

The Current ES Safety Codes Roadmap

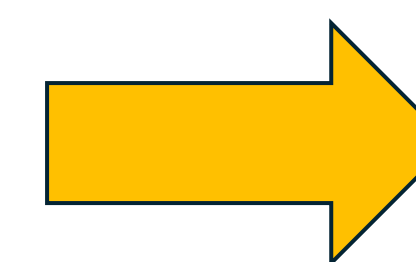
Which road(s) are the best to follow



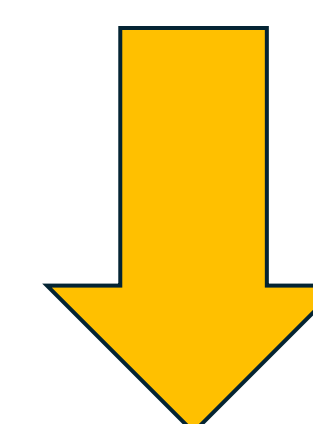
While other regulatory clouds and liability issues hang above.



At the 20K foot level, the two Fire Codes and NFPA 855 and UL 9540 are considered the baseline standards that govern ESS Installations.



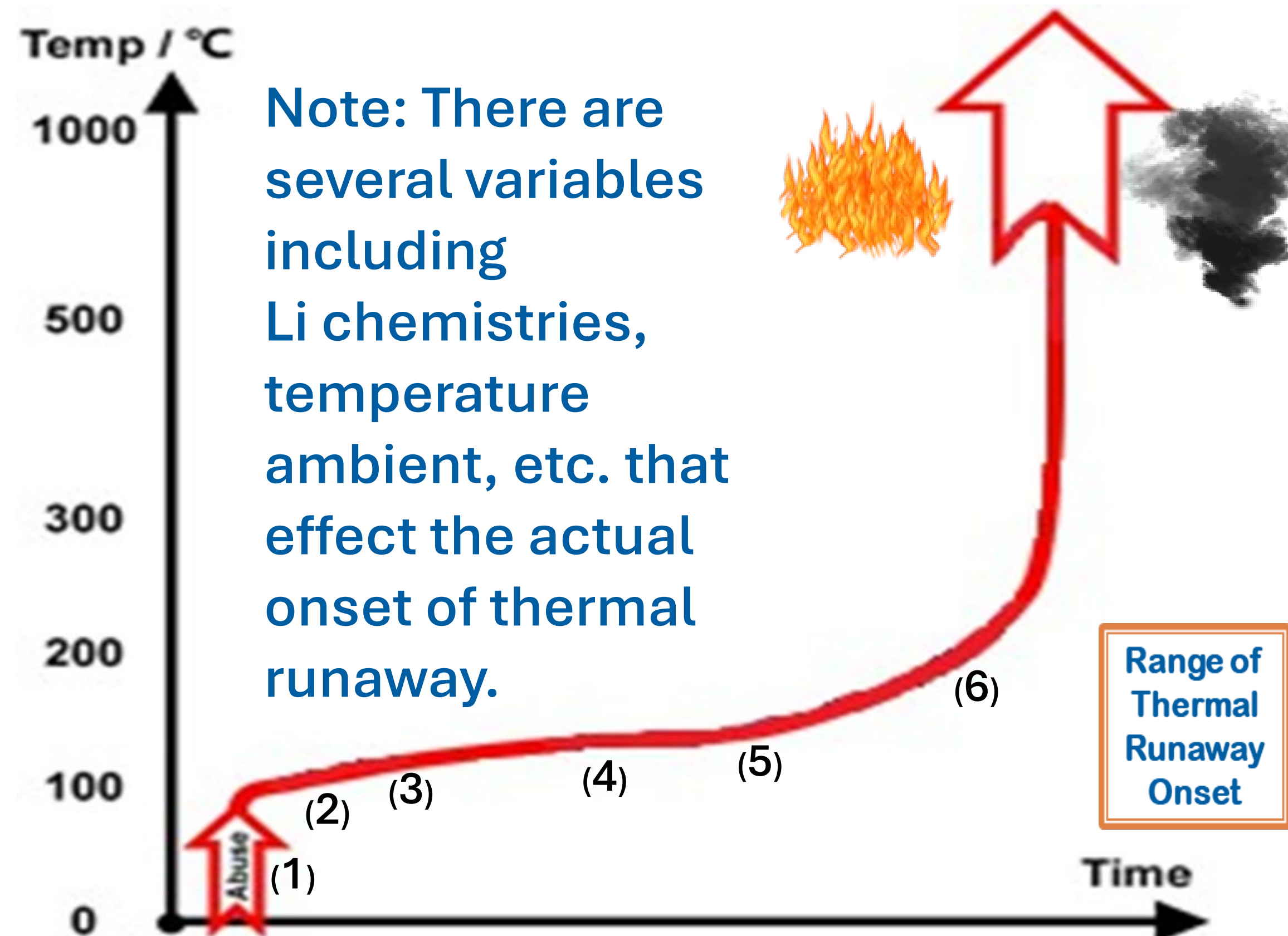
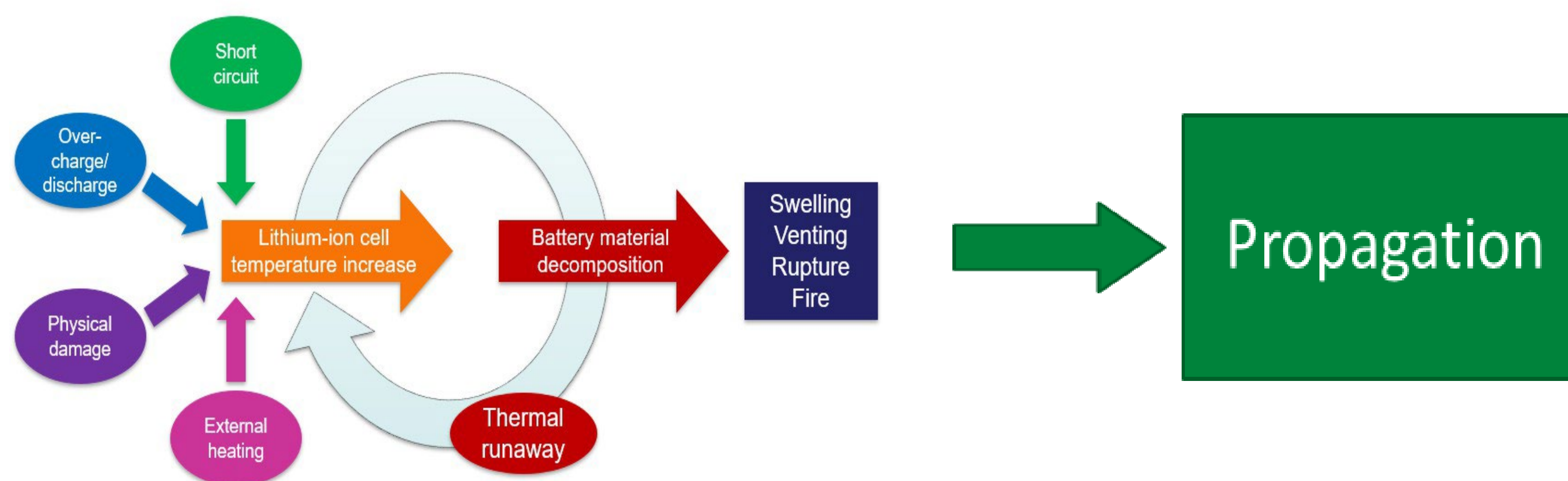
However



There are significant SAFETY issues that add Complexity for Li-ion Batteries

HAZARDS THAT CAN LEAD TO THERMAL RUNAWAY

- Electrical
- Mechanical
- Fire/Explosion
- Chemical



Note: There are several variables including Li chemistries, temperature ambient, etc. that effect the actual onset of thermal runaway.

- (1) Heating starts
- (2) Negative electrode protective layer (SEI) breaks down (~80°C)
- (3) Negative electrode breaks down with electrolyte ($\geq 100^\circ\text{C}$) *Note: LTO breaks down around 375°C.*
- (4) Separator melts, possibly causing short circuit ($\geq 120^\circ\text{C}$)
- (5) Positive electrode breaks down, generating oxygen (130-150°C) *Note: the LFP electrode breaks down ~275°C.*
- (6) Oxygen reacts with electrolyte ($>150-180^\circ\text{C}$)

During this process gasses (some toxic) are released, and fire can ignite inside the cell, but not in all cases.

Reference: John T Warner, Lithium Battery Chemistries 2009

Note: Chart put together by Curtis Ashton and Chris Searles. All values should be confirmed by the OEM you are working v

BESS TYPE	General Specifications ¹				Applications				Monitoring		Thermal Runaway	\$ per kWh
	Wh/kg	Wh/L	Cycles to 80% DOD	Yrs on Float	Data Ctr	Utility	Telco	PV Micro-grid	BMS	ESMS		
LFP	100	105	5,000	13	YES	YES ²	YES ³	YES ³	YES	YES	YES	\$400
LMO	100	120	1,500	13	YES	YES ²	YES ⁴	NO	YES	YES	YES	\$550
LNMC	135	120	2,000	13	YES	YES ²	YES ⁴	NO	YES	YES	YES	\$550
LTO	80	80	15,000	20	YES	YES ²	YES	YES	YES	YES	YES ⁵	\$600
NaNiCl	90	110	2,000	20	YES	YES ²	YES	YES ³	YES	YES	NO	\$800
Na-Ion	90	100	2,000	13	YES	YES ⁵	YES ⁵	YES ⁵	YES	YES	NO	\$600
NaS	200	350	4,500	15	NO	NO	YES	YES	YES	YES	NO ⁷	\$300
NiMH	50	35	3,000	13	YES	YES	YES	YES	YES	YES	YES ⁵	\$450
NiZn	70	115	700	13	YES	YES	YES	NO	YES	YES	NO	\$650
Ni-Cd	55	80	1,500	25	YES	YES	YES	YES	NO	Option	NO	\$625
VLA	25	50	3,000	20+	YES	YES	YES	YES	NO	Option	NO ⁸	\$300
VRLA (AGM)	40	90	2,500	15+	YES	YES	YES	YES	NO	Option	NO ⁹	\$200
VRLA (Gel)	40	90	3,000	15+	YES	YES	YES	YES	NO	Option	NO ⁸	\$200

As a result 26 Technical Groups have been initiated by the NFPA 855 Committee to incorporate other potential BESS technologies and considering adding a new NFPA 800 standard that will address the full cycle of BESS technologies.