidies for 160,000 electric scooters through 2010.

EV Motivation and Challenges

- Leasing vs. purchase of cars/batteries?
- Infrastructure models – charging at home, pay as you charge?
- WTP for lower running/maintenance costs?

- Tax incentives
- Environment and climate change
- Price of gasoline
- Attributes –speed, range, price

Business models and ROI

Purchase motivation for EVs

Infrastructure demands

Design and functional requirements

Branding/ model choice

- Where should charging stations be located?
- What are consumer's preferences regarding accessibility at work/on weekends?

- How critical is OEM reputation with EV?
- Do consumers know key players and models?
- Will consumers buy EVs from non-traditional OEMs?

- Are usage patterns suitable to capabilities?
- Will there be a need to tradeoff other convenience until battery technology improves?

EV Standards and Regulations

UL Standards Development Process

Purpose: facilitating the development, publication, and distribution of world-class standards that contribute to UL's public safety mission

~60% of UL standards are recognized as American National Standards through ANSI consensus process

Through industry support, the UL standard may be harmonized with International IEC or ISO Standards with national differences

1300+ standards apply to over 20,000 product categories, 80,000 plastics and 900,000 components

All UL standards available free of charge to UL customers

http://www.ansi.org/

STANDARDS
are our business

IEC

ISO International Organization for Standardization

SAE

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UL Standards Technical Panel - STP

website:
http://ulstandardsinfonet.ul.com/stp/

membership:
http://ulstandardsinfonet.ul.com/stp/stpmembership.html

Application form:
http://ulstandardsinfonet.ul.com/stp/STP%20Application_electronic.doc

About STP membership:

- Participation is open to all persons who are directly and materially affected by the STP topic
- A person interested in joining an STP must file a signed application to UL that lists his/her interest category and technical qualifications
- Balanced participation ensures that no one interest category is represented in more than one-third of the STP membership
- Membership may be restricted due to balance constraints. An STP Chair has the final decision on the minimum or maximum size for an STP
- STP membership is limited to only one voting member per organization.
- No individual shall represent more than one interest group
- There shall be no proxy voting

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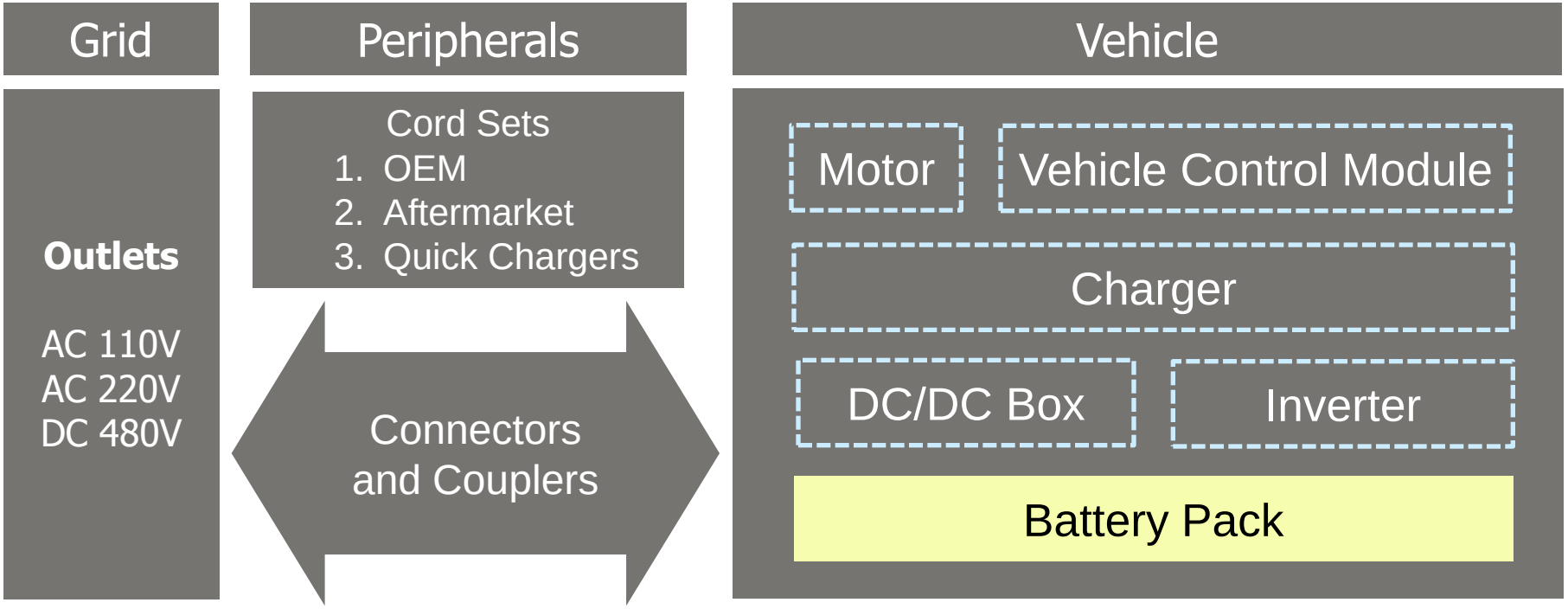
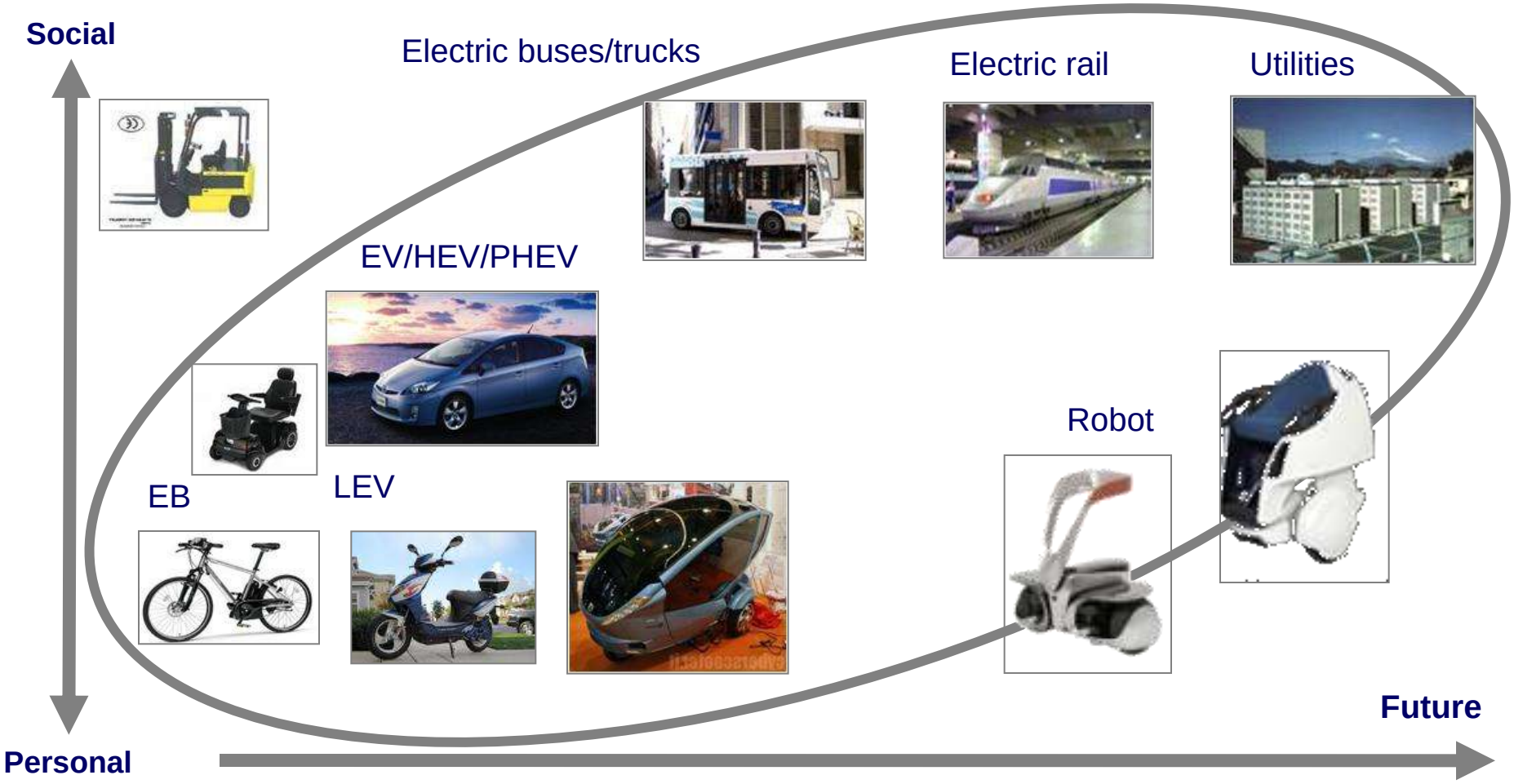
Battery/EV Charging System & Standards



UL Safety standards exist for:

- grid connect elements
- peripheral equipment, and
- some onboard elements (charger, DC/DC Box)

Scope of Large Batteries Standards



Safety Standards and Regulations by Region -EV

	North America	Japan	European Union	International
Safety	UL Standards	DENAN Law	Low Voltage Directive, Machinery Directive and EN standards	IEC standards
Software, EMC and wireless	FCC	N/A	EMC Directive	IEC standards CISPR Standards
Industry voluntary rules and others	SAE Standards** —Industry voluntary rules	JEVS standards*** —Industry voluntary rules	National standards, e.g., QCT 742 (China)	N/A

* FCC (Federal Communications Commission)

** SAE (Society of Automotive Engineers)

*** JEVS (Japan Electric Vehicle Standards)

Certification to applicable standards required

Regulations exist, self declaration required

N/A

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EV Standards by Region

EV Plug, Connector and Coupler

- North America: UL 2251 and SAE J1772
- Japan: JEVS G105
- European Union: EN 62196-1
- International: IEC 62196-1 and IEC 62196-2

EV Charging Stations & Cord Sets

- North America: UL 2202, UL SU 2594
- Japan: N/A
- European Union: EN 61851-1, EN 61851-21 and EN 61851-22
- International: EN 61851-1, EN 61851-21 and EN 61851-22

EV Personal Protective Equipment

- North America: UL 2231-1 and UL 2231-2
- Japan: N/A
- EU: N/A
- International: N/A

EV Charging Stations –Metering Equipment

- North America: UL 916 and ANSI C.12.1,10,20
- Japan: N/A
- European Union: EN 62051- 62055
- International: AS 1284, EN 62051-62055

Global Large Batteries Standards – Current Situation

- While self certification is largely prevalent in this industry, several performance related standards and recommended practices exist
  - SAE standards
    - SAE J2464, Electric Vehicle Battery Abuse Testing
    - SAE J2380, Vibration Testing of EV Batteries
- ISO/IEC committees are in early stages of developing requirements for safety of cell and pack assemblies
- UN requirements for transportation of batteries
- BATSO manual for LEV batteries
- Regional/National Standards
  - FREEDM/EUCAR/USABC requirements
  - Chinese national performance standards for large batteries, e.g. QCT 742
  - Japan- METI developing common strategy and safety standards for rechargeable batteries

UL Standard - Batteries for Use in Electric Vehicles

UL STANDARD
UNDER DEVELOPMENT

Subject 2580 - Scope

Covers: Rechargeable cells, cell modules, battery packs and battery systems for use in electric vehicles

Evaluates: ability to safely withstand simulated abuse conditions based upon the manufacturer's specified charge and discharge parameters

Does not evaluate: the interaction with other control systems within the EV or the performance or reliability of these devices

Standards Technical Panel for UL SU 2580 finalized in Dec 2009

UL Subject 2271 – Light Electric Vehicle Batteries

UL STANDARD
UNDER DEVELOPMENT

Light Electric Vehicle (LEV) – A small on-road or off-road vehicle that uses electricity as its sole source of energy for motive power. LEV's cover, but are not limited to the following vehicles:

- electric bicycles
- electric scooters, and
- electric wheel chairs

Covers rechargeable batteries and battery packs for use in light electric vehicles (LEVs) as defined in this standard, with a maximum output of 60 V, DC.

UL SU 2580 Standards Technical Panel to also review UL SU 2271

Addressing EV Battery Safety

Lithium-Ion Battery Safety Challenges

Issue: Fire due to external abuse to the cell/pack caused by

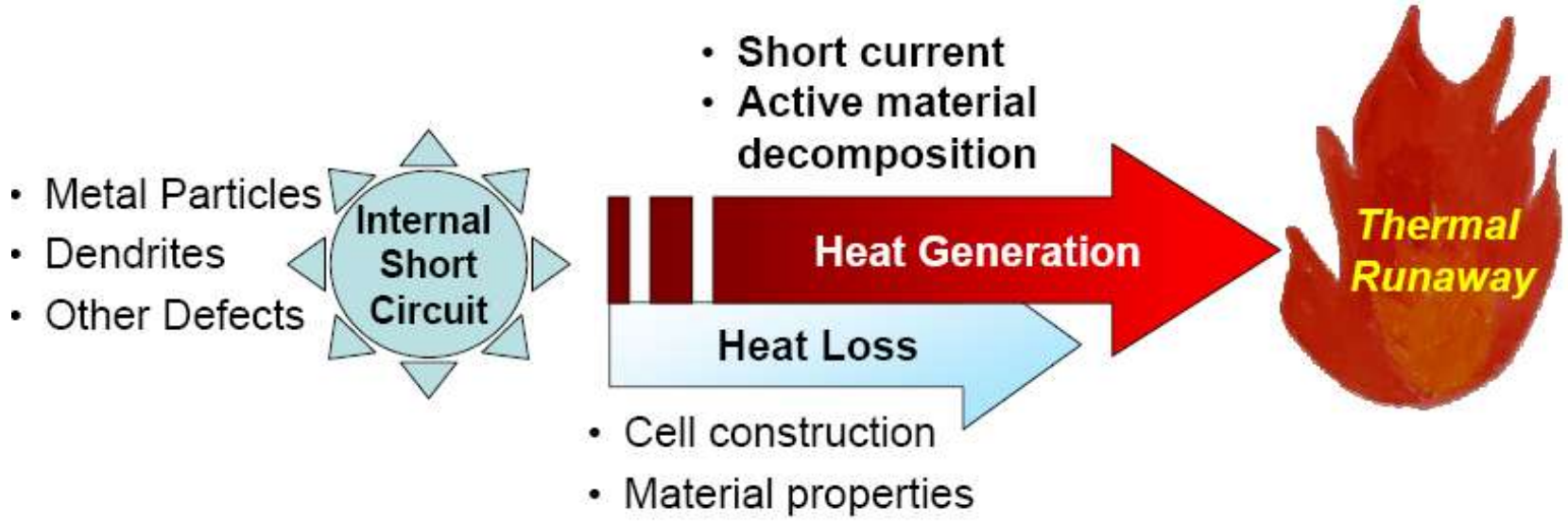
- Overcharge and high rate charge
- Overheating
- Mechanical abuse/crash leading to cell damage

Issue: Cell manufacturing problem

- Contaminant from manufacturing process
- Damage or defect with cell assembly process
- Insufficient or lack of QC measurements

Safety Issues with Lithium Ion Batteries

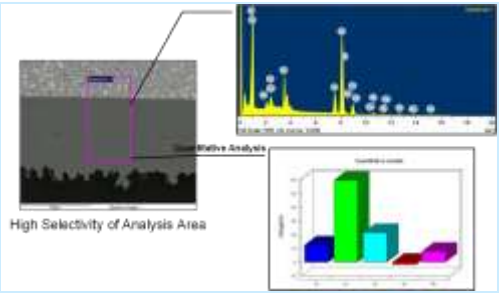
Mechanism of Thermal Runaway Following an Internal Short-circuit



Research and Development

Research tailored to understanding failure modes, improving test methods and standards

- Battery hazard analysis –using FTA and FMEA
- Blunt Nail Crush and Internal Short Circuit test methods evaluation with program partners
- Analysis and identification of battery components including electrolytes, anode, cathode and separator materials
- Thermal, electrochemical and functional materials analysis for surveillance and test method development



Addressing Battery Safety Challenges

Safety standard development and certification enables risk management

- Development of test methods through STP and industry collaboration to ensure rigor, simulating real world conditions
- Partnerships with fire marshals and Authorities Having Jurisdiction (AHJ) to create guidance for fire suppression, extraction/personal protection
- Certification ensures ongoing compliance and no substitution of components/materials
- Electrochemical and functional materials analysis, computational modeling of failures and forensic identification of battery components/materials
  - Supports surveillance and test method development
- Program partnerships with Government National Laboratories and battery supply chain to correlate manufacturing defects with field failures

Conclusions

- Market for electrical vehicles and large EV batteries overall to depend on sustaining Government incentives globally
- Pace of evolution of the large battery technology, global supply base and self certification largely prevalent today create need for standardization relative to infrastructure, battery designs and safety
- UL's participation in standardization activities as related to large batteries safety is to be through industry and ANSI consensus process
- To facilitate technology deployment, Government and Industry need to collaborate to address and secure the infrastructure. Without supporting infrastructure any research or standardization activities necessary to support deployment efforts risk roadblocks

Thank you!

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