THE EVOLUTION OF BATTERY TECHNOLOGY FOR THE EMERGING GLOBAL ELECTRIC VEHICLE MARKET

APRIL 2022

CONTEXT: THE GROWTH OF THE LIB CELL MANUFACTURING INDUSTRY TO SUPPORT EV MARKET GROWTH PRESENTS EXPANDING OPPORTUNITIES FOR INDUSTRY SUPPLIERS AND TECHNOLOGY DEVELOPERS

AND COVERS A BROAD CROSS SECTION OF CHEMICAL AND ENGINEERING SPECIALTIES

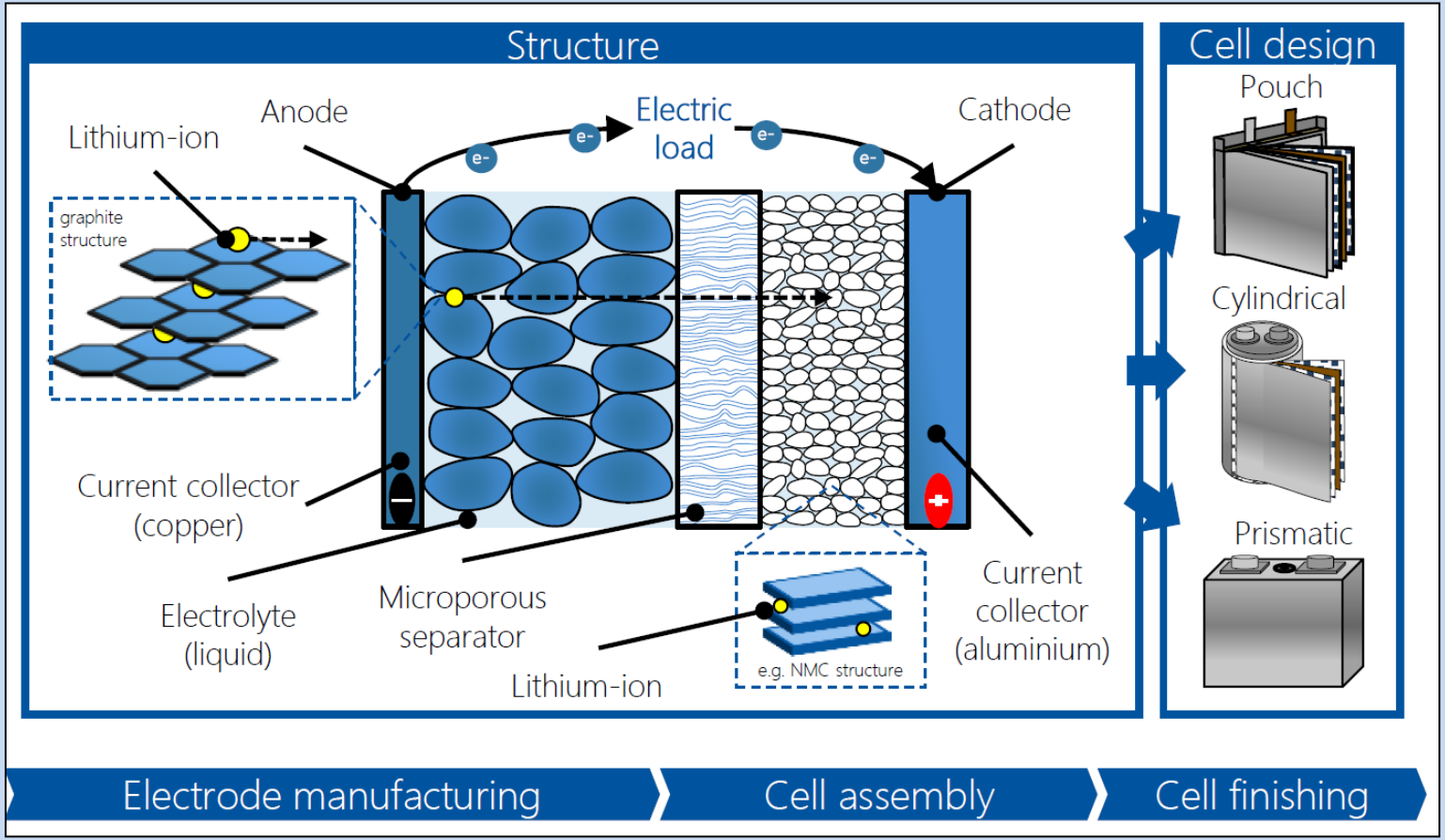
WITH NEW REGIONAL OPPORTUNITIES IN NORTH AMERICA AND EUROPE

Prepared for CCN

Ron Turi – Element 3 Battery Venture, LLC

April 13, 2022

Lithium Ion Cell



Battery Process – Step-by-Step Tour: https://www.pem.rwth-aachen.de/global/show_document.asp?id=aaaaaaaaabdqbtk

EV Applications

Example – BYD Blade Cell and Battery – LFP
96 cm * 9 cm * 1.35 cm
And very few cooling elements in between

https://ibikes.wordpress.com/2021/01/03/blade-cell-to-pack-lfp/

Similar theme:
GM Ultium with long thin pouch cells from LG Energy Solutions, with cooling elements

https://www.designnews.com/automotive-engineering/cadillac-lyriq-reveals-new-details-gms-ultium-battery-technology

https://www.wardsauto.com/alternative-propulsion/gm-joint-venture-prepping-ohio-battery-plant

https://ibikes.wordpress.com/2021/01/03/blade-cell-to-pack-lfp/

Other EV Skateboard Platforms –

- **VW MEB**
- **Hyundai-Kia E-GMP**
- **Volvo-Geely PS3**
- **REE Auto**
- **More!**

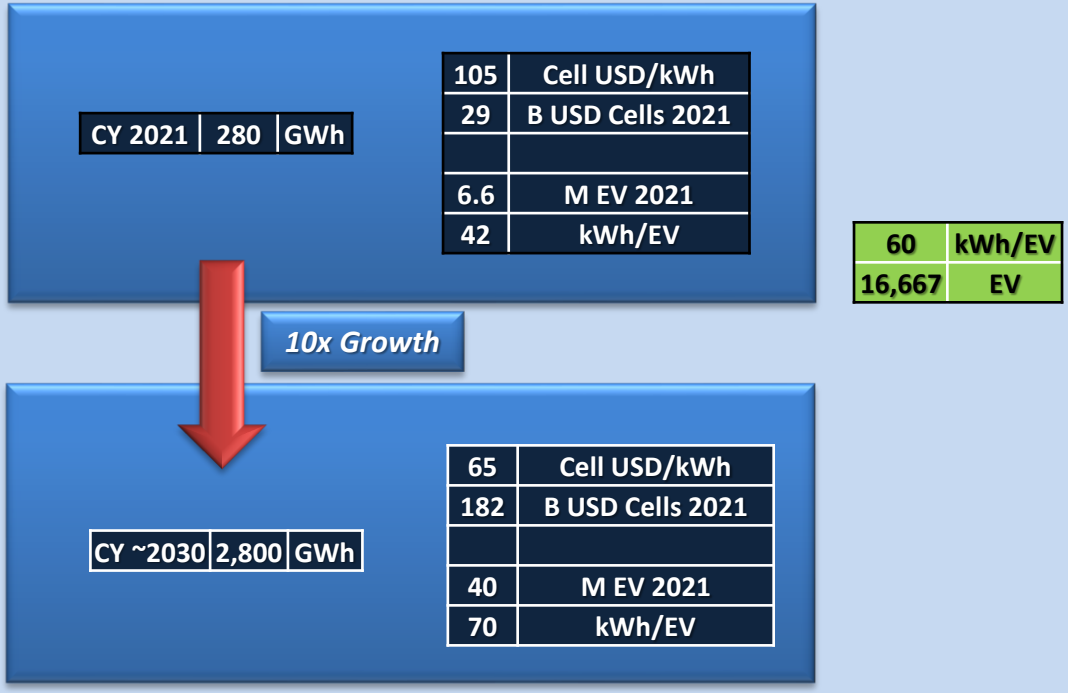
https://ree.auto/

PASSENGER EV BATTERY CELL MARKET SIZE

[>90% LIB MANUFACTURING INDUSTRY SIZE]

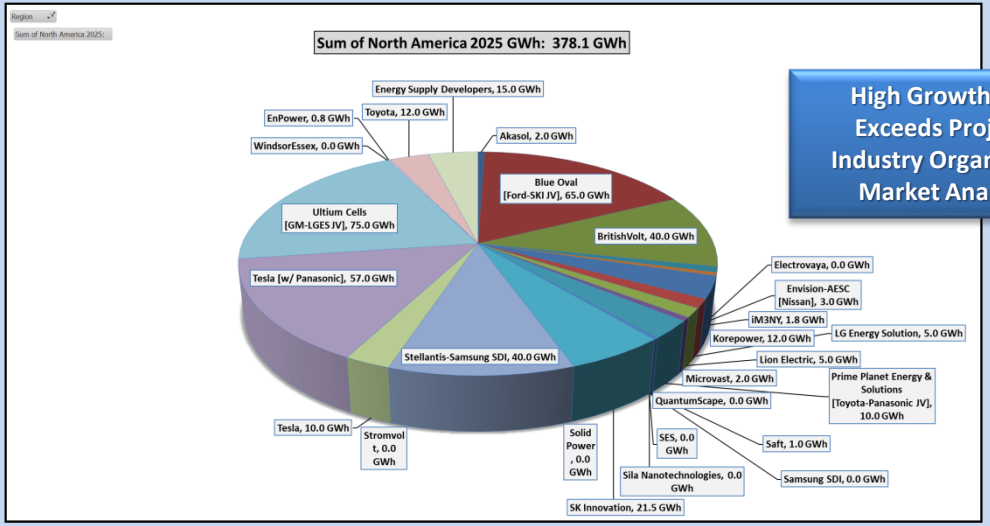
Passenger EV Battery Cell Market Size

[>90% LIB Manufacturing Industry Size]

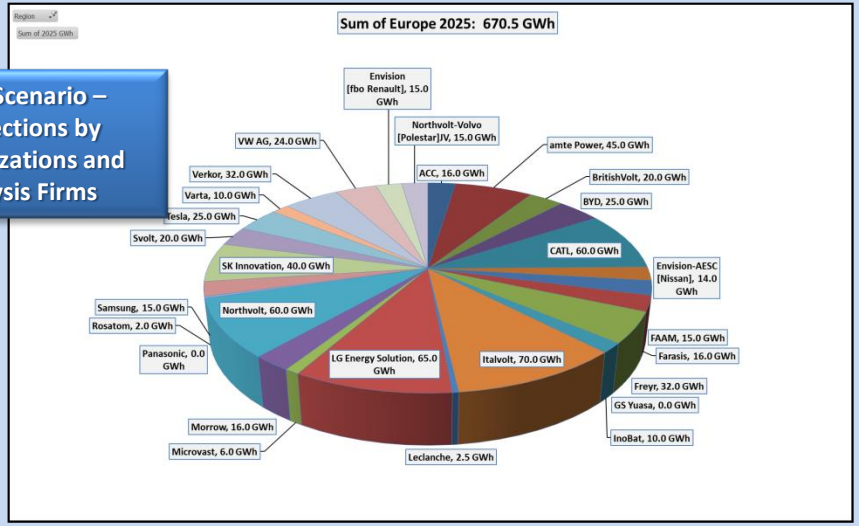


60	kWh/EV
16,667	EV

LIB Manufacturing Industry Growth – Announced Capacity Installed by 2025



High Growth Scenario – Exceeds Projections by Industry Organizations and Market Analysis Firms



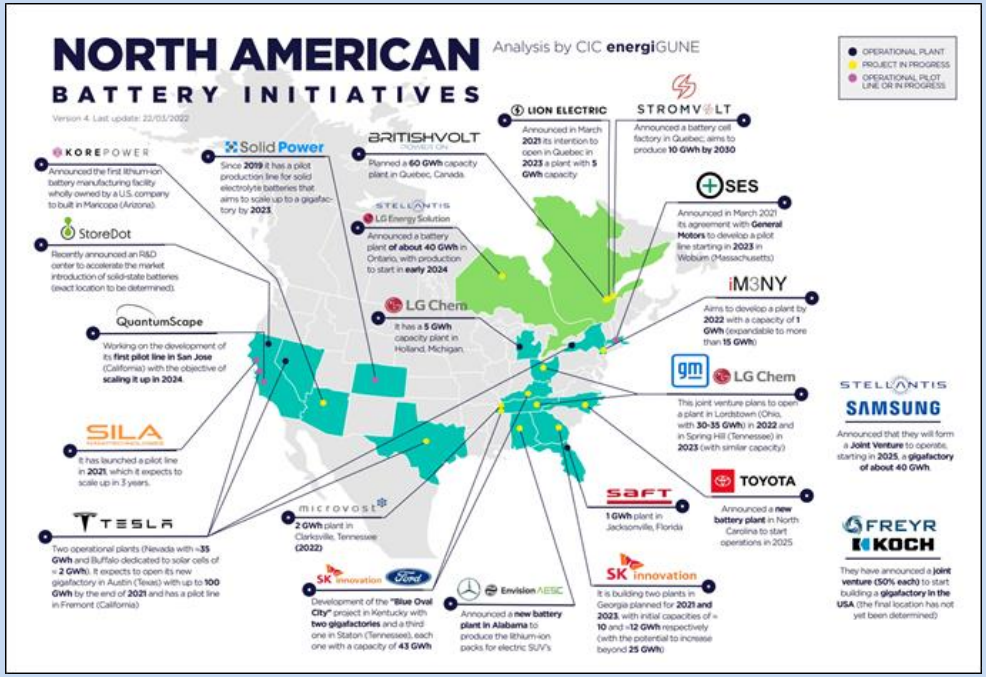
	2025 GWh	
Europe	671	35%
North America	378	20%
China	850	45%
	1899	

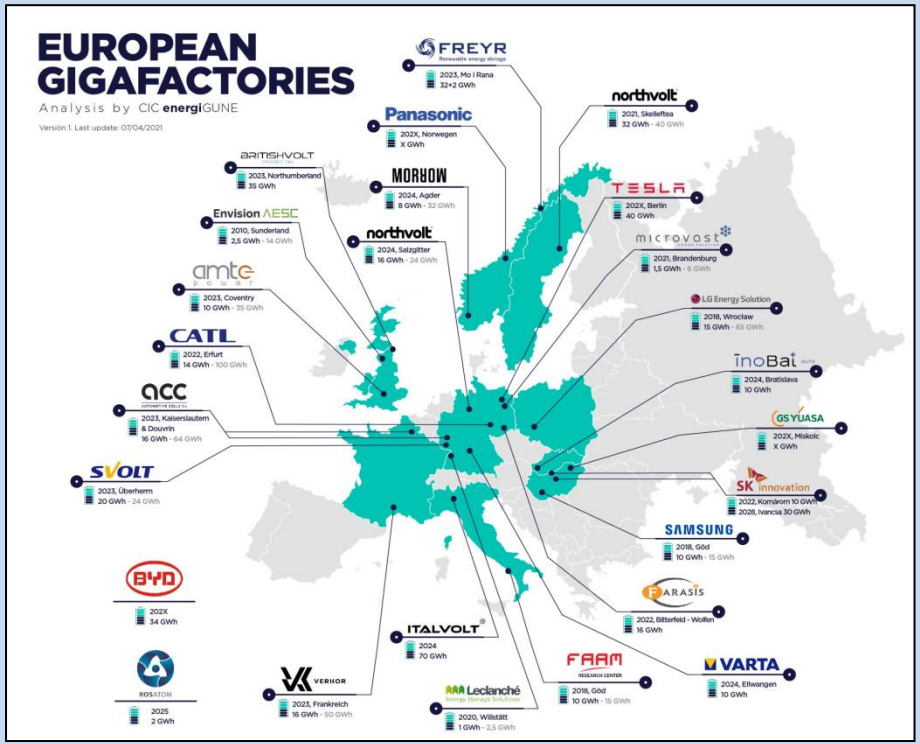
Industry announcements more than double GWh installed over Market Analysis Projections.

This view skews would shift the sigmoidal curve toward the present. 2025 in this view looks like 2028 in the market projections.

The more easily Addressable Markets in Europe and North America Regions together would be ~10 B of CAPEX for CY 2025.

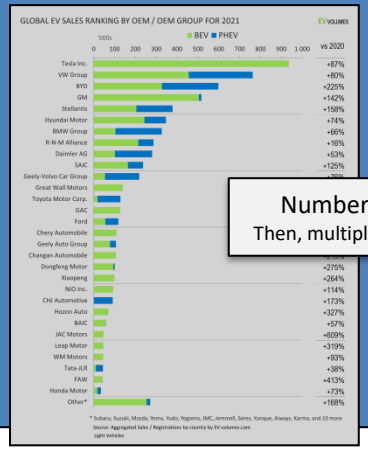
LIB Manufacturing Industry Growth – Announced Capacity Installed by 2025

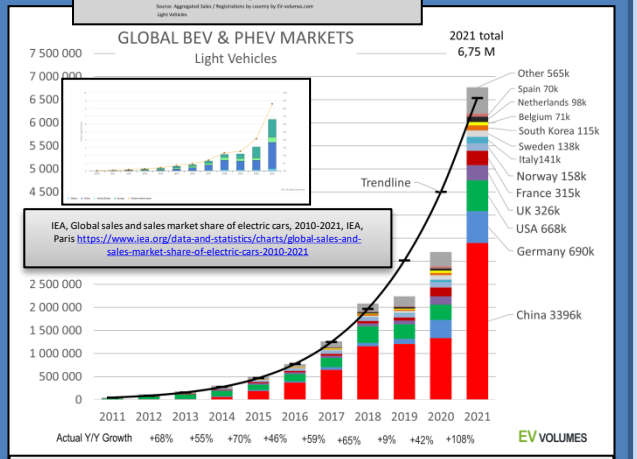




https://cicenergigune.com/en/blog/north-america-battle-electric-car-battery-gigafactories

EV LIB Cell Manufacturing Industry Growth – Data Sources



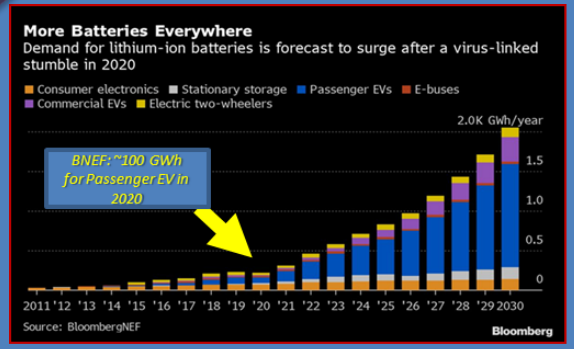


IEA, Global sales and sales market share of electric cars, 2010-2021, IEA, Paris https://www.iea.org/data-and-statistics/charts/global-sales-and-sales-market-share-of-electric-cars-2010-2021

https://ev-volumes.us14.list-manage.com/track/click?u=ca04a955ee00c125a45b8d88f&id=32d8dc9225&e=b084fd9d4a

Number of EV Sold
Then, multiply by kWh per EV

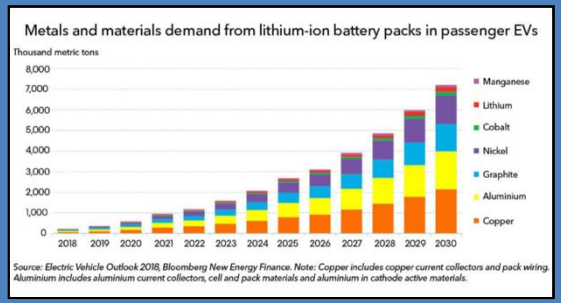
GWh of EV Batteries Manufactured



https://www.bloombergquint.com/technology/the-electric-car-battery-boom-has-screeched-to-a-halt-for-now

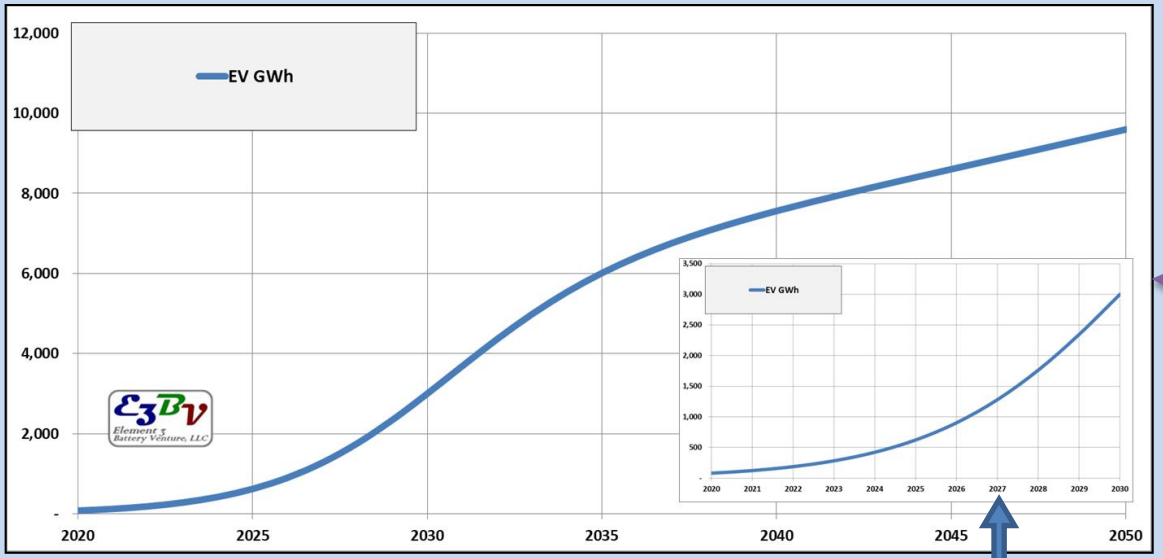
BNEF
Adamas
McKinsey
...
LIB Manufacturer Announcements

Tons of Raw Materials Used in EV Battery Manufacturing
Then check by LIB Compositions



Roskill
Benchmark Minerals
...
LIB Supplier Reports

LIB Manufacturing Industry Growth – E3BV "Compilation"



Looks "exponential" for 2020 to 2030 window

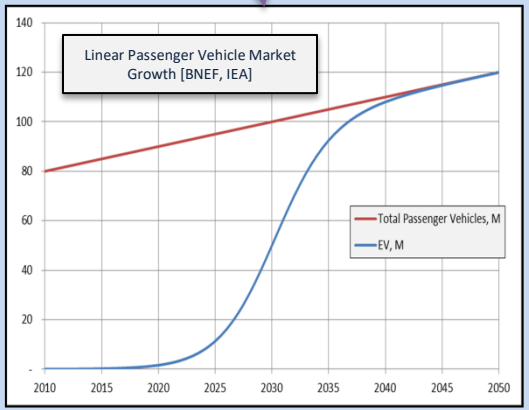
Sigmoidal Curve Model based on Multiple Inputs

From Industry Organizations and Market Analysis Firms

Without Weighing in Industry Announcements

Global Average kWh per Passenger EV	
2020	40 kWh/EV
2030	70 kWh/EV
2040	90 kWh/EV
2050	120 kWh/EV

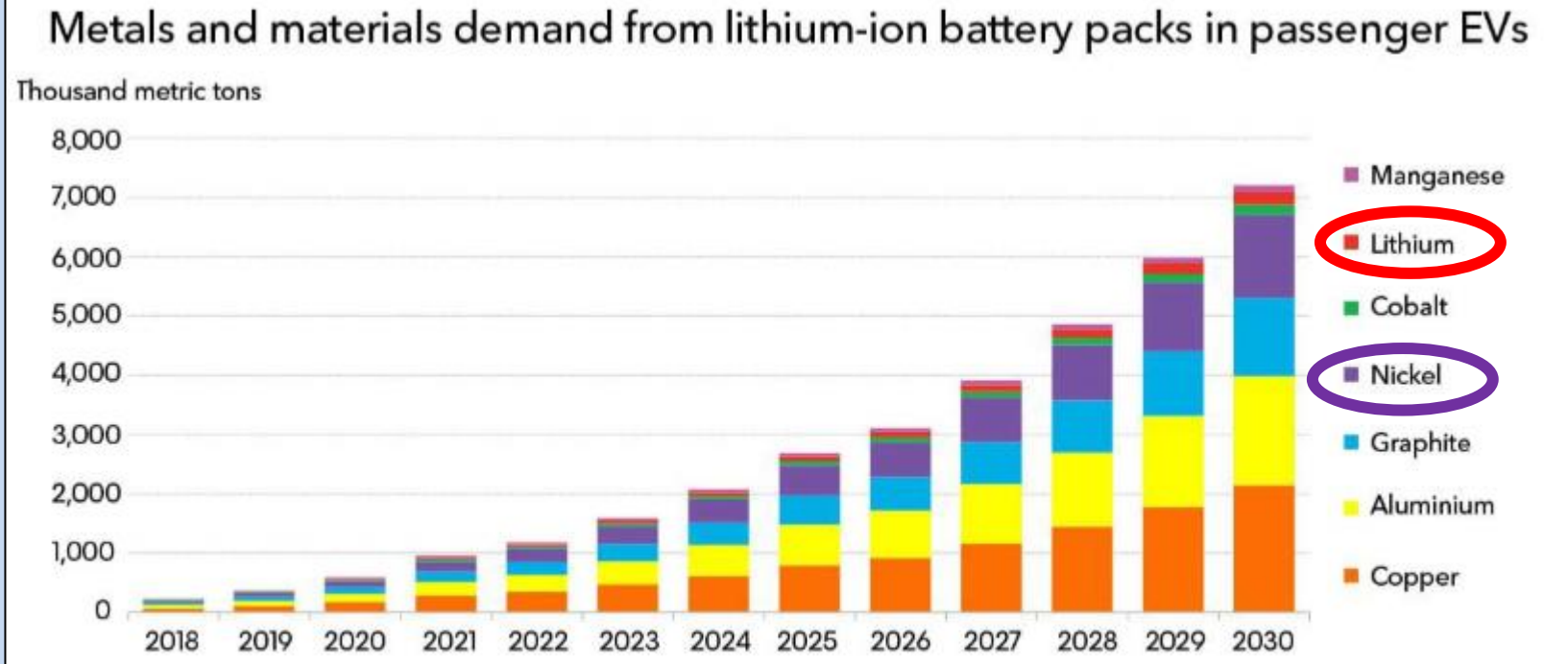
E3BV Assumption



LIB Industry Supply in the face of Growth

EV Battery Market Growth is Exciting for the Supply Chain – Near Term Exponential

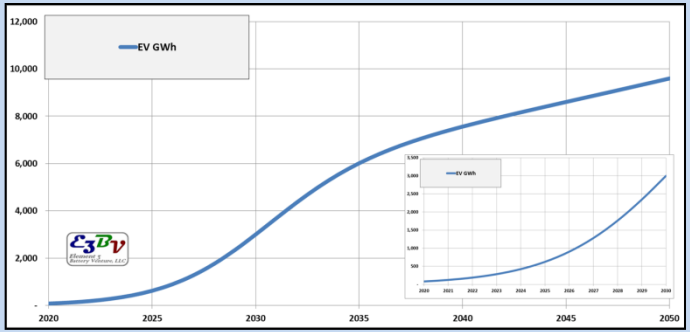
Projections of materials Technology Advancement – based on implementing cathode improvements → Ni-rich Cathode



Source: Electric Vehicle Outlook 2018, Bloomberg New Energy Finance. Note: Copper includes copper current collectors and pack wiring. Aluminium includes aluminium current collectors, cell and pack materials and aluminium in cathode active materials.

https://recyclinginternational.com/technology/snt-powering-up-dead-car-batteries-is-not-a-problem/16197/

LIB Manufacturing Industry Growth – Effect on Supply

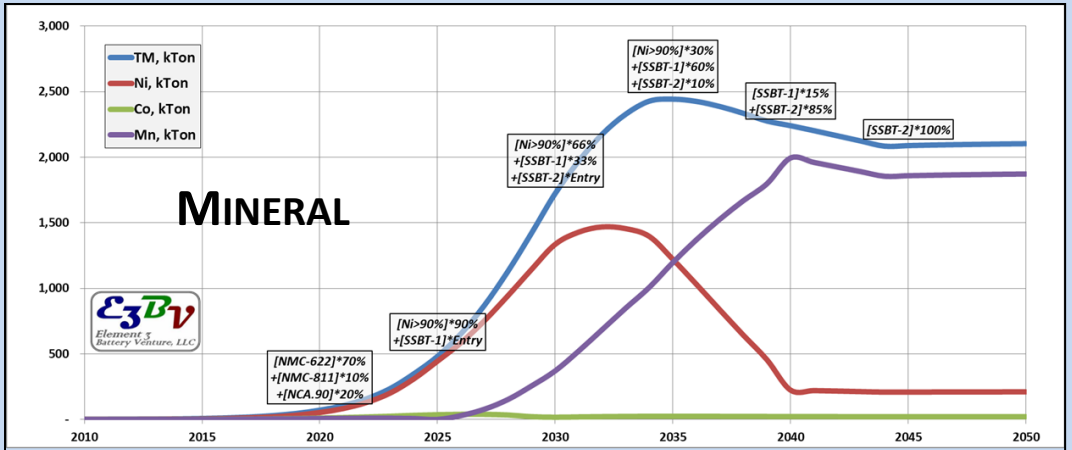


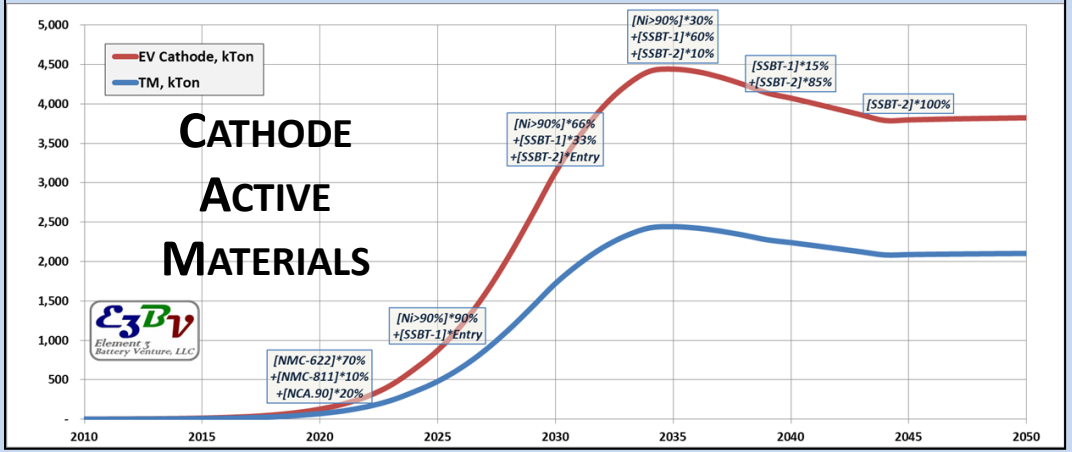
Sigmoidal Curve Model with Mineral and CAM Demand

These change shape, since the Cathode Chemistry Changes!

Potential for –

- Ni bottleneck – 5 to 8 years mineral development time frame
- Adoption of Lithium Iron Phosphate [LFP]

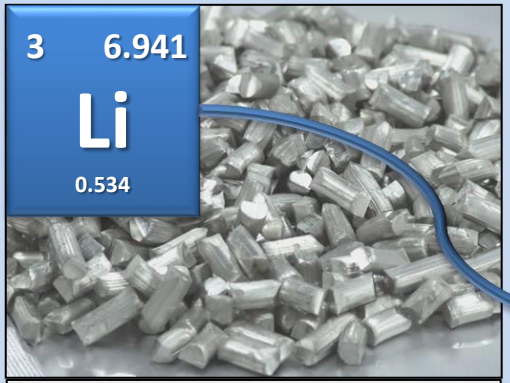




LFP versus Metal Oxide Cathodes In Lithium Ion Cells

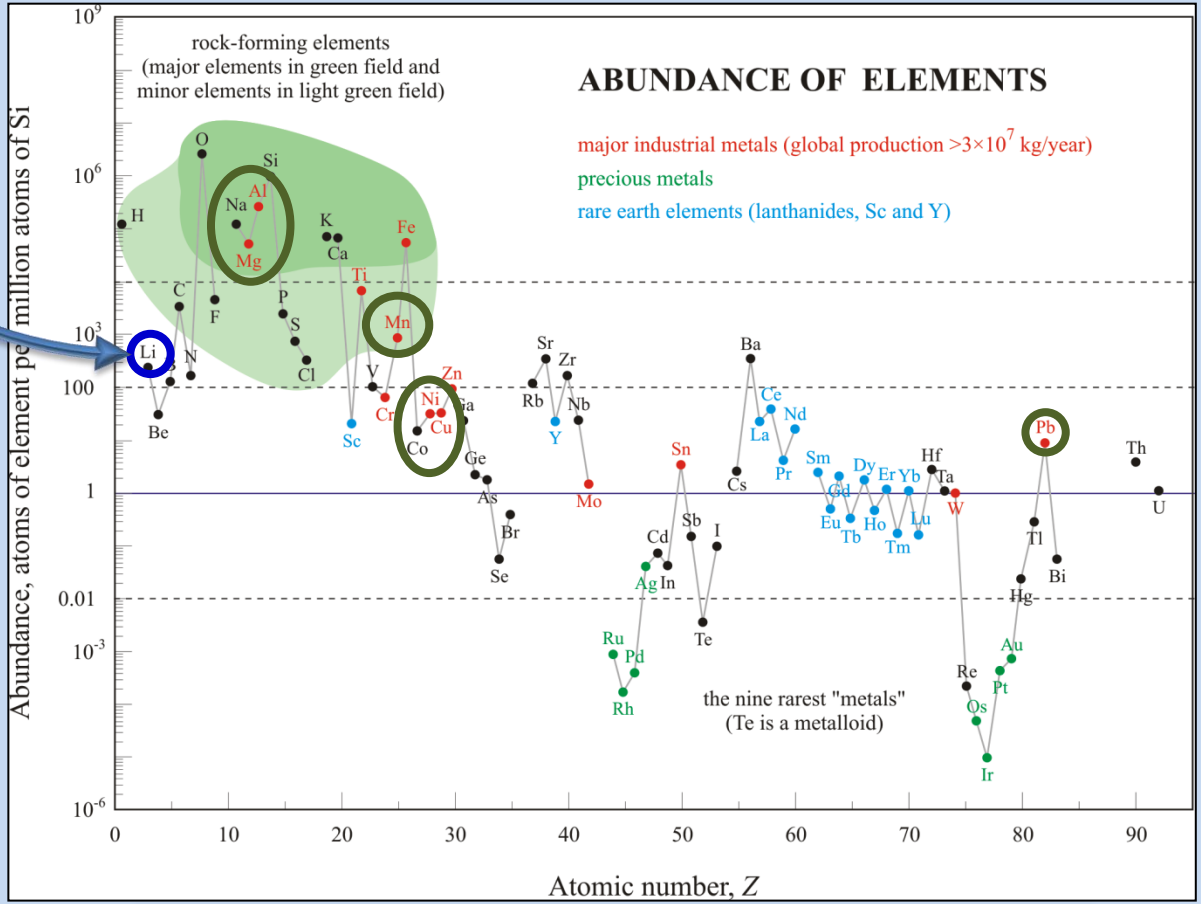
Property	Lithium Iron Phosphate [LFP]	Lithium Ion Ni-rich Cathode, Graphite	LFP with Silicon Anode or SSBT	Lithium Ion Ni-rich Cathode with Silicon Anode or SSBT	High Voltage Phosphate SSBT	High Voltage Metal Oxide SSBT
Energy Density Wh/L	300 Wh/L [Mature]	500 Wh/L [Going toward 650]	~500 Wh/L [Mature]	~1,000 Wh/L [EV OEM Motivation]	~1,000 Wh/L	~2,000 Wh/L
Safety: Cathode Autothermal temperature, ˚C	290˚C [anode initiates 150˚C]	170 to 190˚C [anode initiates 150˚C]	290˚C [Silicon initiates 150˚C, SSBT does not]	170 to 190˚C [Silicon initiates 150˚C, SSBT does not]	170 to 190˚C	220˚C
Cell Level Cost	85.USD/kWh	~125.USD/kWh 2020 ~100.USD/kWh 2025	Si: 60.USD/kWh SSBT: 45.USD/kWh	Si: 85.USD/kWh SSBT: 75.USD/kWh	45.USD/kWh	60.USD/kWh
Battery Level Cost [*Notional*]	100.USD/kWh	~150.USD/kWh 2020 ~120.USD/kWh 2025	Si: 75.USD/kWh SSBT: 60.USD/kWh	Si: 100.USD/kWh SSBT: 90.USD/kWh	55.USD/kWh	70.USD/kWh
Charge Voltage, Cell	3.65V Good for safety for liquid electrolyte Bad for manufacturing cost – more cells in series	4.2V Limited by electrolyte stability and cathode collapse	3.65V Cathode is already emptied	Si: 4.2V SSBT: 4.35V Limited by cathode collapse	5V	5V
Battery Life [*Notional*]	Long ~3,000 cycles Low annual TCO	~2,000 cycles	Si: ~1,000 cycles SSBT: Long ~5,000 cycles	Si: ~1,000 cycles SSBT: Long ~5,000 cycles	SSBT: Long ~5,000 cycles	SSBT: Long ~5,000 cycles

LITHIUM, LITHIUM EVERYWHERE?



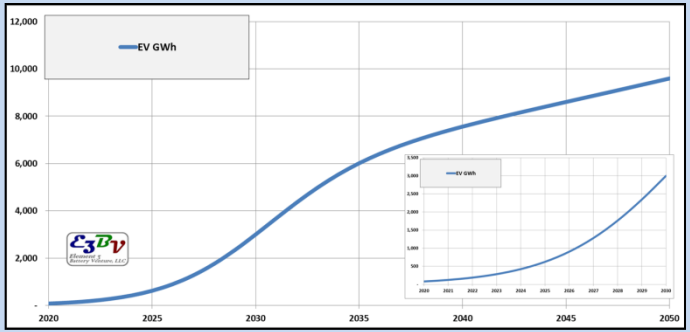
https://www.reade.com/media/zoo/images/lithium_elements_eb20b4c9a88cda92768c83e77e12e1de.jpg

1. LITHIUM IS NOT RARE
2. LOWEST DENSITY METAL, SOLID
3. 3,861.MAH/G – HIGHEST CAPACITY METAL
4. -3.04 V – FIFTH HIGHEST STANDARD ELECTRODE POTENTIAL OF ANY ELEMENT



https://www.periodni.com/pictures/relative_abundance_of_chemical_elements.jpg

LIB Manufacturing Industry Growth – EOL EV Battery / Recycling?

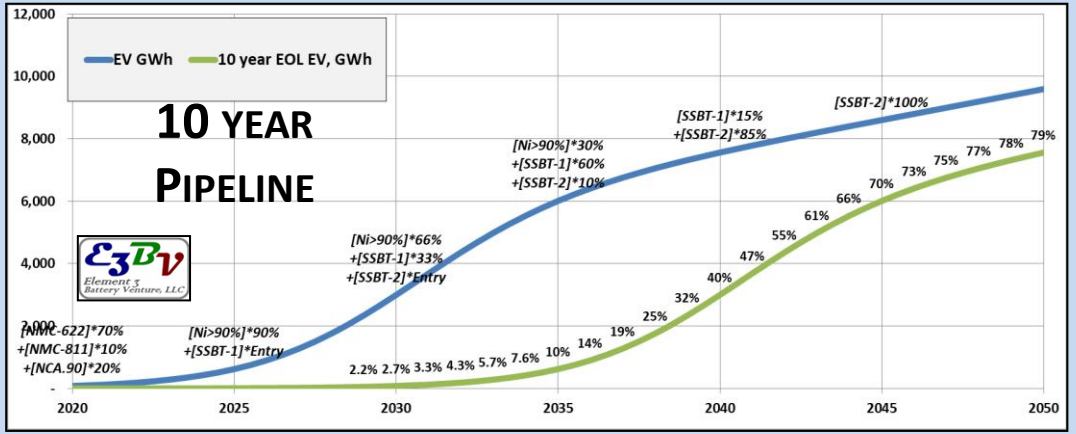


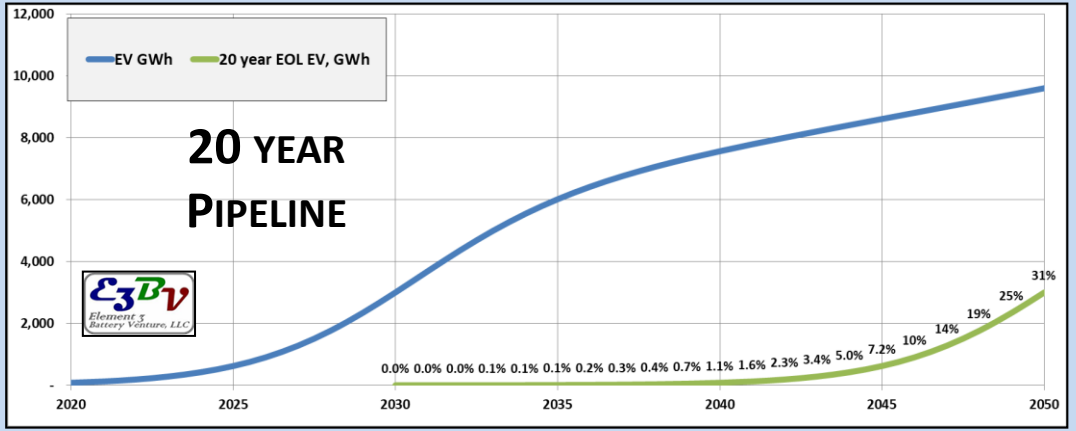
Sigmoidal Curve Model with End of Life [EOL] EV Batteries

Long pipeline!

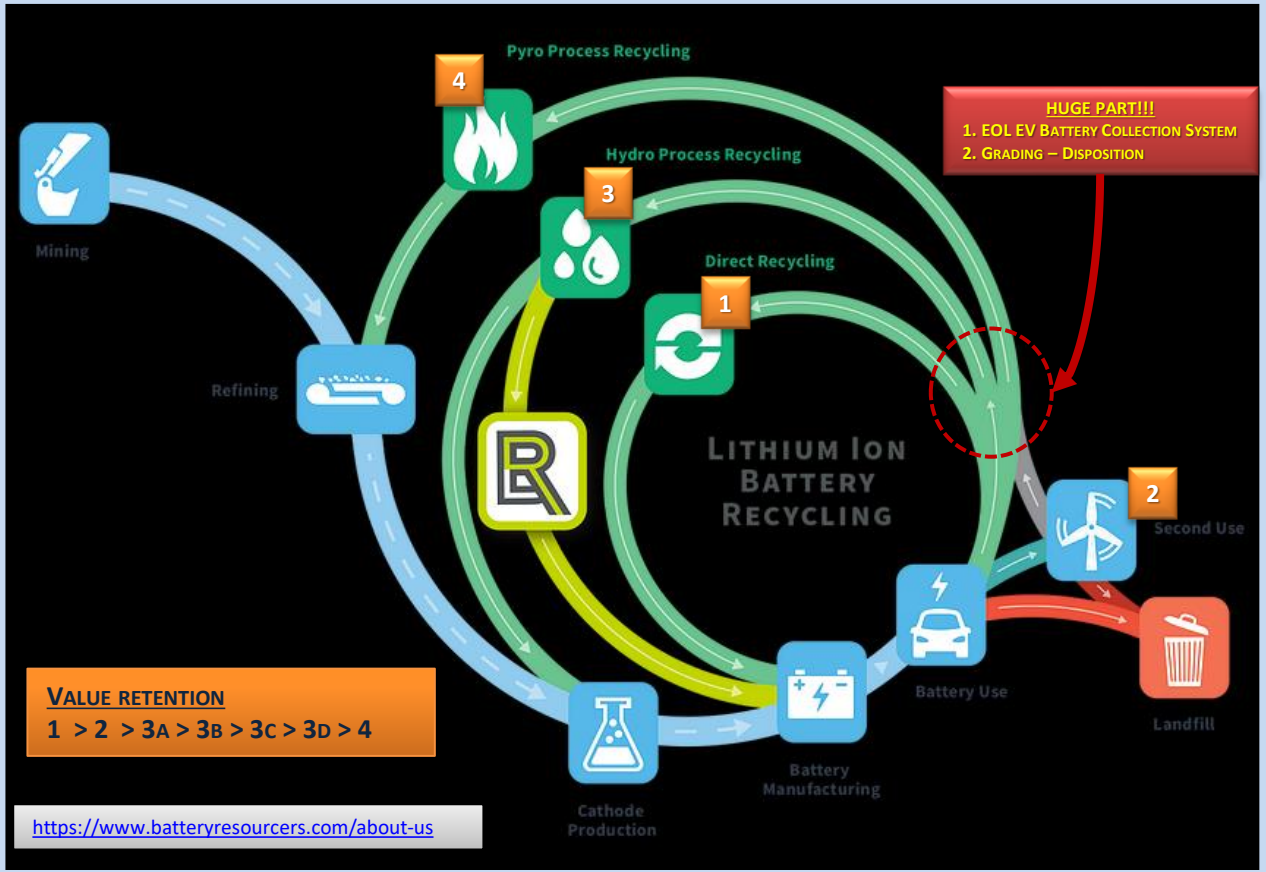
Potential for –

- EV Battery Remanufacturing
- Second Use as Grid ESS Batteries – Auto OEMs → Utilities
- Last resort, reclaim metals





Competition for EOL EV Battery Supply



1. Remanufacturing [Direct Recycling]

- Spiers, Cardone, Dorman

2. Second Use

- Grid energy storage – Utility and Behind the meter, capacity firming of renewables, grid stability – Numerous Battery Assemblers!
- Forklifts, materials handling, floor cleaners, robotics
- Commercial backup power – Telecommunications networks, Data Centers, Hotels, Business centers

3. Emerging Hydrometallurgical Recycling

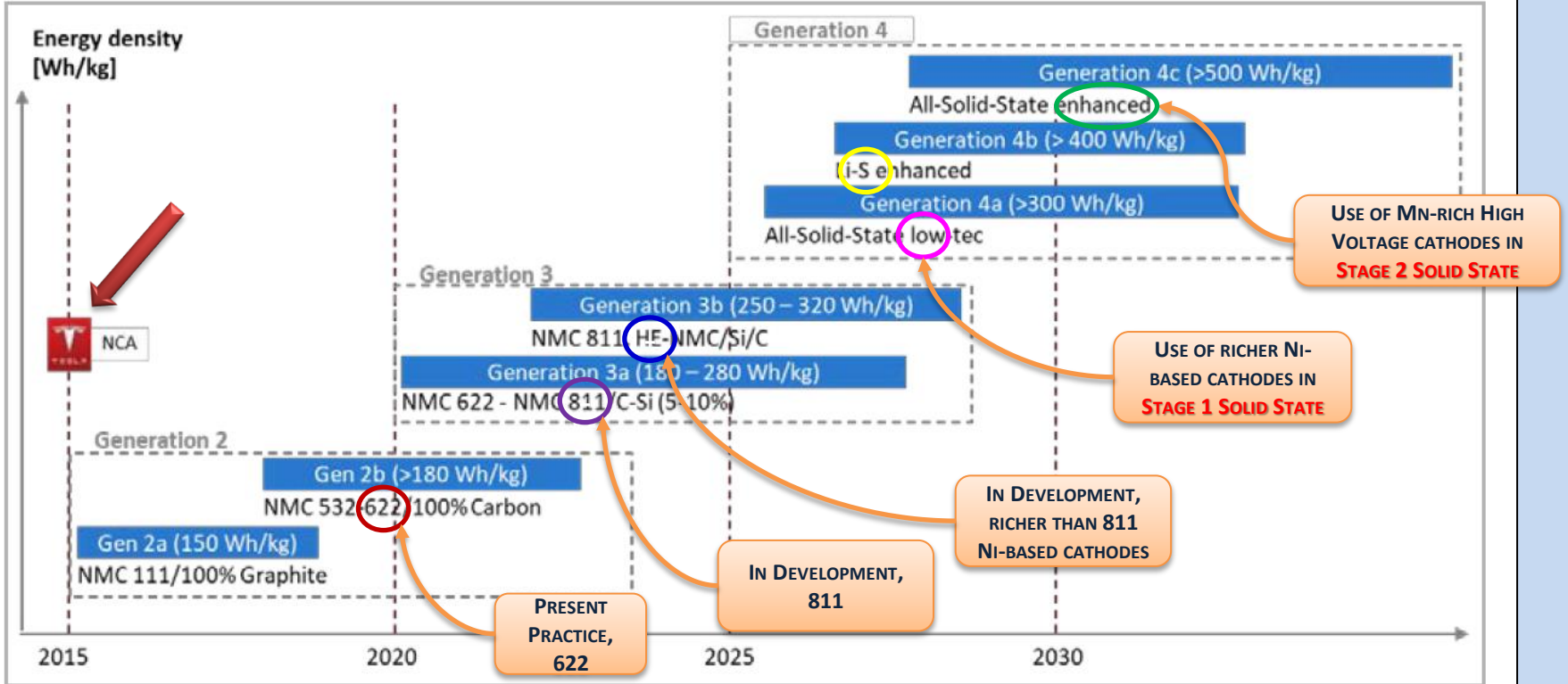
A. Cell repair
B. Electrode recovery
C. Active cathode material recovery
D. Metal salts – precursors to make cathode materials

4. Pyrometallurgical Recycling

- Smelting to recover metals using High temperature rotary kilns – existing industry
- Adaptation of existing lead smelting
  - Lead acid battery manufacturers
  - Independent Lead acid battery recyclers
- Adaptation of existing mineral processing industry

COMPETITION AMONG EV BATTERY MAKERS – EV OEMS DRIVES TECHNOLOGY

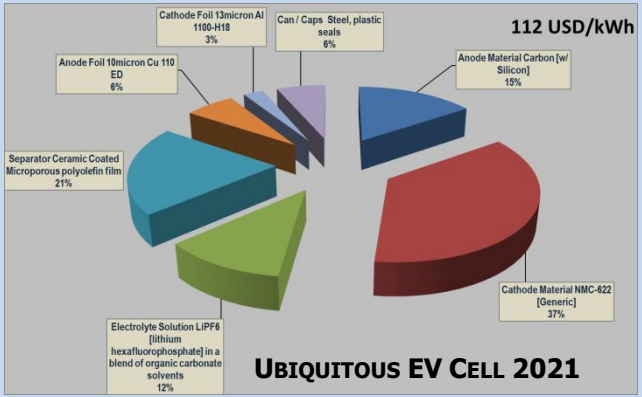
Cathode Active Material Progression

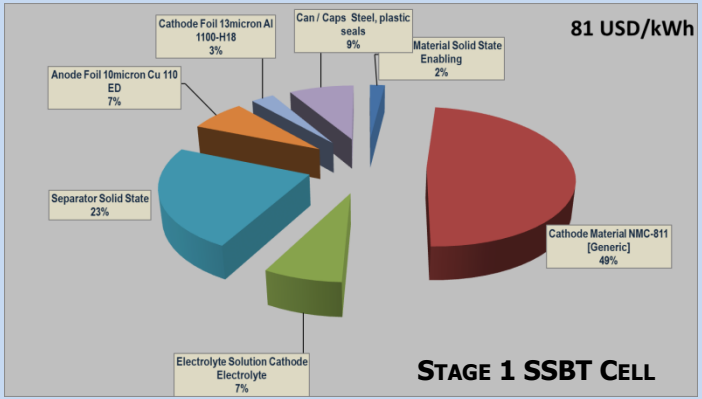


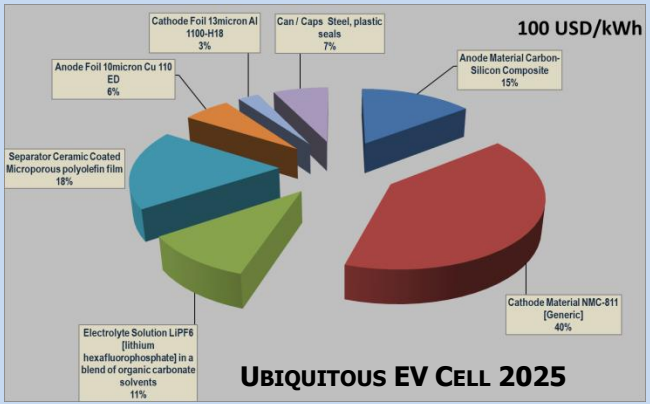
Sharova, Varvara et al. (2020), *Evaluation of Lithium-Ion Battery Cell Value Chain*, Working Paper **Forschungsförderung**, (168) Hans-Böckler-Stiftung, Düsseldorf https://www.econstor.eu/bitstream/10419/217243/1/hbs-fofoe-wp-168-2020.pdf

How does Solid State Battery Technology Reduce Materials Cost?

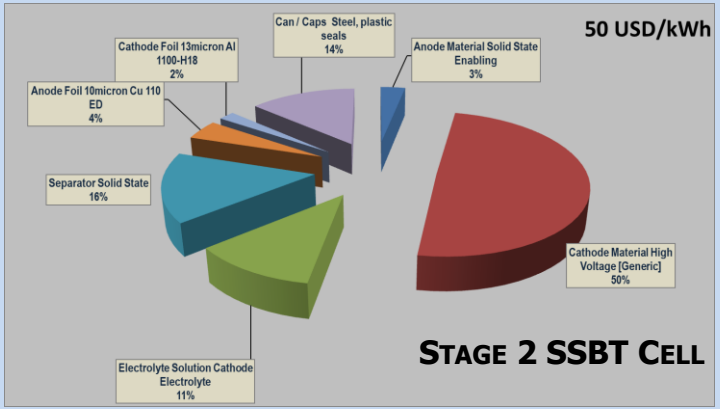
Stage 1 Materials







Stage 2 Materials



How much Li per kWh?

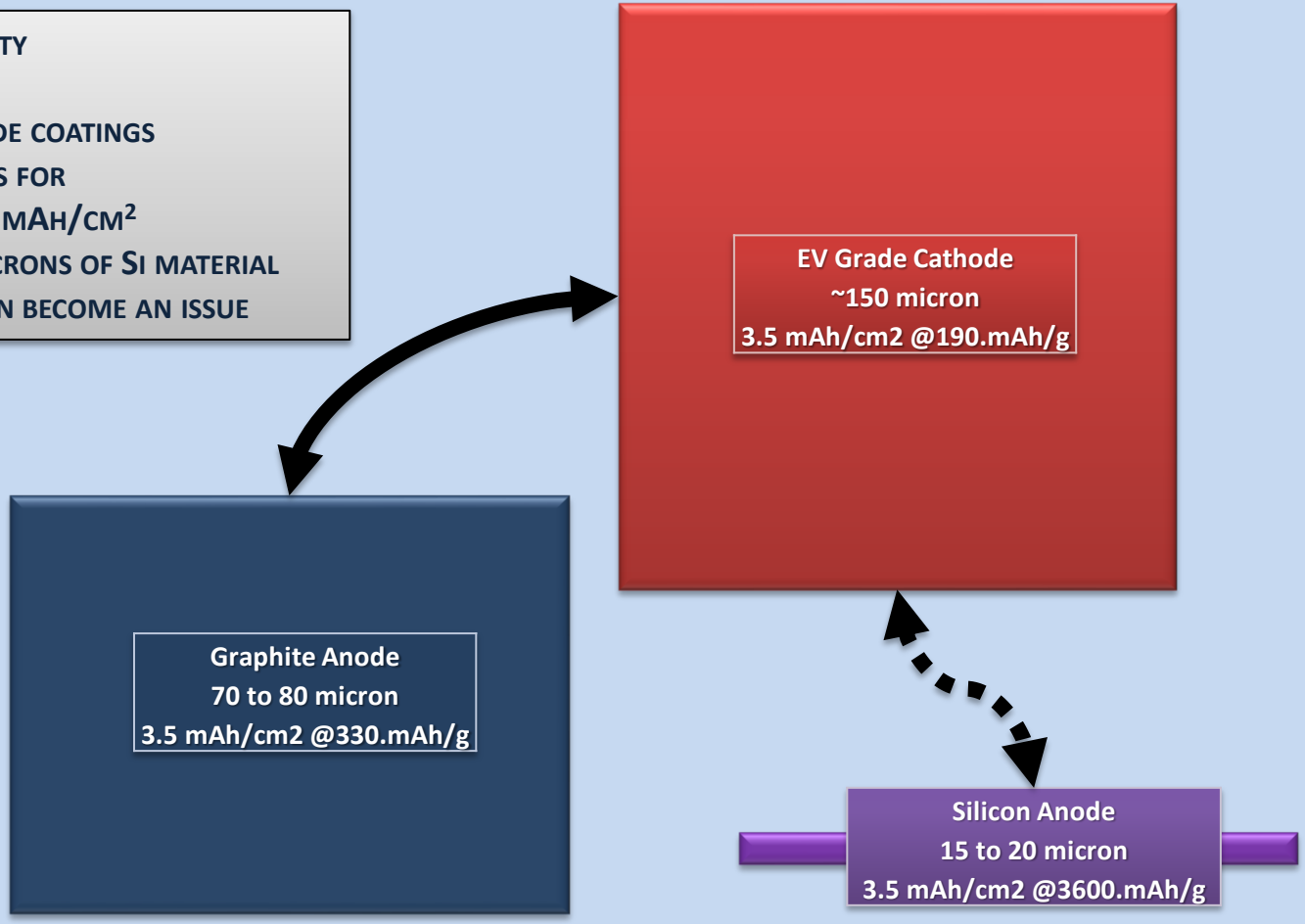
Effect of CAM

	Ni %mass in Cathode			Theoretical mAh/g	Actual mAh/g	Utilization %	Material Cost USD/kg	Material Cost USD/kWh	Ni g/kWh/Ute	Li g/kWh/Ute
LNO	60.1%	JMAT [abandoned]	2021	274	220	80%	14.3	17.5	739	87.3
NCA-90.05.05	55.0%	Sumitomo	2019	279	205	73%	14.7	19.4	806	95.2
NCA-85.10.05	51.9%	Sumitomo	2017	279	195	70%	15.3	21.2	847	100.1
NMC-811	48.3%	SKI-Cosmo	2018	275	185	67%	14.7	21.5	882	104.2
NMC-622	36.3%	Ecopro	2018	277	170	61%	15.2	24.2	963	113.8
NMC-532	30.4%	Umicore	2017	278	160	58%	14.5	24.5	1,027	121.4
NMC-111	20.3%	Umicore	2017	278	150	54%	15.9	28.6	1,097	129.7
LCO	0.0%	Umicore	2010	274	140	51%	26.3	50.8	1,158	136.9

COMPETITION AMONG EV BATTERY MAKERS – EV OEMS DRIVES TECHNOLOGY

The Engineering Challenge of Silicon Anode

2. Poor Electronic Conductivity
   → Semiconductor, undoped
3. Achieving very thin electrode coatings
   → Match practical cathodes for capacity by area, limit ~4.mAh/cm^2 that is often 10 to 20 microns of Si material
      → Uniformity can become an issue



Major Developers of Silicon Anode Materials

Company	Technology	Association	Cell Level Energy Density , Wh/L	Cycles to 80% Capacity
Sila Nanoechnologies	Scaffolding to hold Si Nanoparticles	BMW [2023], Daimler, Samsung, ATL	450	500
Enovix	Silicon Pieces Shaped into 3D	2021	900	700
Group14	Si-Hard Carbon Composite	REC [EnerG2 spin-out] SCC55 120 ton/yr WA ATL, BASF, and SK Innovation	900	2000
FerroGlobe	Silicon Mineral Processor	BioSolar - North Carolina A&T State University		
Evonik	Si Core from reduced silane gas with transition to graphite shell	Siridion Black Particles		
NanoGraf*	Holey Graphene Wrapped Si Nanoparticles	JNC		
Farad Power*	Si Composite with Renewable Carbon Precursor - Furfural Alcohol			
Aspen Aerogel	Aerogel of SiO2, Aerogel of Carbon	Evonik, SK Innovation		
Enevate	Numerous Approaches			
Nexeon	Complete Cells - SiOx?	Wacker, NSP-2		
Advano				
Elkem Battery Materials	Siliane Core Technology [PV]	Vianode subsidiary		
Sicona				
Shin-Etsu	Siliane Core Technology			
Amprius	Vapor Deposition Grown Si Nanofibrils	Stanford, BAIC [Biejing Electric], AirBus	[450]	[250]
3M	Transition Metal Doped Si	In use as additive - booster		
OneD				
Paraclete				
Tesla	Battery Day 2020, Thick SEI Layer, ionomer	Dalhousie U - Jeff Dahn?		
BYD	Announcement of Silicon-LFP Celss	For Blade Battery		

GROWTH OF EV BATTERY MANUFACTURING PLANTS

SILA NANOTECHNOLOGIES - SCAFFOLDING

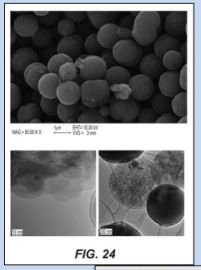


FIG. 24

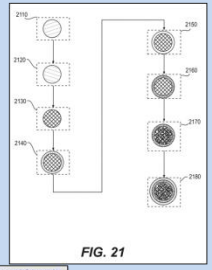
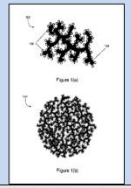
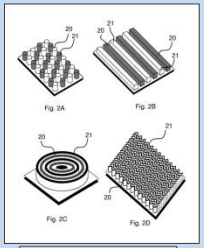


FIG. 21



- SCAFFOLDING AND MORPHOLOGY
- FILLS WITH LI DURING CHARGING
- SHELLS – ACTIVE OR NOT ACTIVE
- BINDERS FOR SI NANOPARTICLES
- DOPANTS TO SCAFFOLDING

ENOVIX – 3D SILICON STRUCTURES "ENGRAVED PILLARS"



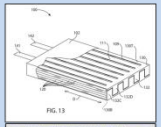


FIG. 13

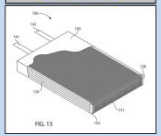


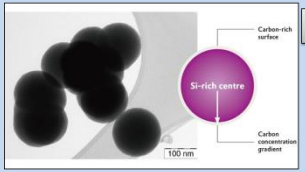
FIG. 15

- SHAPING SILICON PIECES IN 3D
- DIRECTING SI EXPANSION
- SPACERS IN THE 3D STRUCTURES
- SEPARATORS FOR 3D STRUCTURES
- CELL CONSTRAINTS

TESLA BATTERY DAY 2020 – SILICON PARTICLES WITH SSE POLYMER

- IONOMER → SOLID STATE POLYMER?

EVONIK SIRIDION BLACK – SI CORE WITH CARBON SURFACE



- GRADIENT OF INCREASING CARBON CENTER TO SURFACE
- SILANE CORE TECHNOLOGY

GROUP14 – HARD CARBON COMPOSITES

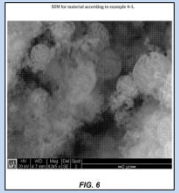
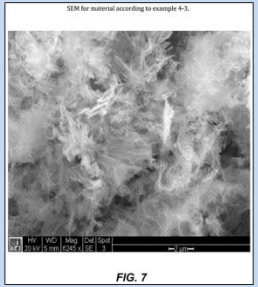
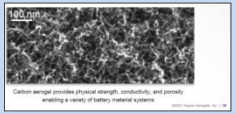


FIG. 6

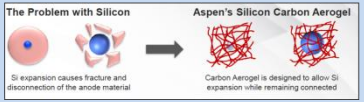

SEM for material according to example 4-3.
FIG. 7

- HARD CARBON PROTECTS SI
- FEATHERY COMPOSITE

ASPEN AEROGEL – SILICON PARTICLES IN CARBON AEROGEL



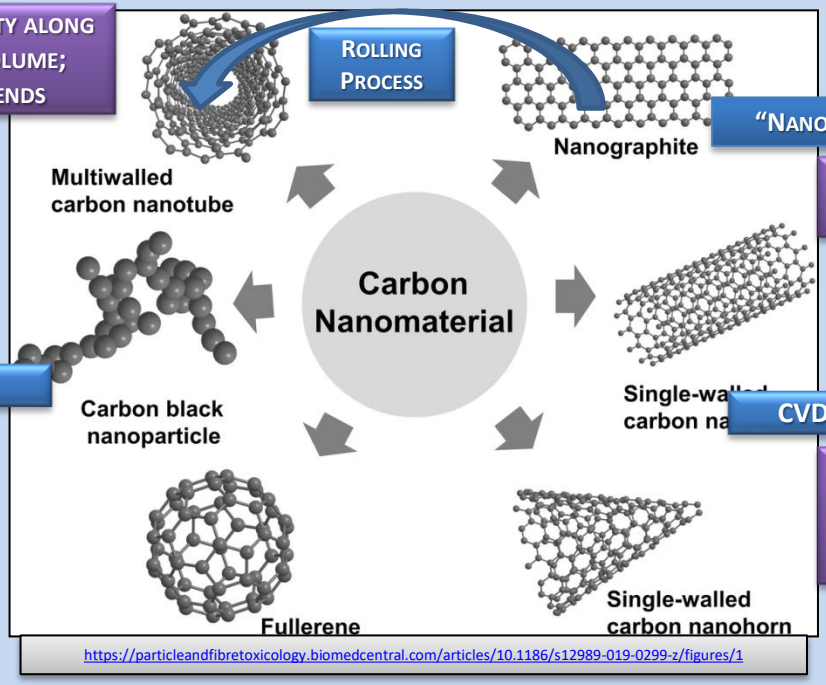
- ALREADY DEVELOPED CARBON AEROGEL
- EMBED SI PARTICLES



Brief Overview – What is a CNT?

Performance is all about Shape

MWCNT Excellent conductivity along its length; takes up more volume; more contact at the two ends



https://particleandfibretoxicology.biomedcentral.com/articles/10.1186/s12989-019-0299-z/figures/1

"Nanographite" = Graphene Nanoribbon

Graphene Wraps around materials; takes up little volume

Furnace Process

Carbon Black Engulfs lots of volume, makes many contact points

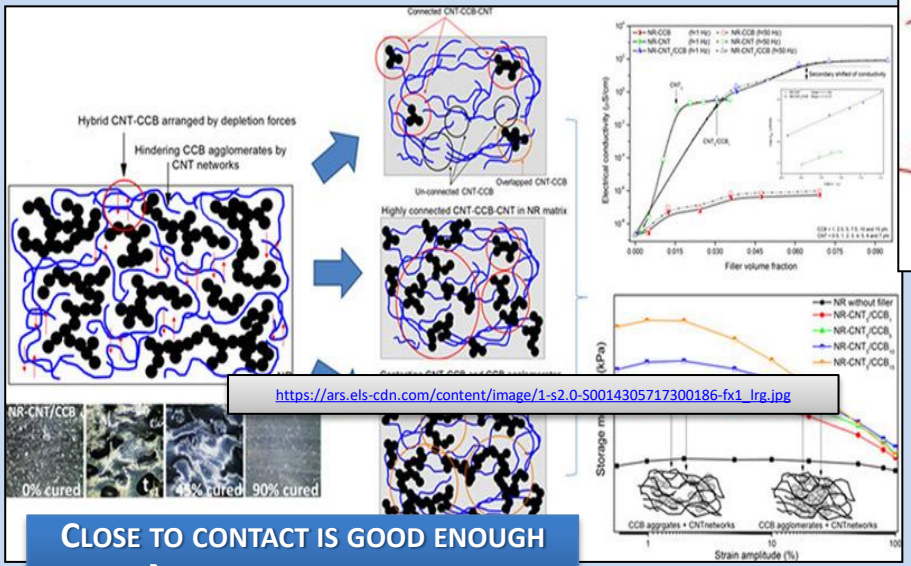
CVD Process $$$

SWCNT Excellent conductivity along its length; takes up little volume; contact best at the two ends

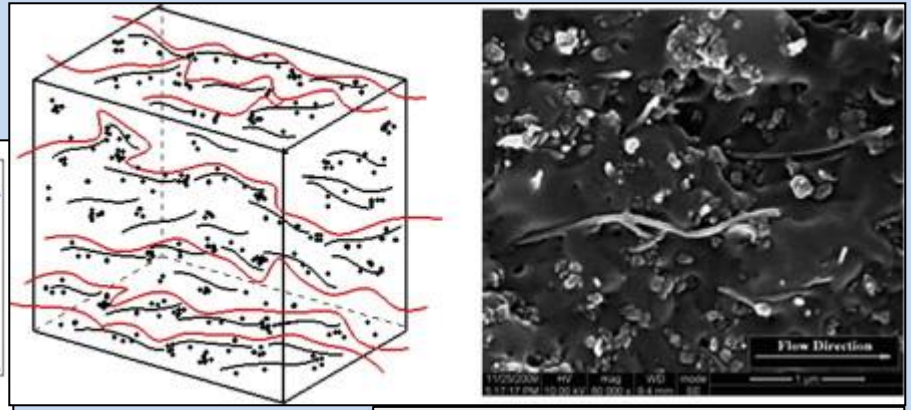
CNT Example Uses in Electrodes

Connected Network - Structure

CNT and Carbon Black Networks



https://ars.els-cdn.com/content/image/1-s2.0-S0014305717300186-fx1_lrg.jpg



https://ars.els-cdn.com/content/image/1-s2.0-S0032386112001103-fx1.jpg

Conductive Material	Traffic System Analog
Carbon Black	Local Roads
CNT	Limited Access Highways
Graphene	Parking Lots

Close to contact is good enough → Electron tunneling

SOLID STATE MATERIALS → SSBT CELLS

https://solidpowerbattery.com/

https://www.theverge.com/2020/12/8/22158573/quantumscape-solid-state-battery-ev-range-charge-vw

https://www.industryweek.com/technology-and-iiot/energy/article/22015201/technology-guru-bill-joy-is-betting-on-a-bulletproof-battery

Solid State Battery Developers

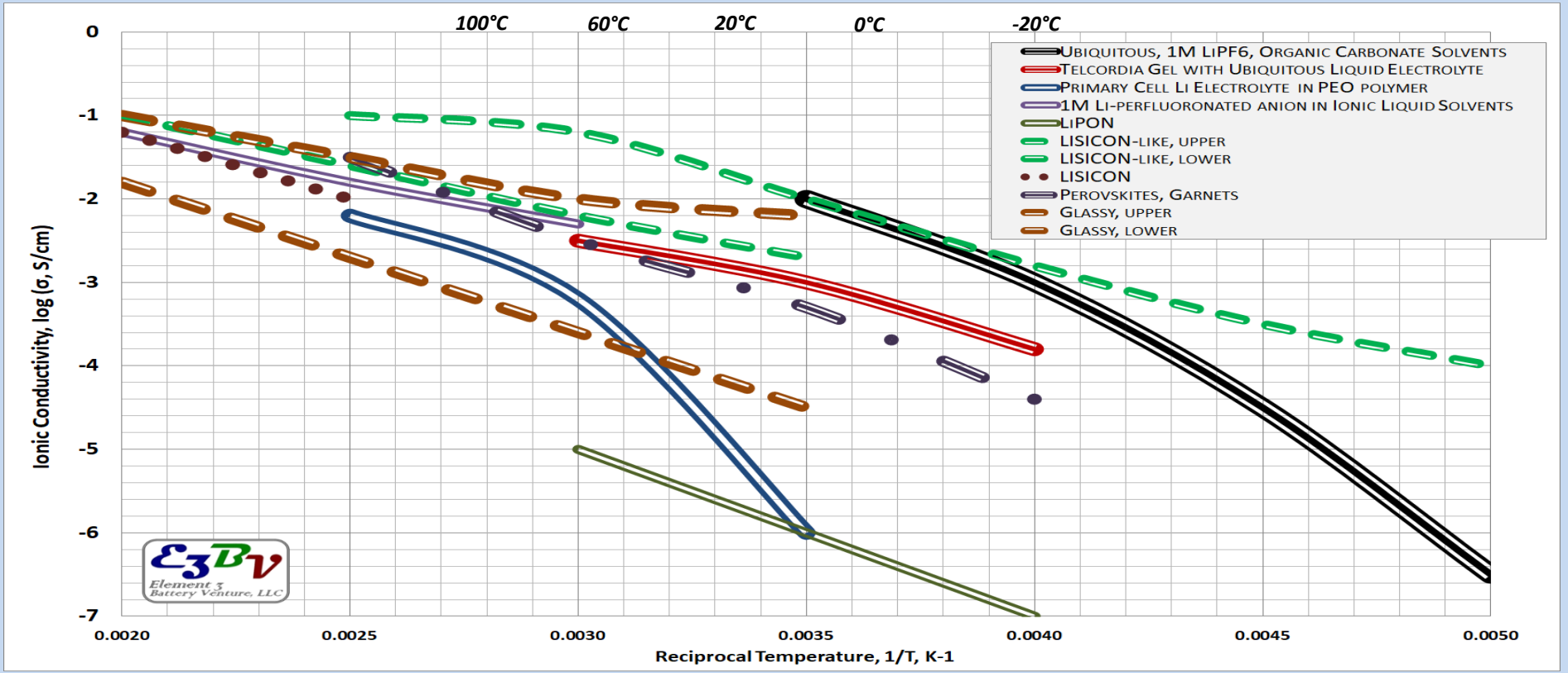
There are a few companies that *appear* ready to begin production scale up and target initial commercial sales of solid state EV cells by 2025 to auto OEM partners - QuantumScape [ceramic, garnet], Solid Power and Toyota [sulfide glass] and Ionic Materials [polymer].

Company	SSBT Type
Ilika	Ceramic
Ion Storage Systems	Ceramic
ProLogium	Ceramic
Corning	Garnet Ceramic
KIIT	Garnet Ceramic
NGK	Garnet Ceramic
QuantumScape	Garnet Ceramic
Pathion	Glassy
PolyPlus / Ohara	Glassy Layer
Sion Power	Glassy Layer
Saft	Hydride
Boulder Ionics	Ionic Liquid
Io-Li-Tec	Ionic Liquid
Cymet	LiPON
Dyson [SAKTI3]	LiPON
Front Edge Technology	LiPON
Infinite Power Solutions	LiPON
Ambri	Molten Electrodes
SLAC	Perfluoroglyme

Company	SSBT Type
Bollere	Polymer
BrightVolt [Solicore]	Polymer
Ionic Materials	Polymer
Seeo	Polymer
Solid Energy	Polymer
24M Technologies	Semi-Solid
Arlanxeo	Sulfide Glass
Idemitsu Kosan	Sulfide Glass
Mitsui Kinzoku	Sulfide Glass
Samsung [Young-Gun Lee]	Sulfide Glass
Sidus Energy [IBM, M-B, Central Glass (JP)]	Sulfide Glass
Solid Power	Sulfide Glass
Toyota	Sulfide Glass
BYD	UNK
Fisker	UNK
FujiChem	UNK
Hitachi Zosen Corporation	UNK
Jiawei Long Power	UNK
Johnson Battery Technologies	UNK
Lionano	UNK
Piersica	UNK
Qing Tao Energy Development	UNK
Soelect Inc	UNK
Soundon New Energy Tech	UNK
TeraWatt [SF Motors]	UNK

In addition, others Stakeholders have IP for SSB technologies –
battery manufacturers: LGES, Murata, GS-Yuasa, LEP, Panasonic, …
EV OEMs: Hyundai-Kia, Nissan, GM, Daimler, …
Chemical Companies: Shin-Etsu, Postech, Sumitomo, Mitsui, BASF, …

Solid State Materials – How Conductive by Type

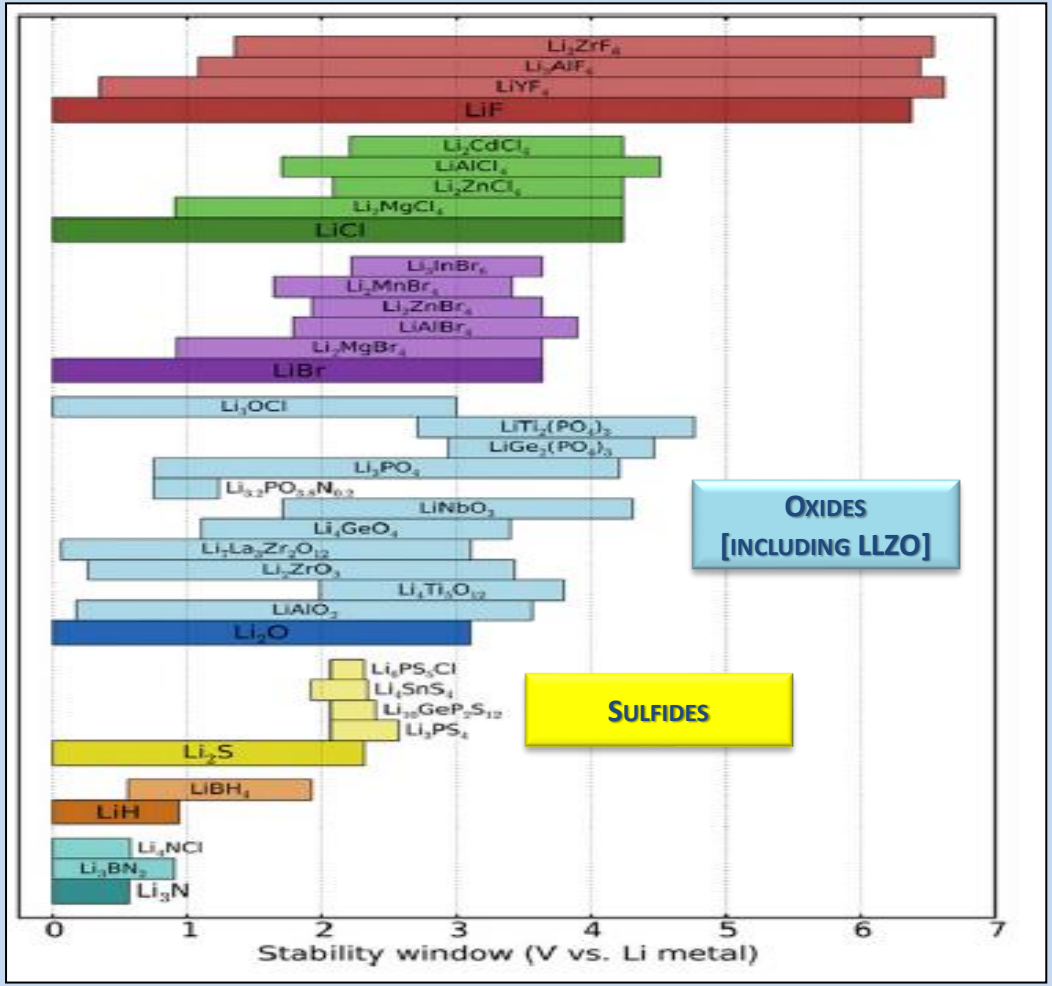


https://www.accessengineeringlibrary.com/content/book/9781260115925/toc-chapter/chapter22/section/section24
[Author content, Ron Turi: 22C.0. SECTION C: SOLID-STATE ELECTROLYTES (CERAMIC, GLASS, POLYMER), in Linden's Handbook of Batteries, Fifth Edition, Kirby W. Beard [Ed.] ISBN: 9781260115925 2019 McGraw-Hill Education

Can we predict the SSBT Winner? NO.

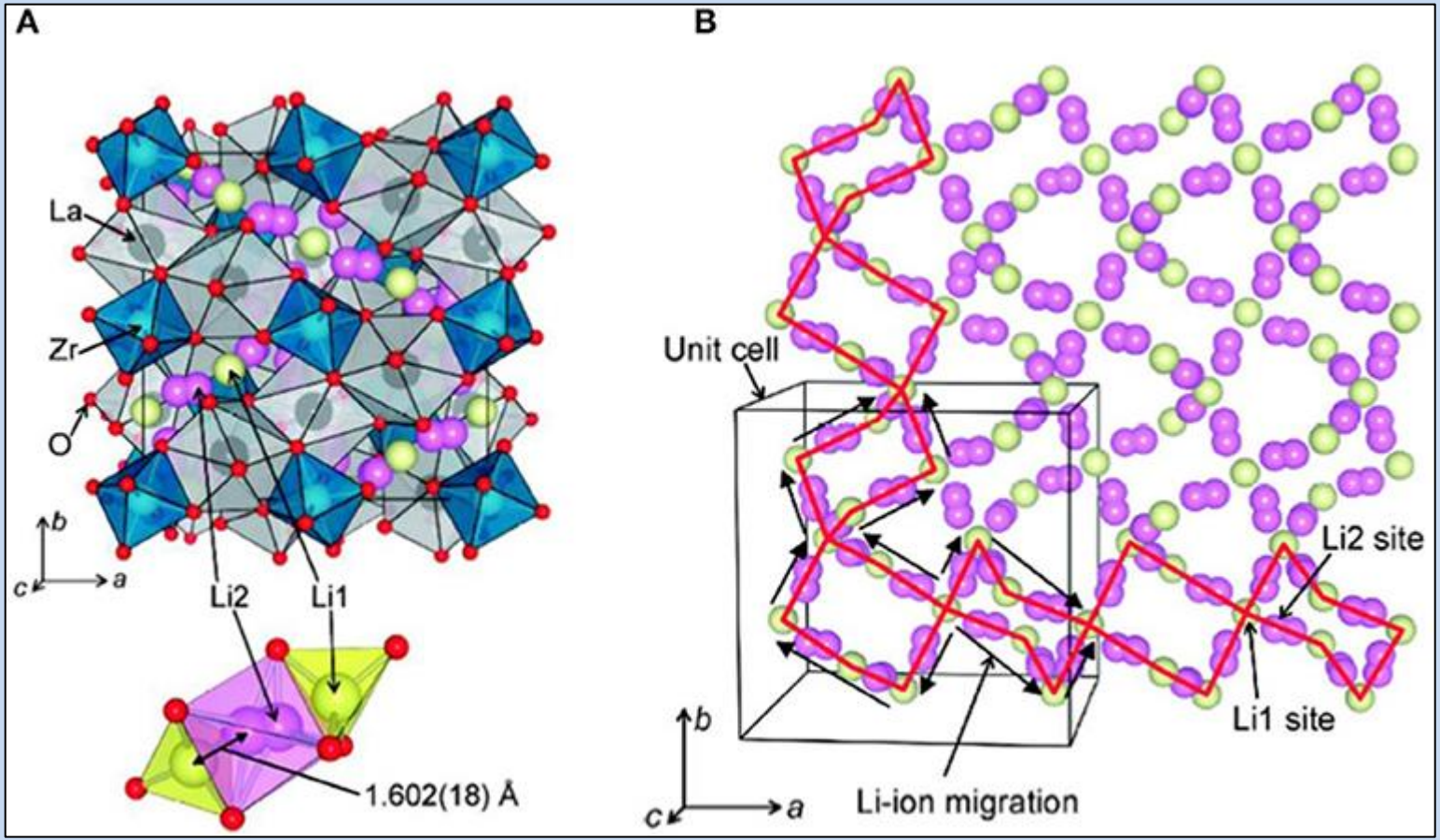
	Ionic Conductivity and Temperature Range	Electrochemical Stability Window	Anode Dendrite Management Material Strength, Defects, Flexibility / Non-Fragile	Anode Plating Control	Availability of Precursor Materials, Processing Separator, Cathode-SSE composite	Ease of Scale Up in footprint, stacking, connectors
Ceramic	Medium	High	High / Low	???	Low	Low
Sulfide	High	Low	Low	???	Medium	Medium
Polymer	Low	Medium	Low	???	High	High

Solid State Materials – Electrochemical Stability Window [ESW] by Type



https://www.cell.com/chem/pdf/S2451-9294(18)30530-8.pdf
Xia, Shuixin, et al. "Practical Challenges and Future Perspectives of All-Solid-State Lithium-Metal Batteries." *Chem*, vol. 5, no. 4, Apr. 2019, pp. 753–85. *DOI.org (Crossref)*, doi:10.1016/j.chempr.2018.11.013.

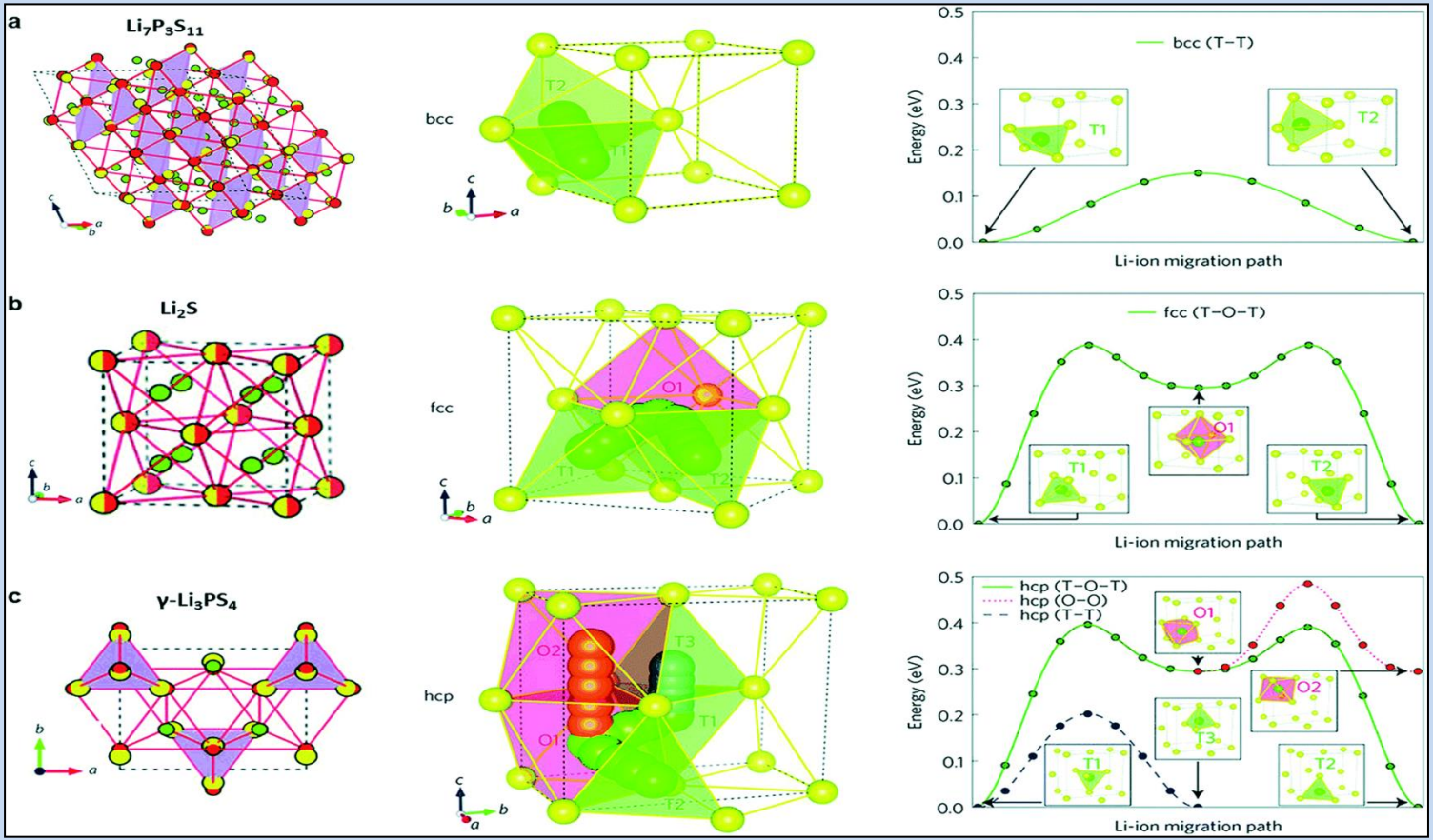
SOLID STATE MATERIALS – GENERIC LLZO GARNET



ACTIVATION ENERGY ~0.3 EV

https://www.frontiersin.org/files/Articles/548294/fchem-08-00468-HTML/image_m/fchem-08-00468-g001.jpg
Kim, Abin, et al. "Research Progresses of Garnet-Type Solid Electrolytes for Developing All-Solid-State Li Batteries." Frontiers in Chemistry, vol. 8, Frontiers, 2020. Frontiers, doi:10.3389/fchem.2020.00468.

Solid State Materials – Sulfide Glass



https://pubs.rsc.org/en/content/articlelanding/2019/ta/c9ta04555d
Lian, Peng-Jie, et al. "Inorganic Sulfide Solid Electrolytes for All-Solid-State Lithium Secondary Batteries." *Journal of Materials Chemistry A*, vol. 7, no. 36, The Royal Society of Chemistry, Sept. 2019, pp. 20540–57. *pubs.rsc.org*, doi:10.1039/C9TA04555D.

Can we predict the SSBT Winner? NO.

Most probable: There will be more than one winner –
too many factors are undetermined and commercialization relies on success for multiple factors

- Commercial Scale Up
  - Consistency / uniformity in large batches "campaigns"
  - True assessment of TRL [technology readiness level] – requires "open kimono"
  - Supply chain development – ceramics, glasses, polymers

- Long Lasting Solid State Design – Performance at EOL [end of life] versus OEM warranty
  - protection against lithium dendrite growth
  - Loss of lithium – stability of cathode materials – esp., unproven novel HV cathodes
  - Loss of rate capability for fast charging – several failure modes / root causes
  - Mechanical endurance

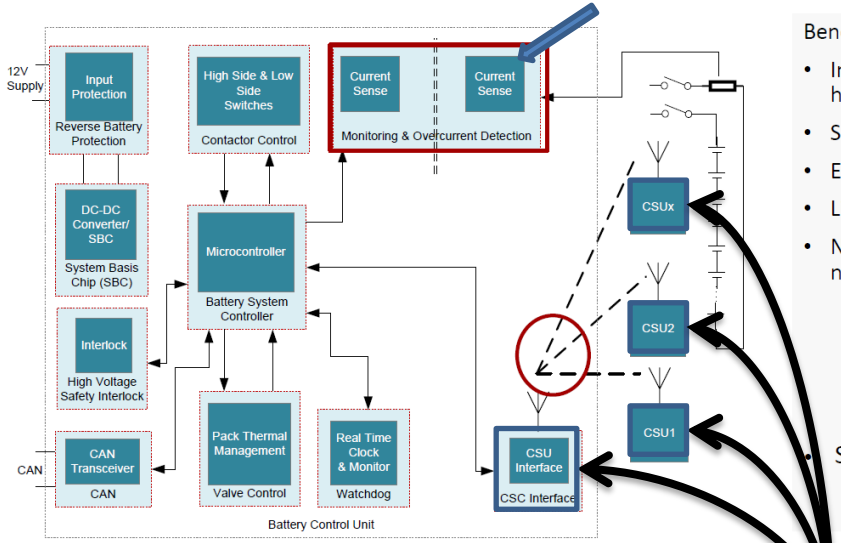
- Lithium ion EV batteries – the empire strikes back [sort of]
  - Improved electrolyte solvents – "million mile" battery technology and SLAC liquid for Li metal plating
  - Silicon anode – price point unknown, but enables higher energy density, closer to as Stage 1 SSBT [pre-lithiation]
  - Designs for lower cost manufacturing – level the playing field wrt SSBT simplicity – e.g., Tesla tabless 4680 cylindrical, LG Energy Solutions 110cm long, wide tab pouch cell for GM Ultium battery

- Materials Design and Engineering – of course!

BATTERY TECHNOLOGY LEVEL INNOVATIONS

WIRED → WIRELESS BMS ELECTRONICS

Wireless battery management system



Benefits:

- Increase reliability by removing harnesses and wiring
- Scalable and re-usable design
- Easier to mount, serve and repair
- Lighter
- Nodes communicate in wireless star network topology
  - Failure of one node does not cause failure of complete communication chain
  - High throughput , low latency, robust
  - Supports up to 100 nodes connected
  - Fulfill ASIL-D error failure rates in harsh RF environments
  - Communication encrypted

Simpler HV/LV isolation concept

- No need of galvanic isolation BCU/CSU

https://www.ti.com/lit/ml/slyp670/slyp670.pdf

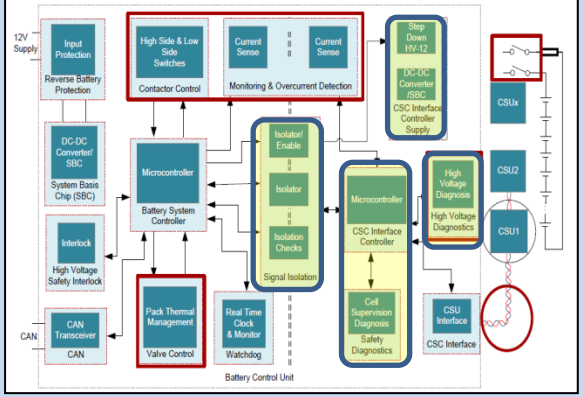
SimpleLink™ Wireless MCU CC266C2R-Q1

SimpleLink 2.4-GHz CC2662R-Q1 wireless MCU

- 7-mm-by-7-mm
- 48-pin quad-flat no-lead (QFN) wettable flank (WF) packages

US$3.20 in 1,000-unit quantities

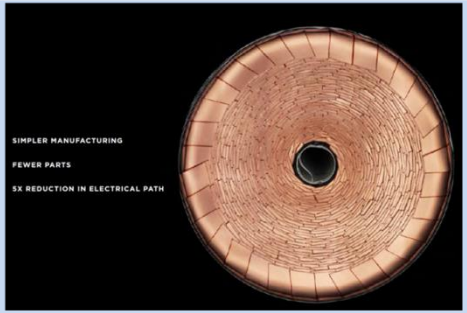
Wired battery management syste



Cell Assembly Innovation

Tabbed Cylindrical – 4680

- *Fewer cells in a pack*
- *Better heat transfer enables larger cell without overheating in supercharger*
- *Manufacturing Throughput ??? In kWh/hour; fewer stop-and-start's*
- *Optimized cell size ~ 46 mm diameter x 80 mm length provides 3.3X more volume, but 5X the energy [efficiency?]*
- *Cutting the uncoated edges of the copper current collector into "shingles" =>* ***MANUFACTURING ENGINEERING FEAT!***



Before

After

https://tesla-share.thron.com/content/?id=96ea71cf-8fda-4648-a62c-753af436c3b6&pkey=s1dbei4

MULTI-DISCIPLINARY

Electrochemistry	Ionic Transport
Electronics / Modeling	Thermal Analysis
Physical Chemistry / Materials Science	Organic Chemistry

Volta Foundation [Battery Bits] https://www.batterybrunch.org/battery-report https://medium.com/batterybits/the-battery-report-2021-442ed2a06324
Materials Project https://materialsproject.org/
BatPaK https://www.anl.gov/partnerships/batpac-battery-manufacturing-cost-estimation
NAATBATT https://naatbatt.org/

TRENDS

The EV Battery industry and market is very dynamic.

- Trends include legacy auto OEMs scrabbling to transfer manufacturing and operational assets from ICE to EV before 2035 and in most cases, before 2030.
- The supply chain for EV Batteries is tight - from Li and Ni mineral to EV grade cells. Auto OEMs must work with as many EV cell manufacturers as possible if there is a chance to fulfill reservations for 100k's of EV model orders - VW AG, Ford, GM, Tesla, ...
- Meanwhile, auto OEMs seek to control the EV Battery supply chain - manufacturing EV cells in-house and securing offtake agreements for minerals and other key cell components. Cell makers - esp., LGES and CATL - are also moving to secure materials and contracts with auto OEMs to prevent being cut out of the supply chain!
- And there is a rush to build new LIB gigafactories - accelerated by the trend for regionalizing the EV ecosystem and EV Battery manufacturing, with local supply chain development in Europe and North America.
- OK, add to this the unprecedented willingness of auto OEMs to disrupt existing processes - even switching battery design and chemistries to gain competitive advantages - and every passing month looks different.
- Of course, all legacy auto OEMs have sever cases of Tesla-Envy and there are many EV Battery examples as well as EV manufacturing and skateboard / EV drive system examples of this as copy-cat behavior - esp., by VW AG.

So, trends aplenty!

Thank You!

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