



# The Outlook for Lithium-Ion Batteries in Stationary Applications

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# Agenda

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- 1** Introduction
- 2** Li-ion basics
- 3** Safety
- 4** Reliability and availability
- 5** Charging
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# Introduction

- Li-ion success in portable applications now moving to all types of electric vehicles
- Li-ion factories coming online in USA under ARRA funding
- High volume capabilities and lags in EV acceptance will drive manufacturers to explore other applications
- ...including standby power
- Are you ready?



# Li-ion basics – drivers

- Compact and lightweight
- Sealed, with no routine maintenance
- Very high efficiency: >95%
- Long calendar and cycle life (some technologies)
- Intelligence (charge management, SOC indication, communication...)
- Cost reduction in high volume production

# Li-ion basics – a family of electrochemistries

## ■ Positive electrode (cathode)

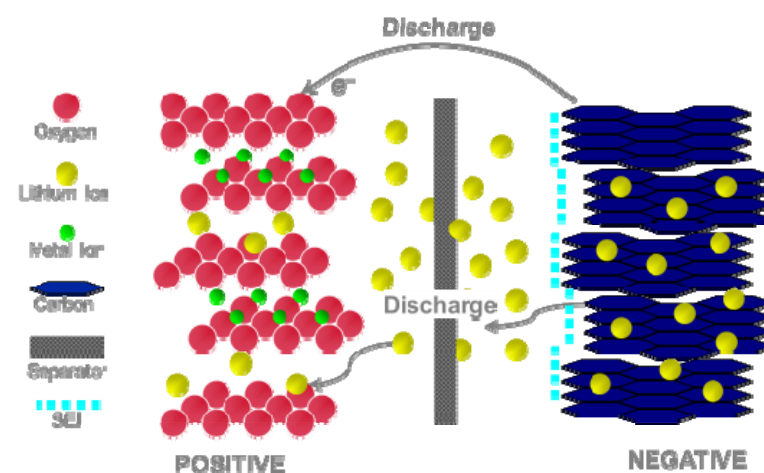
- > Lithium cobalt oxide - LCO
- > Lithium nickel-cobalt-aluminum oxide - NCA
- > Lithium nickel-manganese-cobalt oxide – NMC
- > Lithium manganese oxide - LMO
- > Lithium iron phosphate - LFP

## ■ Negative electrode

- > Graphite
- > Hard carbons
- > Lithium titanate

■ Varying cell voltages – but all higher than lead-acid

■ Non-aqueous



# Li-ion chemistries: trade-offs (various existing cathodes and graphite anode)

LFP trade off safety for less energy and less life

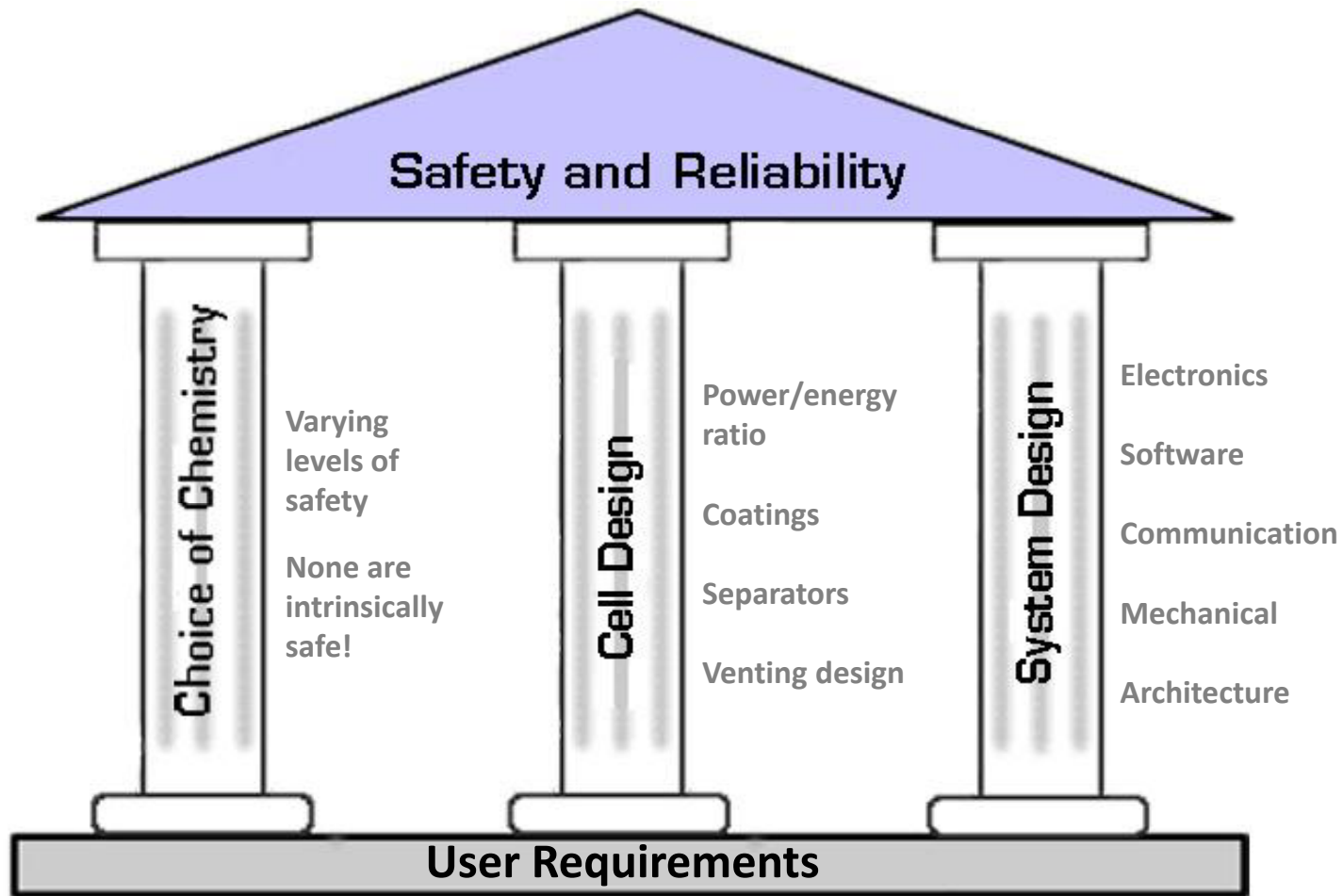
Cobalt is expensive

LMO trade off safety against performance

	LiCoO <sub>2</sub>	NCA 4.0V	NCA 4.2 V	NMC	LiMn <sub>2</sub> O <sub>4</sub>	LiFePO <sub>4</sub>
Energy Wh/kg or L	Good	Good	Highest	Good	Average	Average
Power	Good	Excellent	Good	Good	Good	Good
Low T	Good	Good	Good	Good	Excellent	Average
Calendar life	Average	Excellent	Good	Good	Poor	Poor > 45°C
Cycle life	Average	Excellent	Good	Good	Excellent	Excellent
Safety ( <b>cathode only</b> )	Poor	Poor	Poor	Poor	Average	Excellent
Safety ( <b>cathode &amp; anode</b> )	Poorer	Poorer	Poorer	Poorer	Average	Good
Cost/ kWh	Higher	High	High	High	Lowest	High
Maturity	High	High (Saft)	Medium	Medium	High	Medium

# Safety

## ■ The three pillars of system design



# Safety (cont.)

- Robust system design can make any Li-ion chemistry extremely safe
- Using a “safe” chemistry does not guarantee system safety



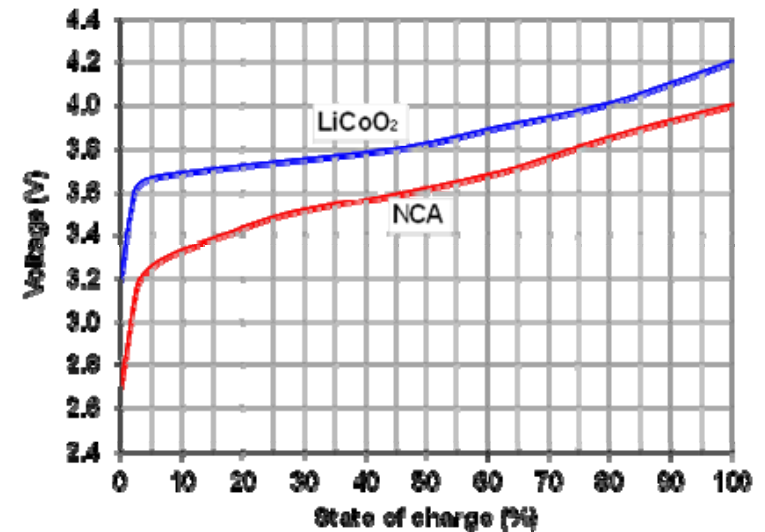
Google: Report of Investigation NRECA PHEV Fire.doc

# Reliability and availability

- Using electronics at cell level introduces additional failure modes
  - > Statistical series system – failure of one component results in loss of string
- With proper system design and communications, battery is self-diagnostic and can alert the user
  - > Reliability is lower, but availability remains high
- Parallel strings are mandatory in critical standby applications
  - > Level of redundancy appropriate for application
  - > Strings must be designed for higher loads due to loss of other string(s)
    - String-level circuit breakers and switches

# Charging

- Higher Li-ion cell voltage can make it challenging to work within traditional application voltage windows
- Sloping characteristic of SOC as a function of applied voltage
- Charge currents must be limited at high SOC and low temperatures
- Some massively paralleled systems based on consumer cells cannot be continuously float charged
  - > Charger ripple when battery offline?



# Sample applications

## ■ Questions exist for most applications

## ■ Telecom outside plant

- > Parallel strings OK
- > Voltage window must be verified
- > Current limiting?



## ■ Utility substations

- > Parallel strings?
- > Continuous float voltage level with no equalize?



## ■ UPS

- > Parallel strings OK
- > Current limiting?



# Summary

- Li-ion batteries expected to be promoted more aggressively for standby applications
- Compelling benefits in some applications
  - > Less so for others
- What is a user to do?
  - > Analyze your needs and flexibility to change the application to suit the battery
  - > Consult IEEE Std 1679-2010 “IEEE Recommended Practice for the Characterization and Evaluation of Emerging Energy Storage Technologies in Stationary Applications”
  - > Ask the right questions and don’t accept sales pitches at face value

**Thanks for listening!**  
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