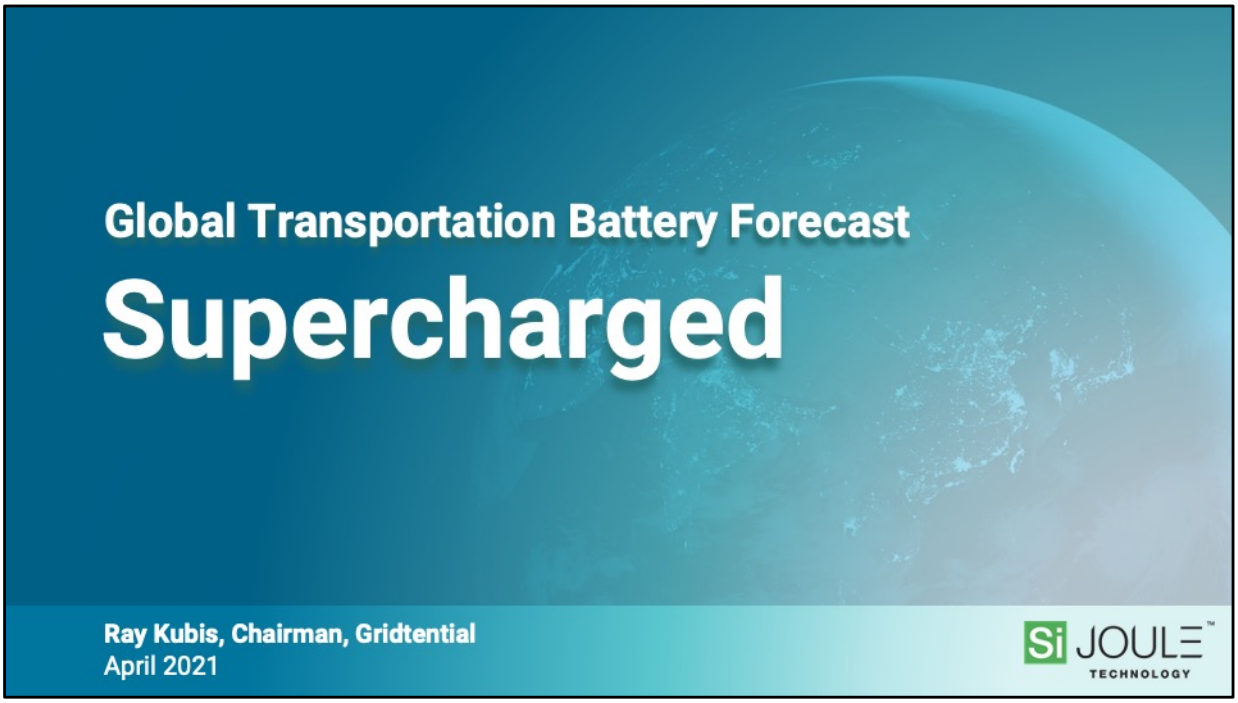
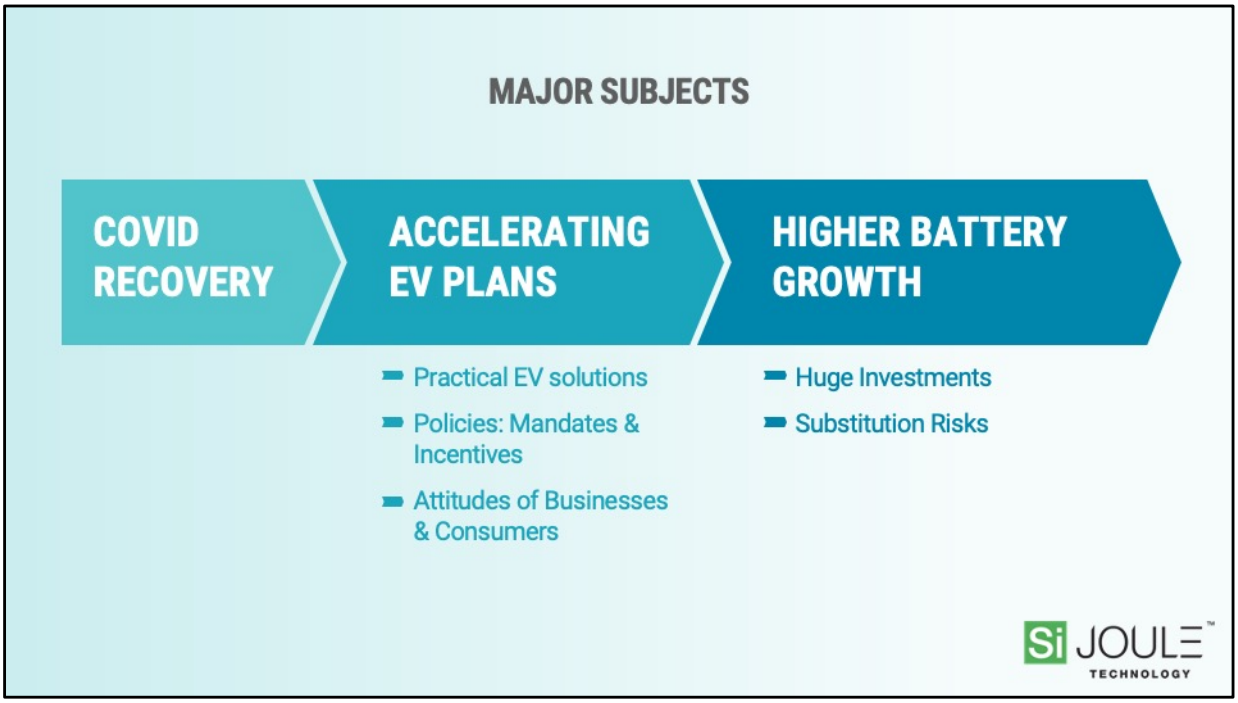


It has been only seven months since the last Transportation Battery Briefing, yet it has been an especially active time for electrification in transportation across the world and its impact on batteries. Hence the subtitle, SUPERCHARGED, for the Clean Energy Transition to Net Zero Emissions.

As Presented to the Battery Council International (BCI) on Earth Day, April 22, 2021.

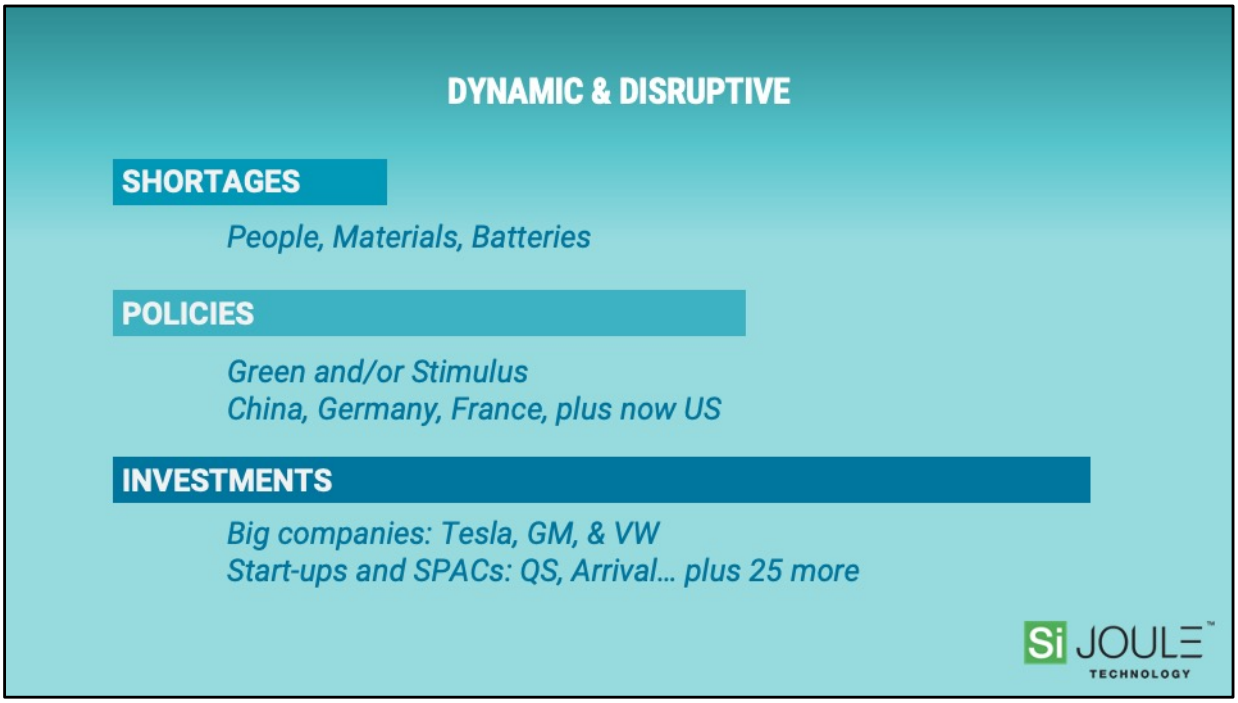


We will quantify the impact on battery demand through the pandemic, and expound on the breadth of accelerating electrification plans in all kinds of vehicles, which drives even higher battery industry growth in the forecast I will share today.

The drivers for more electrification in transport start with more practical and affordable vehicles, adding to the significant mandates and incentives by governments worldwide.

Also important is the shifting attitudes by companies and consumers to more seriously address and reduce carbon emissions toward NET ZERO per person, per company, per country and the planet.

I will provide insight on the higher battery forecast, and discuss the substitution risks across vehicle platforms and to existing lead-based and lithium-based battery technologies.



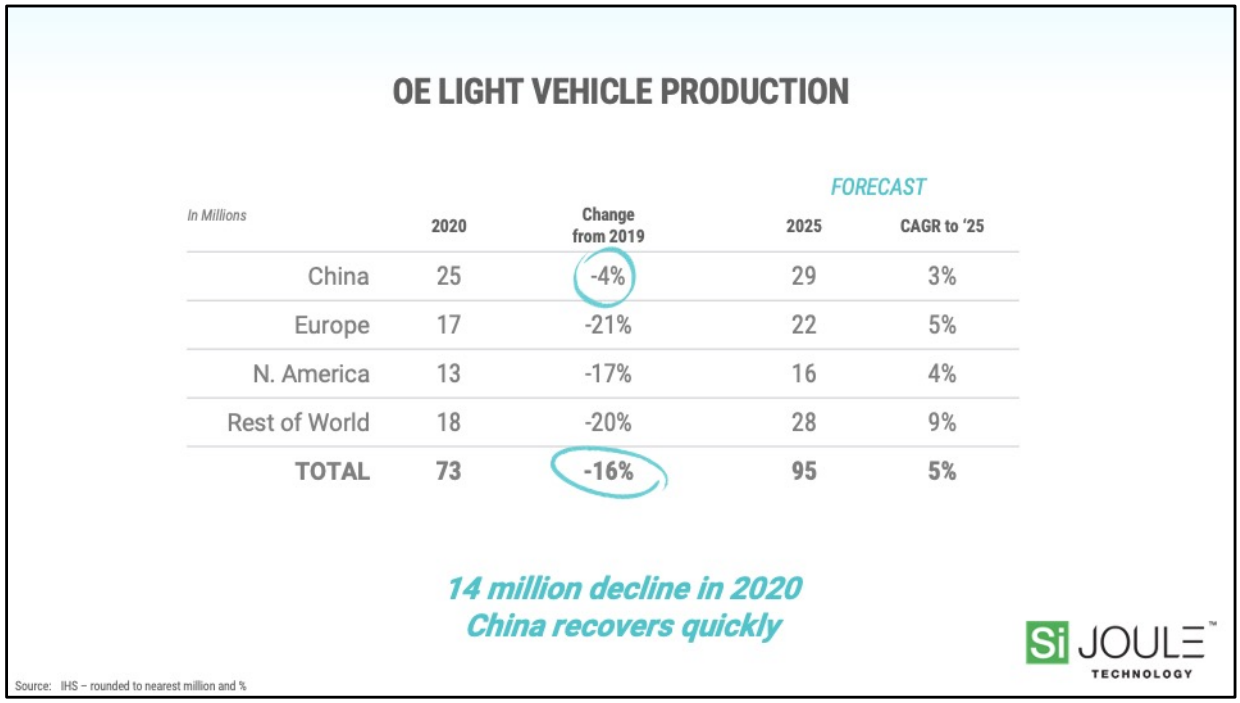
For vehicles and batteries of all types, whether it is the pandemic or the clean energy transition, we are going through a dynamic and disruptive period in our industry, which is a real challenge for business leaders and their technology teams.

Yet, there is no disputing that opportunities abound for decisive battery companies investing and executing well on the right platforms. I aim to provide you some insight to help with your tough decisions where to focus resources. In my opinion, many companies and industry groups are pushing very hard, and many others moving far to slowly, given the changes around us.

The pandemic first stopped businesses, disrupted supply chains, and created employment issues from high absenteeism, to social distancing, and constantly evolving government regulations.

And policies and social consciousness has shifted in many countries, pressuring companies and plans. And this has sharply influenced stock markets and investment platforms. Tesla's $700 Billion market value (@4/12) exceeds the value of the 10 largest car companies combined. And QuantumScape and others have the cash and multi-billion dollar valuations backing their lithium battery improvement plans.

And there are at least 100 other battery, vehicle and charging start-ups receiving hundreds of millions of new investments from governments and private investors, and now also from SPACs (special public acquisition companies). So, an awful lot of smart researchers and engineers are working with substantially more funding to accelerate technology development and capacity across vehicle and battery platforms.



Let's quantify some of the changes which impacted our industry in 2020 and our forecast. New light vehicle production declined 16% worldwide in 2020 as the pandemic shut plants and reduced purchasing as the virus spread from Wuhan to Europe, the US, and the rest of the world.

From a full stop in February, China's new vehicle production recovered strongly in the second half, aided by stimulus funding and incentives. Europe's lockdowns, especially in Italy and Spain led to a nearly one quarter reduction in production. After temporary vehicle production shutdowns in the US, there was a surge in new and used vehicle demand, yet supply chains could not respond as quickly, pushing some demand into 2021 along with notably increasing the price of new and used vehicles in the US.

The outlook for new passenger car and light commercial vehicles (under 3.5 tons) is to bounce back in 2021, and average nearly 5% growth to 95m vehicles by 2025. However it is worth noting this is approximately the same as the 2018 production, even if the mix of vehicles will be notably different, as we will discuss later.

LV REPLACEMENT BATTERIES

In Millions	2020	Change from 2019	*FORECAST* 2025	CAGR to '25
China	61	14%	78	5%
Europe	58	–	63	2%
N. America	82	5%	91	2%
Rest of World	221	–	244	2%
TOTAL	**422**	**1%**	**476**	**2.5%**

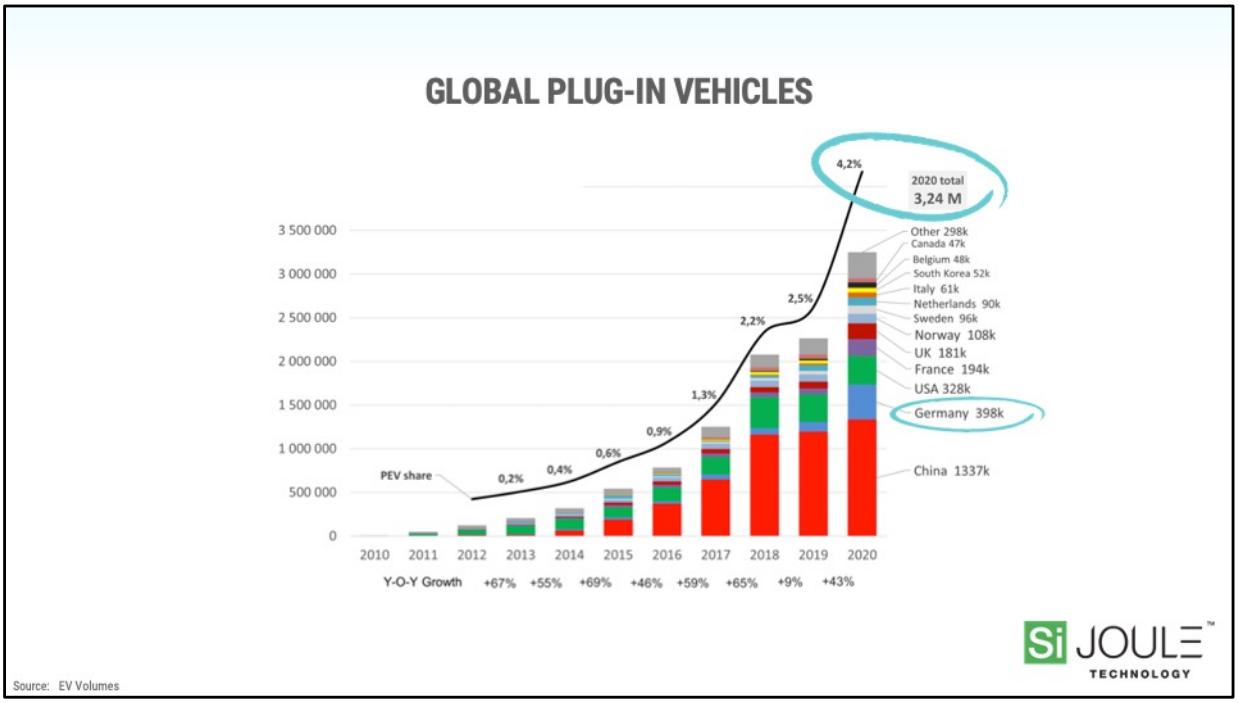
For Light vehicles <3.5 ton – 7,000 lbs
Included stop/start, SLI & Auxiliary
Excludes Heavy Duty, Marine, Utility, etc

Si JOULE™ TECHNOLOGY

For many producers of lead-based batteries, the robust recovery of replacement battery demand has been a challenge, beginning in mid 2020 through to March 2021. Especially in China and the US, a snap back in demand from weakened, possibly sulfated batteries from disuse, and production output restraints from higher absenteeism created shortages and longer lead times for light vehicle and commercial batteries.

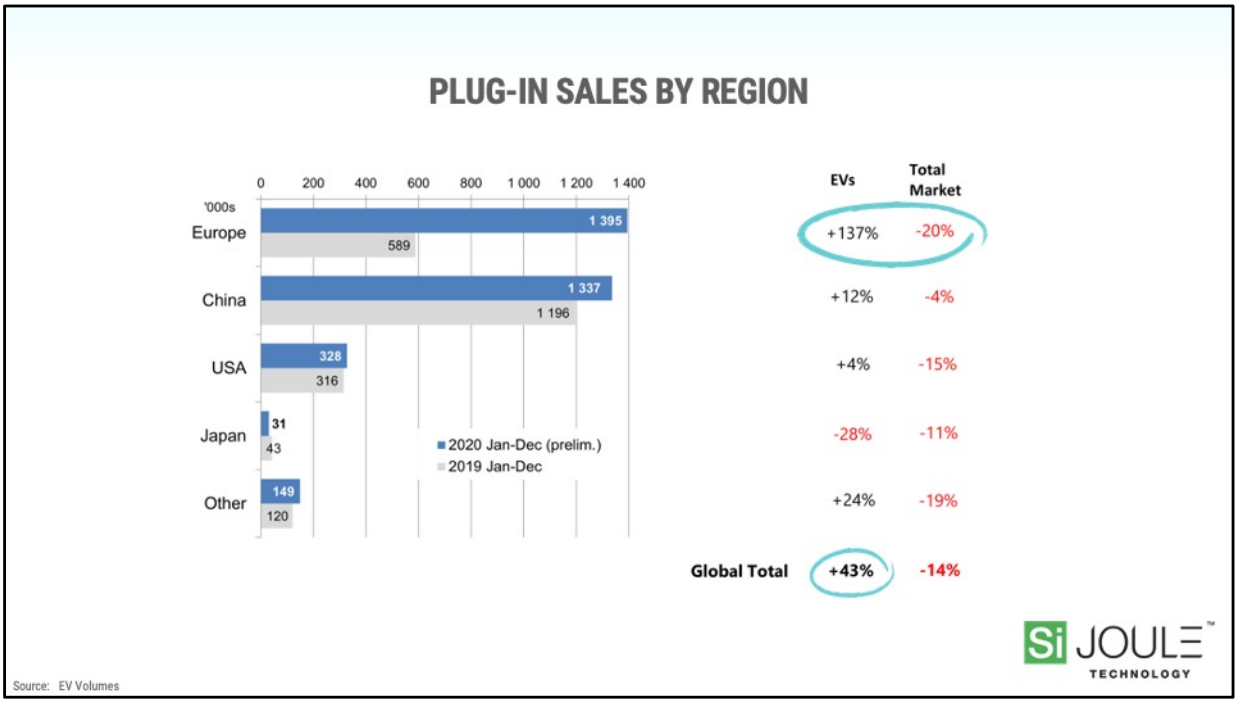
In spite of the shortages, replacement battery shipments grew in 2020 an estimated 5% in North America and 14% in China. Insight from Europe and the rest of world was only anecdotal, and estimated close to 2019 levels given longer stays at home, and lockdowns from Italy to India.

The outlook for light vehicle replacement batteries in 2021 is for some further above average lift, and then to return to historical demand growth rates of 1-2% in Europe and NA. China should sustain at least 5% growth, thanks to new vehicle growth there across the last ten years. We will cover specialty battery growth later, and now shift to highlight the electric and hybrid vehicles and sectors driving much higher battery consumption.



Regardless COVID, many factors converged in 2020 to support a notable acceleration in EV and hybrid battery demand across large and small vehicles.

Here is a ten year summary of EV and plug-in hybrid sales, accelerating to 3.2 million vehicles in a pandemic year, which was 4.2% of all new light vehicles worldwide. The detail here shows China in red, as the largest, followed by Germany and then the US.



Europe led the acceleration of EV demand for light vehicles in 2020, with big incentives from France and Germany leading to 1.4m EVs and plug-in hybrids. And this trend was accelerating late in 2020 and into the first quarter of 2021. The green policies are a big factor. In France, you can receive up to 7,000 Euros rebate for a qualified, modest sized EV purchase, or pay an emissions tax of over 20,000 Euros for some gas guzzling BMWs or Land Rovers.

In spite of the decline in global new vehicle sales in 2020 of 16%, EV and plug in hybrid sales worldwide increased from their small base by 43%, with increases also coming from China and the US. Let's look at some vehicles and details by region.

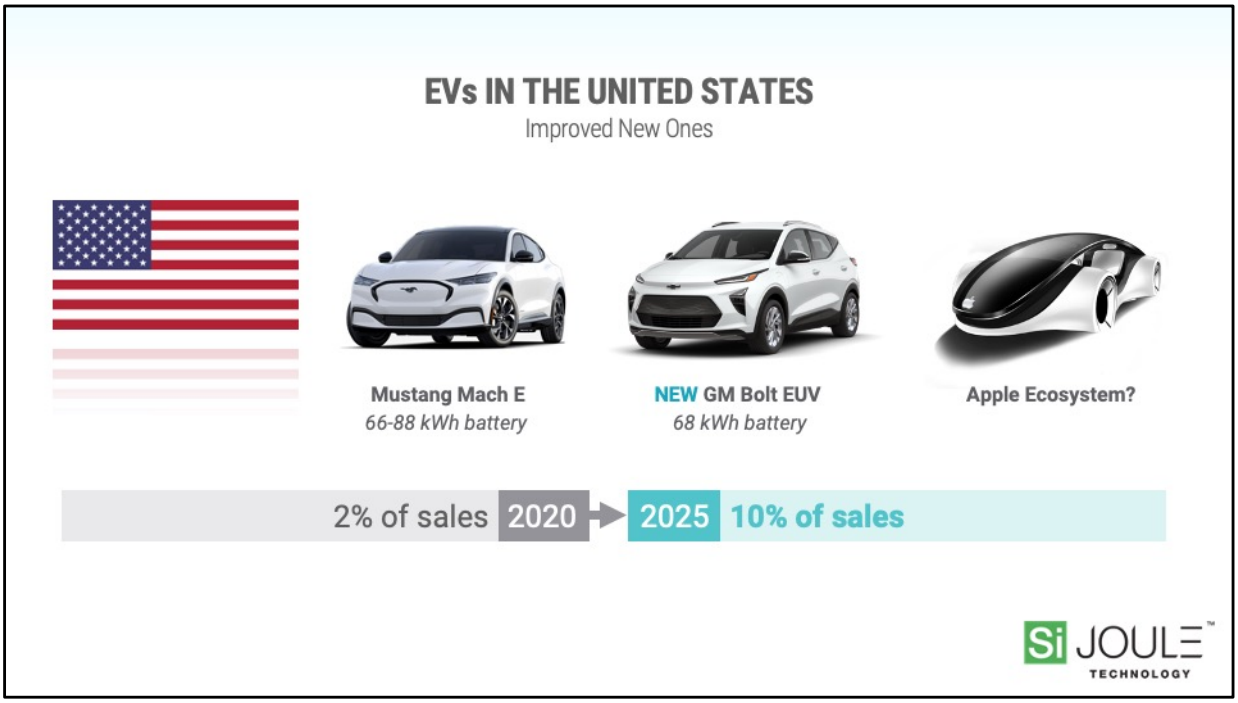
Beyond the incentives and mandates, new and more affordable vehicles, especially from Renault and VW, are now passing the sales rates for Tesla . Renault sold about 100,000 of their small ZOE, and VW's ID.3 launched later, reached number #1 in December, and their ID.4 SUV is likely to deliver significant sales gains in 2021, and not just in Europe. By 2025, IHS forecasts about 1 in 5 new vehicle sales in Europe will be EVs or plug-in hybrids.

China's EV sales grew 12% in 2020 to over 6% of total new vehicle sales. Wulang's Mini EV is a $5,000 small family limited feature car which led in unit EV sales in 2020. Wulang's EV could be considered a step-up from eBikes and the Low Speed EVs still sold for use without license or highway capability for small families. The vehicle comes from the JV of GM, SAIC and Wulang. The Mini EV tops out at about 60 miles per hour and a claimed 100 mile range from its lithium, LFP-type, batteries.

Tesla, BYD and NIO are selling their EVs at $30,000 to $100,000, yet obviously appealing to different market segments. And though safety regulations and consumer preferences surely vary by country, the "MINI" EV entrants in China offer a glimpse into the range, complexity and potential of the Global EV market. Beyond Wulang's Mini in China, we could highlight other small vehicle options in India from Suzuki, and to Fiat's 500e in Italy, and others all the way up to the nearly $200,000 Porsche Taycan.

As seen in so many industries, and often from China, a company may start by selling something small and cheap, and rapidly progress to larger and better. So, the race is on for EV product development. And recently, Xaomi, the large Chinese phone maker, earmarked a $10 Billion investment to develop and sell electric vehicles.

By 2025 IHS forecasts EV penetration to be 17% of new light vehicles in China.

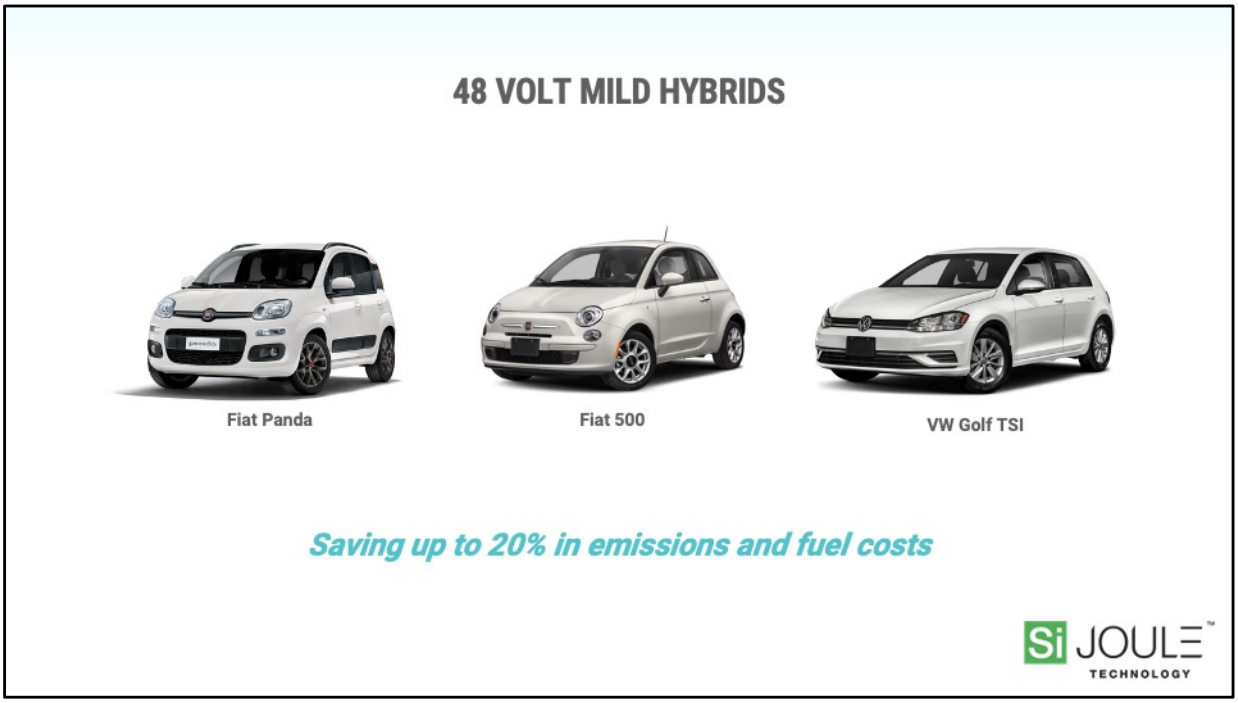


In the US, Ford and GM are chasing the Tesla dominance in EV sales with their new entrants including the Mustang and Bolt EUV (electric SUV) at more affordable prices, with still great product experience. Each global market has its idiosyncrasies, and the US EV sales still represented only 2% of total new vehicles in 2020. Yet new electric pickup trucks and SUVs from existing major companies and new entrants like Rivian, Workhorse and Fisker will soon reach the market. And we might just see the entrance of Apple into the EV vehicle business.

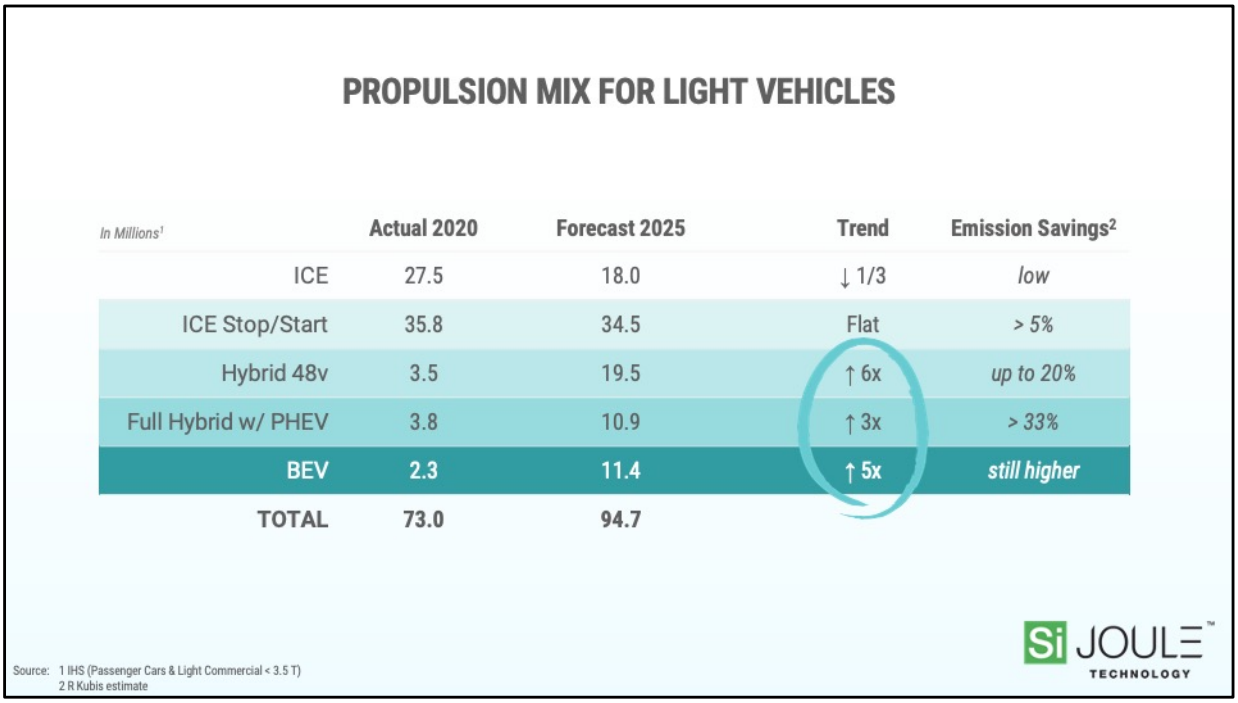
The IHS forecast for US EV adoption is at 10% of new vehicles by 2025, or 1/2 the relative market share of EVs forecast in Europe.

The headlines on climate change and EVs seldom touch on the huge contributions from the real and significant fuel EFFICIENCY gains linked to better batteries in stop/start applications and the full range of hybrid vehicles from plug-in hybrids to the growing 48 volt mild hybrid applications.

If a climate conscious young family is looking for a nice, efficient and affordable vehicle to run on batteries only for short trips, and still have the full flexibility for longer mileage travel, I would say you might consider the Toyota RAV4 Prime as a great example, saving emissions and money. You can ride 30+ miles on electric for most daily trips, and achieve almost 50 mpg on longer trips, significantly reducing Co2 emissions compared to vehicles of only 5 years ago. As Donna Snyder of East Penn commented, “the contribution of these ever better and smarter vehicles seems overlooked by many.”



Shown here are the most popular models integrating the 48 volt technology in Europe, saving up to 20% on emissions and fuel use. This advanced technology represented about 500,000 new vehicles sold in 2020, regardless the pandemic. Economic versions of the Stellantis Fiat Panda and Cinquecento (500), and VW's popular Golf, were the largest sellers, yet the technology was also present in new models from BMW and Mercedes. Integral to these systems are DC/DC converters, a 48 volt starter/generator and a hardworking 48 volt battery. These are lithium batteries today, yet smart, lower cost advanced bi- pole lead based batteries are also targeted for these applications.



Here is the forecast of the mix of new vehicles sold by type of propulsion system from the standard internal combustion engine all the way to electric only vehicles which I have included in the battery forecast, and this is based on data from IHS.

The good news is by 2025 over four of every five vehicles sold worldwide are forecast to be reducing a lot of emissions. Vehicles with the stop/start function are forecast still at over one third of new vehicles. The adoption of 48 volt architecture, so-called mild hybrids, are forecast to increase 6X to about 20 million vehicles per year, which save up to 20% of fuel and emissions with low implementation costs. And full hybrid and pure EVs are forecast to exceed 10 million of new vehicle sales each by 2025.

You may see forecasts of much higher adoption rates for full EVs, and that may happen in select countries and states, as we have seen in Norway, or probably will in Germany and California.

Yet for much of the rest of the world, where coal remains the dominant source of electricity, and where charging stations are limited, EVs are possibly not as good a solution for consumers or the environment until much later.

Hence, the efficiency gains of stop/start and the full range of hybrids remains a real positive contributor to the reduction of the consumption of fossil fuels for the next couple decades at least.

One of the reasons light vehicle sales growth has moderated is the proliferation of so many transport options for urban dwellers including UBER, and a widening array of so-called Micromobility options.

Micromobility transport in urban centers has evolved through the pandemic and is now growing into 2021. The eMicromobility sector includes eScooters and eBikes of both the pedal-assist and no-pedal, eMoped type. And they can be owned, leased or shared from a range of expanding companies. Public transport use remains down 75% in many European and US cities due to health concerns, recreating traffic and emission issues, even with so many working from home.

Until recently eBikes were principally a China story, and in 2020 following the lockdown, China eBike sales jumped as a safe alternative to public transport. Replacement eBike batteries also surged. Huw Roberts of CHR Metals also recently released report on eBikes and mix of batteries, with most of the China bikes+mopeds still favoring AGM type lead batteries due to cost. eBikes continue to help many Chinese deliver a child to school, or to make eCommerce deliveries for Alibaba.

In Europe, the US and elsewhere eBike demand has also surged through the pandemic, creating long lead times, especially for the pedal-assist version of eBikes with virtually all lithium batteries in Western markets, and some lead-based batteries in Africa.

A recent study by Deloitte forecast new eBike sales by 2023 to reach 40 million per year globally, and for perspective, this is almost one new eBike sale for each two new cars or light trucks sold.

And that does not count the resurgence of new eScooter use with new business models from Bird, Lime, and others, where eScooters complement the eBike options, especially for shorter trips under 2 miles.

Many of the same cities who pushed back on the unorganized management of bike and scooter sharing programs of the past years, are now welcoming back better organized structures, and providing added travel lanes as a complement to mass transit trains and buses and to reduce car traffic. So, high growth of eMicromobility is likely to continue as a sustainable solution, and possibly displace a material number of light vehicle sales in cities.

We all understand eCommerce has accelerated through the pandemic, with delivery trucks sitting or moving slowly many times each day across neighborhoods and cities worldwide.

Urban delivery has to be one of the most logical electrified applications now emerging, when you consider the duty cycle of these trucks, often driving routes under 100 miles, and with vehicles stopped well over half the time for delivery or traffic. Rivian's roll-out to Amazon, along with Ford's new Transit van range, and Volta Zero's approach or Arrival's new launches may all share in this high growth sector.

EU and many city regulations for CO2 and NOX emissions are contributing to the acceleration of trucking electrification. So, Europe is likely to lead in the adoption of EVs for many trucking segments.

Though China continues to represent over 90% of the deployed eBuses in the world, supplied by BYD and others, many European and other cities worldwide are now broadening their commitments to eBuses from legacy bus suppliers like Van Hool, or new ones like Proterra. The pandemic has hurt 2020 bus sales notably, yet the electrification trend is likely to continue with high government support.

One interesting example shown here is an Autonomous EV bus on trial in Japan, and this one operating next to some pretty expensive aircraft, pointing to the added capabilities coming for some EV buses.

Another EV sector progressing is the school bus market in North America.
In North America about 500,000 mostly yellow, dedicated buses normally transport 24 million students a day to and from school. The typical morning and afternoon bus routes average under two hours.

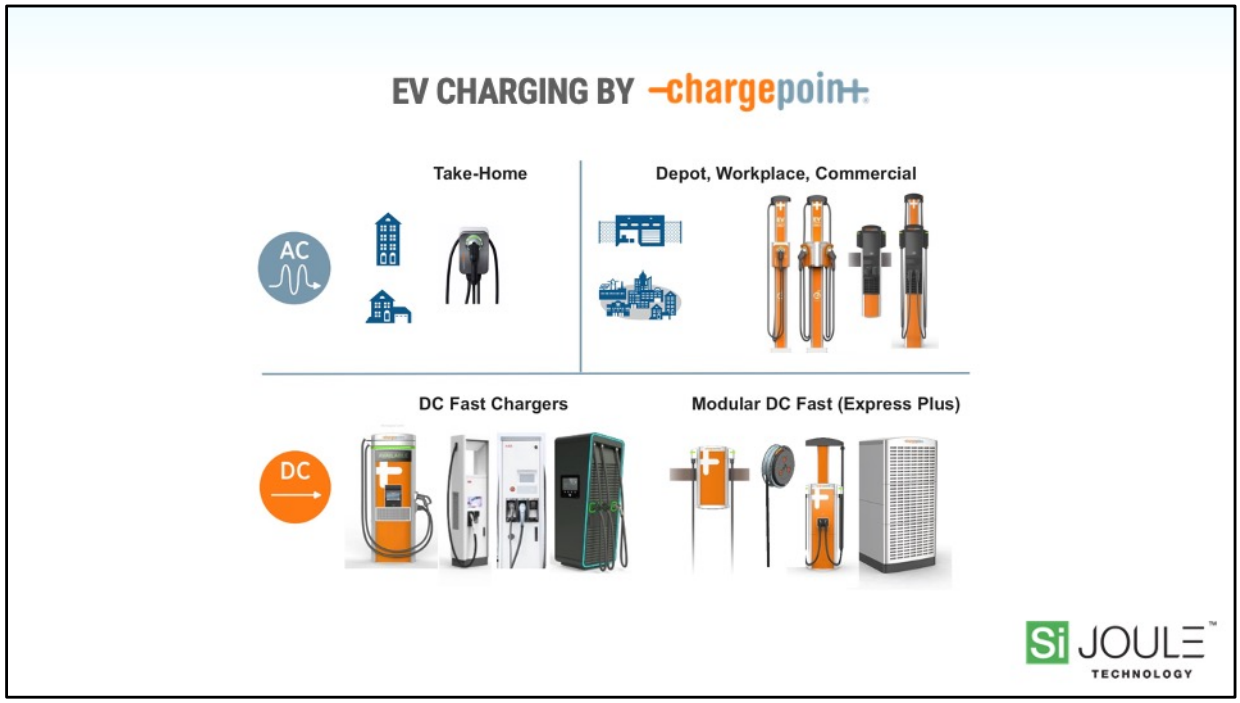
Given the higher cost of buses with big batteries, and often strained school budgets, you might not guess this area fertile for EV application.

Here is an example of a new BlueBird eBus as sold now in North America, and this bus is designed for the perceived sweet spot of range, about 100 miles (160klm), as explained by Trevor Rudderham of BlueBird Bus company.

Another company in Maryland has secured a EV school bus program order for over 500 buses through an innovative leasing program, and many other schools have made initial electric school bus orders.

Their rationale beyond potential energy and maintenance savings include a mix of objectives, including less diesel fumes near children, and even a quiet ride for additional learning/study time. Another possibility is the so-called V2G or Vehicle to Grid app, whereby the buses serve as a grid buffer for the peak electricity demand from 5-9pm when school buses are idle, and then charging them back up overnight when excess and lower cost electricity is available.

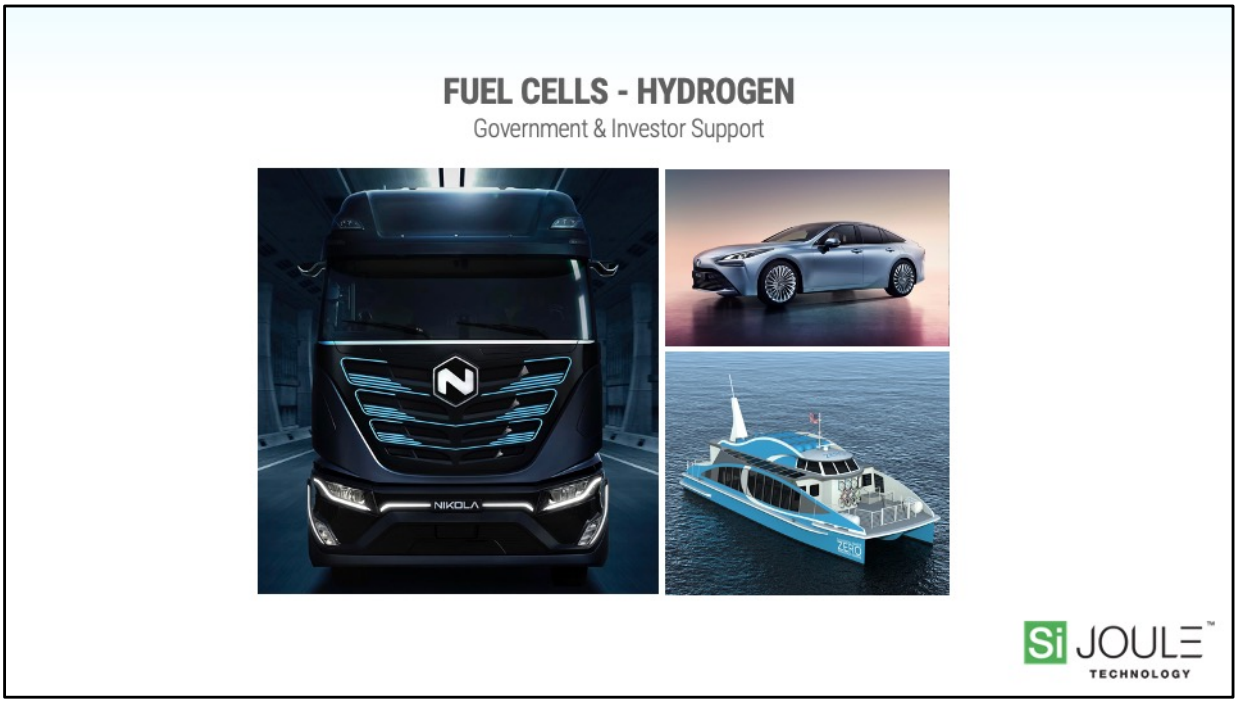
Public policies will have a significant impact how many of the expensive EV school buses are put in use, and the draft US infrastructure bill included a target and funding to support conversion of about 20% of the school buses in the US.



Of course we need charging for all these applications, and there are major charging system rollouts underway in Europe, China and the US from car companies like Tesla and VW, and others like ChargePoint, Blink, and EVGo. The US President has stated a goal of 500,000 EV chargers to better enable future EV sales.

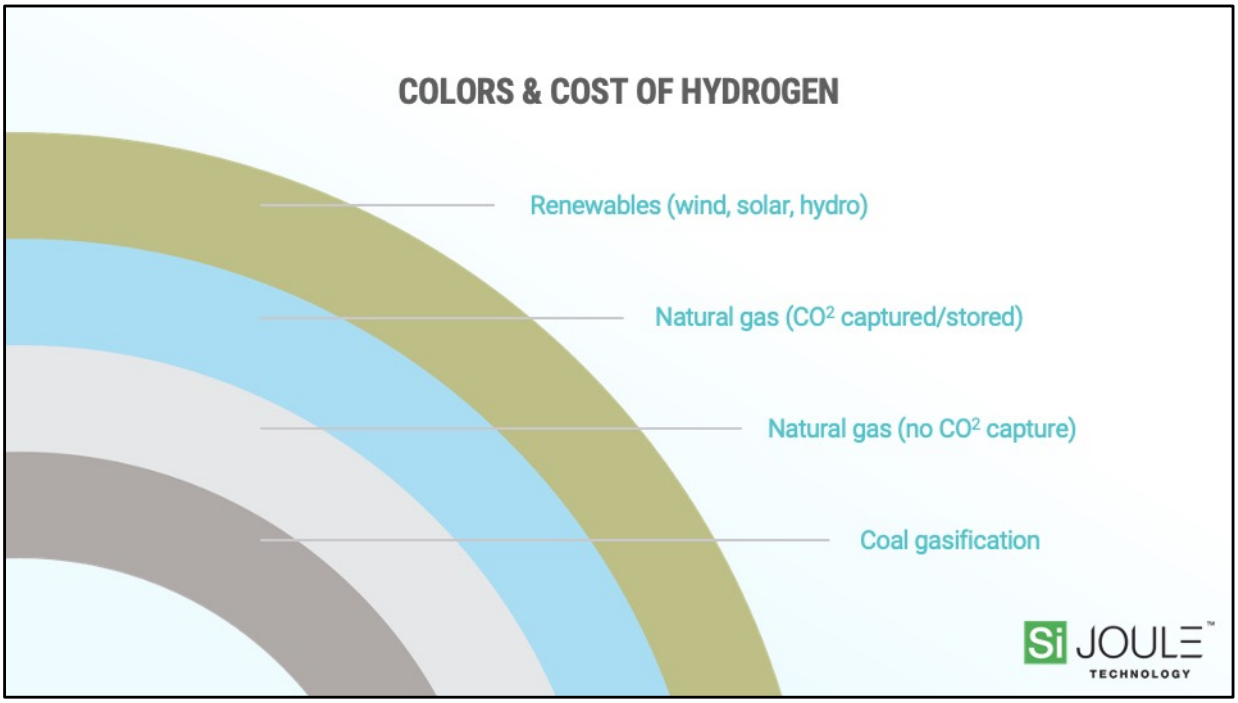
This graphic from ChargePoint shows the breadth of chargers being deployed from 7kW chargers in the home up to faster, so-called level 2 AC chargers at business and for fleets, all the way up to the ultra-fast DC chargers. The very high current draw of the fast DC chargers has sparked some trials for battery packs to help manage the otherwise huge spikes in electricity demand from multiple 500kW chargers.

At this time I have not included battery demand for DC charging in the forecast, yet this could mature as an application for hard working batteries included with charger management systems.



There has been a lot press covering the unique potential of hydrogen to aid our transition away from fossil fuels. Toyota leads in passenger vehicle fuel cell deployment with their impressive Mirai, being driven principally across Japan and California.

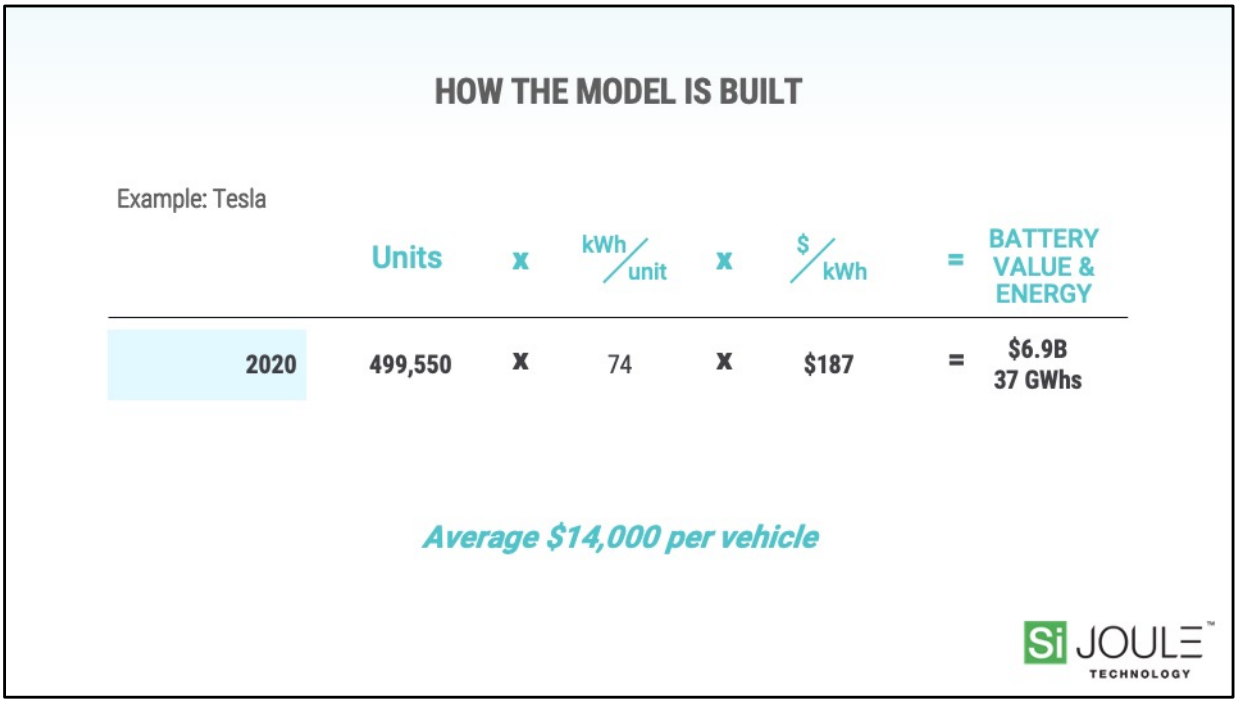
Aside from the infrastructure challenge for fueling stations, there are two key hurdles for hydrogen progress. First, hydrogen today it is not GREEN, generally with an even higher carbon footprint than fossil fuels, and secondly, is the high cost of hydrogen production and delivery or packaging.



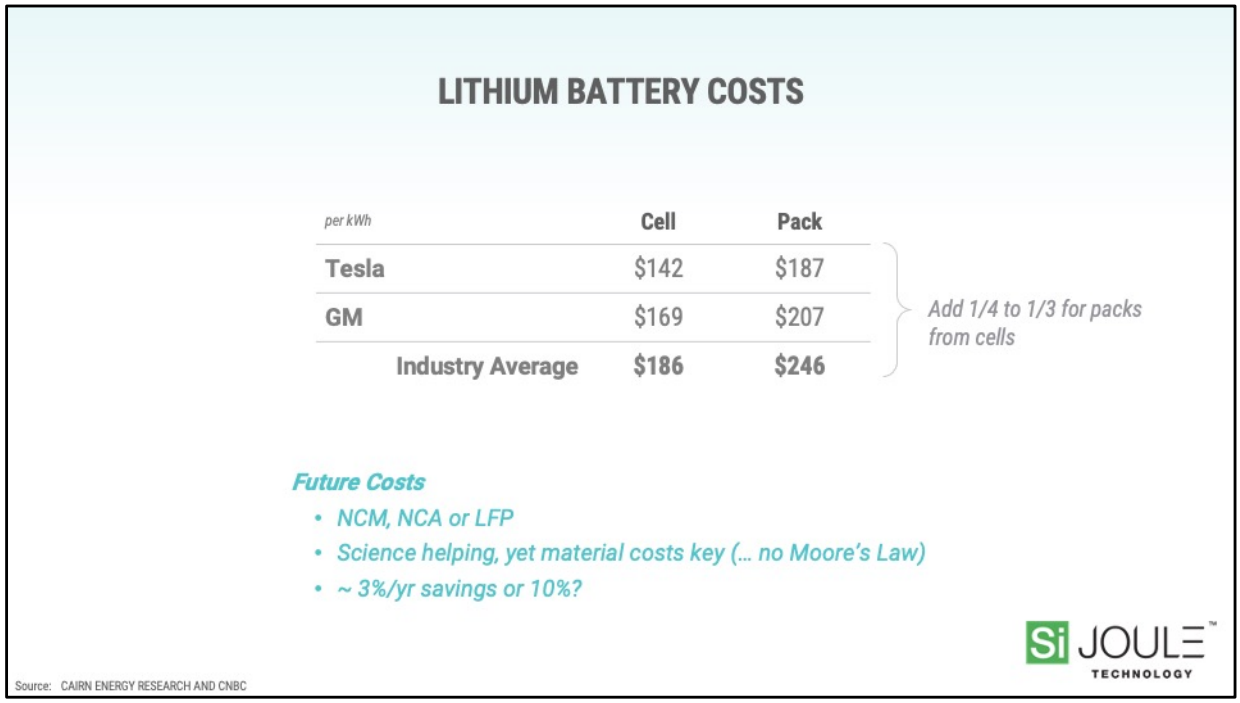
The slide shows a profile of the COLORS of hydrogen production in today's vernacular. It ranges from brown, the worst for the environment at lowest cost from coal gasification to the most green from renewable resources, yet at the highest cost, and natural gas in between. It is possible to produce green hydrogen, yet it remains very costly, and unless favored by high carbon tax schemes, broad commercial deployment may not happen.

However, for some applications envisioned in airplanes, long distance large trucks and ships, there are advocates who may rightly claim batteries probably cannot do job efficiently, and if carbon emissions have to come down in those applications, hydrogen may be an option IF they can get it GREEN and lower the cost.

In the five year forecast, there are less than 200k vehicles with fuel cells in transportation. Yet if a fuel cell vehicle is sold, it will anyway REQUIRE a battery to start and bridge to full operation, and to support safe use.

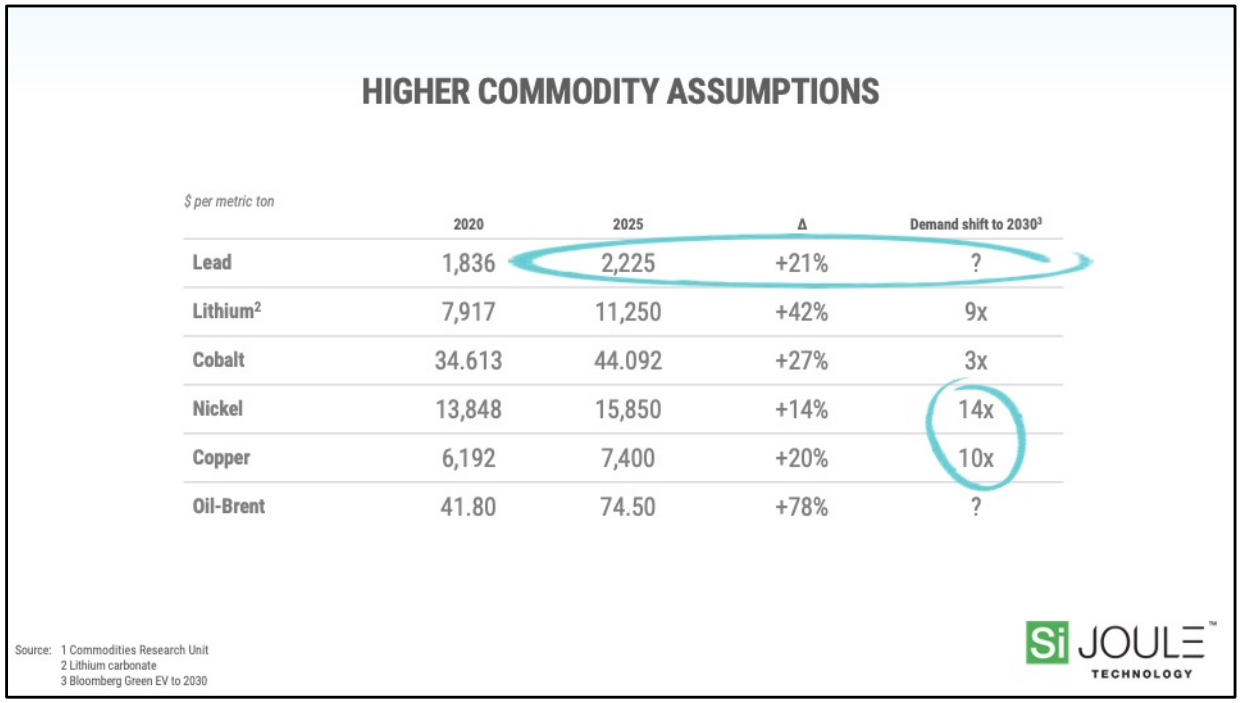


Moving on to the forecast, let me explain the structure of the forecast model using an example of Tesla's estimated battery demand for 2020. Tesla shipped just under 500,000 vehicles, with their largest share being the smaller model 3, which brings the estimated ave kWh content per car to 74 kWhs at an average pack cost of $187 per kWh. This extends to 37 GWhs of batteries for a value of nearly $7 Billion for 2020. Then the forecast to 2025 takes into account changes in vehicle demand, average battery size and cost. And this type of calculation is done for all product categories from eBikes to eBuses to arrive at the transportation battery forecast.



You might ask about battery cost assumptions for Tesla's in 2025 and for the lead-based AGM batteries in Ford's F-150. In short, we have included best available estimates and forecasts. For Lithium batteries, here is a recent survey and estimate covering EV vehicle battery costs in 2020, showing a 10% advantage for Tesla over GM.

I am a bit skeptical of claims to $50 or $75 per kWh in lithium. Advancing science is helping, yet this is still material science, not electronics, so Moore's law does not apply, and I have included 3% per year further reductions in lithium battery costs, not the 10% or so, some may claim from here. Yet knowing my assumptions, you can adjust the forecast for your assumptions.



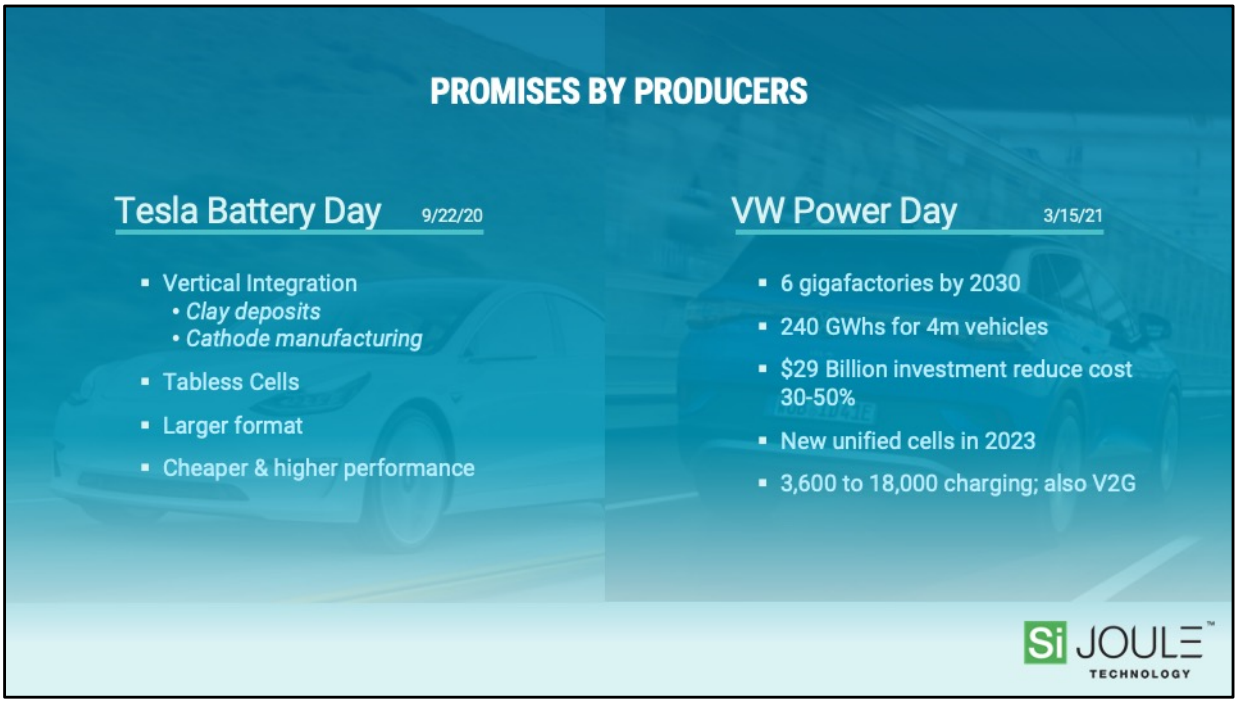
The modest continuous cost reduction forecast considers the probability of higher average material costs to 2025, linked to growth in demand for key materials in the Clean Energy Transition.

The price forecasts shown here are from the respected commodity analyst group, CRU and Neil Hawkes, showing critical lithium battery materials of lithium, cobalt and nickel to increase 14 to 42% by 2025.

Another group Bloomberg New Energy has calibrated the shift in actual quantity demanded for these materials from batteries to increase by 3X to 14X. I believe there will be enough raw materials, yet the costs may increase with higher mining and extraction costs from more difficult sources, as is typical across most extraction industries. Also shown are forecasts for higher lead, oil and copper.

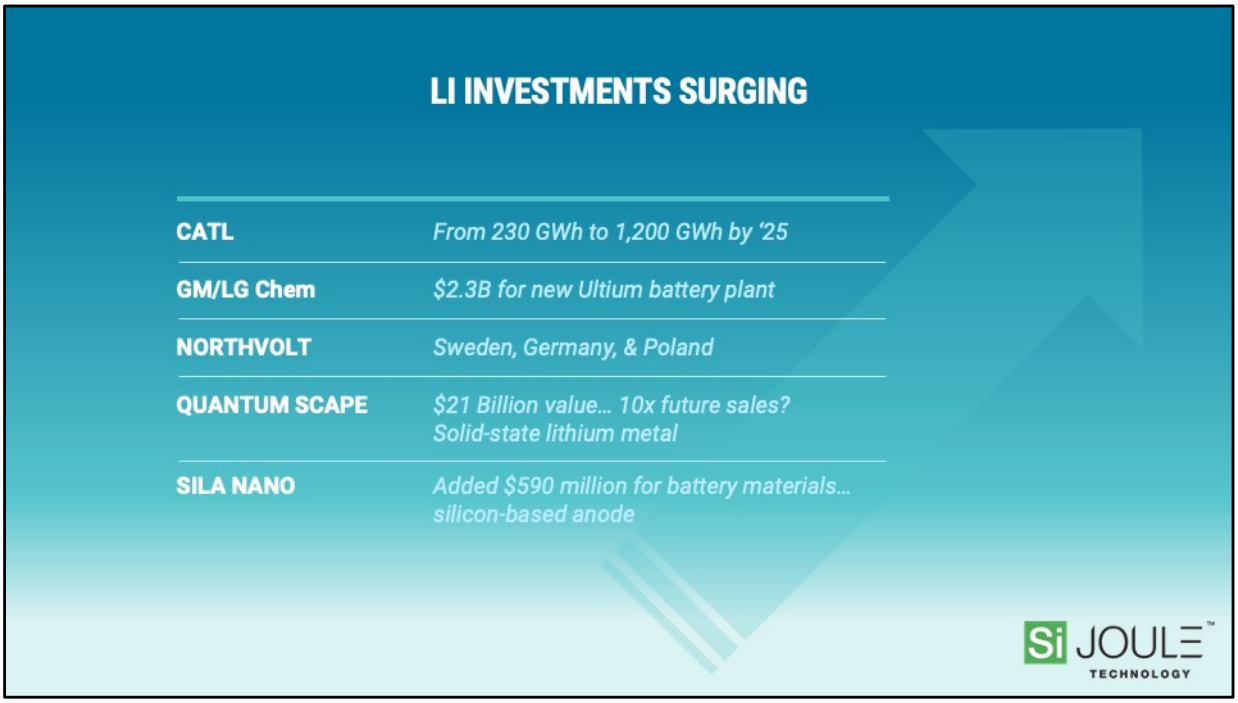
Though you should defer to CRU on well researched commodity and lead prices, another possibility is future lead costs could also be lower if legacy applications for lead batteries decline. And this is combined with the impact of primary lead still coming out of the ground due to co-product zinc and silver mines to supplement recycled lead. And if you add the maturation of lead bi-pole technologies which typically contain 1/3rd less lead per battery, you can derive a different, possibly much lower lead cost forecast.

Can you compete better for diverse ESS and transportation and other applications with lead costs at under $1,000/metric ton or under $.50/pound?



Vehicle companies used to hold impressive press conferences to announce new vehicles. Yet, you may have seen the highly promoted Tesla Battery Day last year, or VW's similar "Power Day" last month, each striving to impress investors with battery investments and technology changes to improve range, charging times and costs. There is no question these two companies and others are "all in" as it relates to batteries, and all those investments should yield product improvements and capacity.

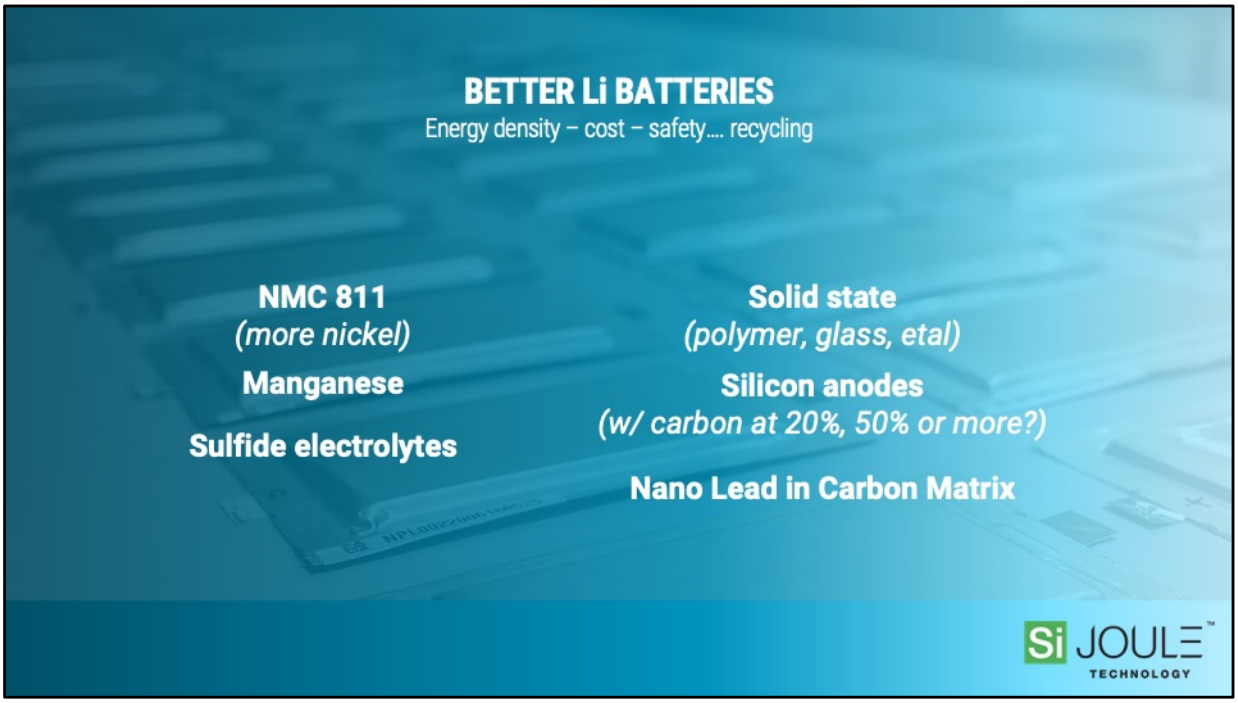
A different question is how likely will the breakthroughs come from Tesla, VW or GM, or from the innovative battery start-ups, many in the US, or from the 4 largest lithium battery makers in China and South Korea, who have thousands of engineers and billions in capacity investments. Let's touch on a few of them.



The world's largest lithium battery supplier, CATL is planning dramatic capacity increases, nearly 5X by 2025 to 1,200 GWhs of capacity across China and in Europe, according to some reports. That capacity is roughly the equivalent to twice the size of the entire existing lead-based transportation battery industry capacity in the world today.

Northvolt, the emerging "local" European lithium producer is progressing from its initial Swedish plant to a second German cell plant, and an announced cell assembly plant in Poland.

US start-ups QuantumScape, Sila Nano and Solid Power are pushing for unique performance breakthroughs in lithium based batteries with different approaches, and they have received significant funding and valuations, even before shipping any commercial products. These are very smart folks with out-sized funding.



What improvements will actually be realized in lithium batteries?

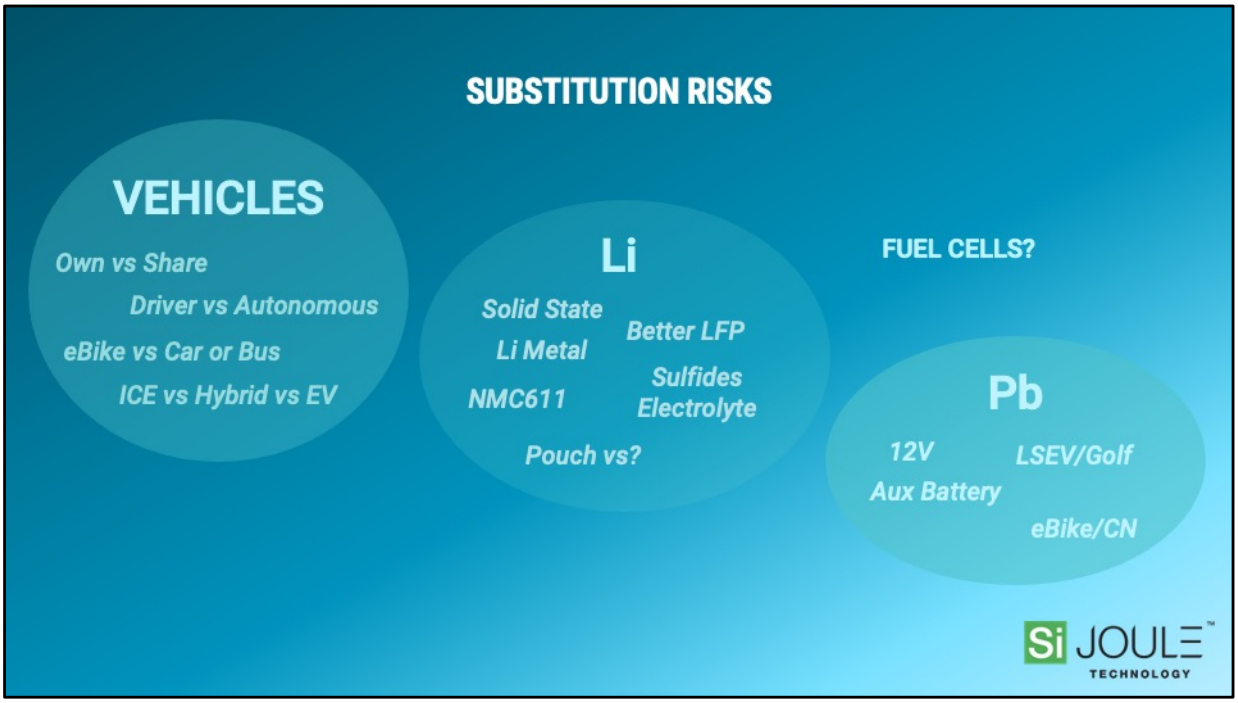
It's safe to say with so many researchers with so much more money behind them, we will get better, cheaper and safer lithium batteries, even if the timing and costs of the improvements are difficult to call.

Solid state solutions should arrive at some point, silicon substituting in the anodes seems likely, and substituting away as much cobalt as possible is progressing. Even one group at Argonne believes Nano lead particles in a carbon matrix for lithium batteries holds unique potential.

Yet, don't write off lead batteries with its low cost and perfect example of an infinitely recyclable solution. This is because advanced lead batteries are on multiple complementary tracks also to improve performance, life and cost by 2 or 3X or more. This is thanks to the efforts of the research consortiums including CBI, LBSRP, and some companies who are driving better active materials and bi-pole formats.

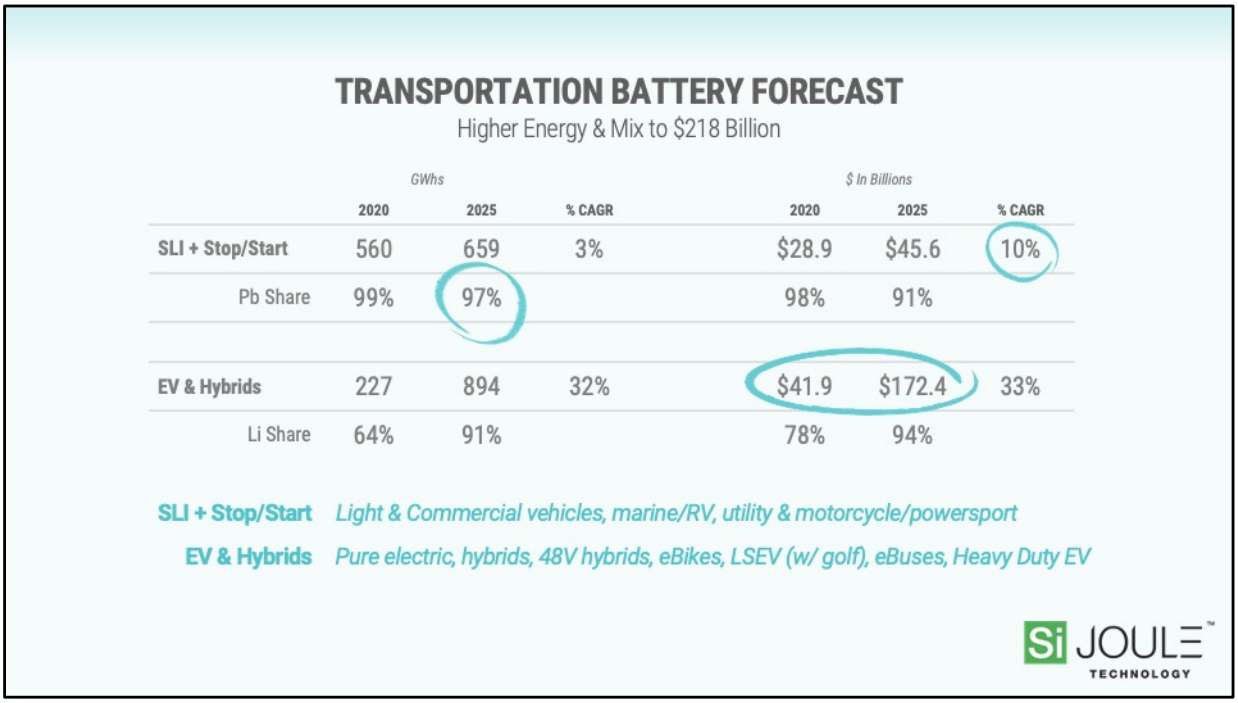
Lead-based batteries are not going to power 500 mile range light vehicles, yet their potential to aid and accelerate the clean energy transition to NET ZERO is significant in so many transportation and ESS and industrial applications that it should not be overlooked. And the technology has a proven and unique track record for a circular economy, along with its demonstrated low cost and safety.

Bi-pole architecture with lead based chemistry is now real with proven sealing, delivering higher voltage and performance blocks. And initial commercial grade batteries for trials are now being shipped in the U.S.



With so many changes across consumer preferences, vehicle propulsion, and battery improvement potential, assessing Substitution Risks is a challenging yet essential part of any forecast.

Will 30 year olds in Munich want to own a car, or simply a leased eBike and periodically opt for a shared car. Or will one of the lithium start-ups obsolete 50% of your billion dollar plant investment. Or will new lithium batteries substitute for the lead 12 volt battery? Will low cost, lighter 48 volt lead batteries substitute for lithium batteries in the growing fleet of mild hybrids? Can fuel cells and hydrogen be cost competitive and green? There are more questions than answers, yet let's go to the forecast where we have made the informed judgements, considering input from many.



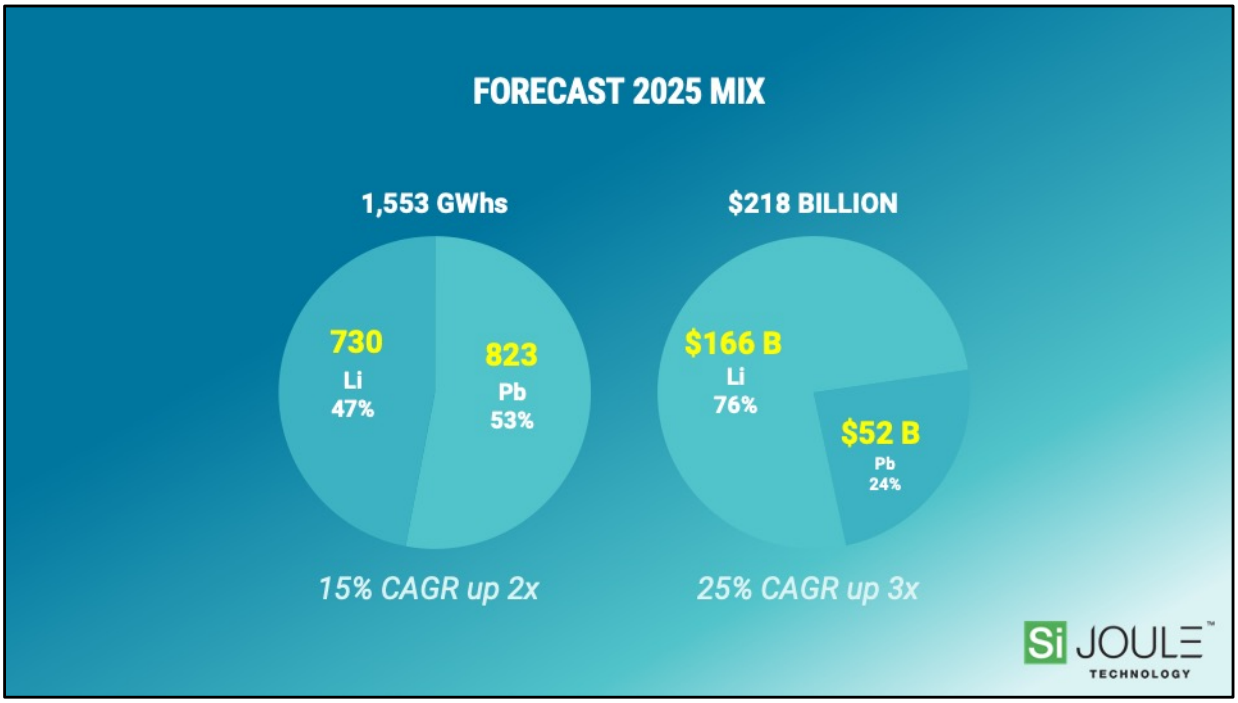
I have split the forecast into two major groupings to help illustrate the impact from the changes in vehicles and batteries. The “SLI and Stop/Start” segment includes the OE and replacement batteries for vehicles with combustion engines, plus auxiliary batteries, and specialty uses for marine, RV, utility and motorcycle applications.

The unit and energy content for this first group is forecast to grow 3%/year, increasing by 100 GWhs to 659 GWhs by 2025 with 97% of the power and energy coming from lead and advanced lead batteries.

The value is forecast to increase at an average of 10% per year due to the rapid growth of better higher performing AGM and EFB batteries, and also Bi-Pole batteries.

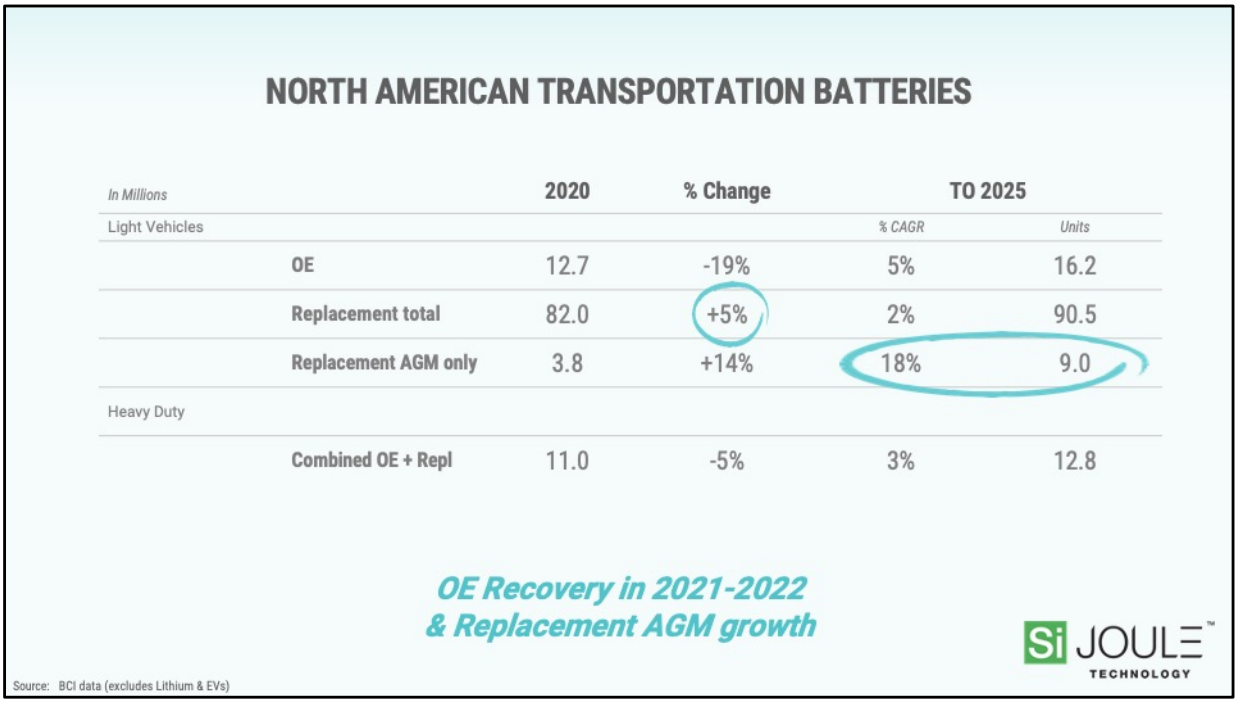
The second grouping of batteries is for all versions of electric and hybrid transportation applications from from the smallest eBikes to the large eBuses, and all vehicles in between.

Across the five years to 2025 both the energy content and value increases by approximately 4X to nearly 900 GWhs of demand and a value of $172 Billion dollars. And it is estimated 94% of these batteries worldwide will be lithium-based technologies. It is expected low cost lead-based batteries will continue to offer value in some low speed EV type applications from golf carts, to tuk-tuks to eMopeds in many countries.



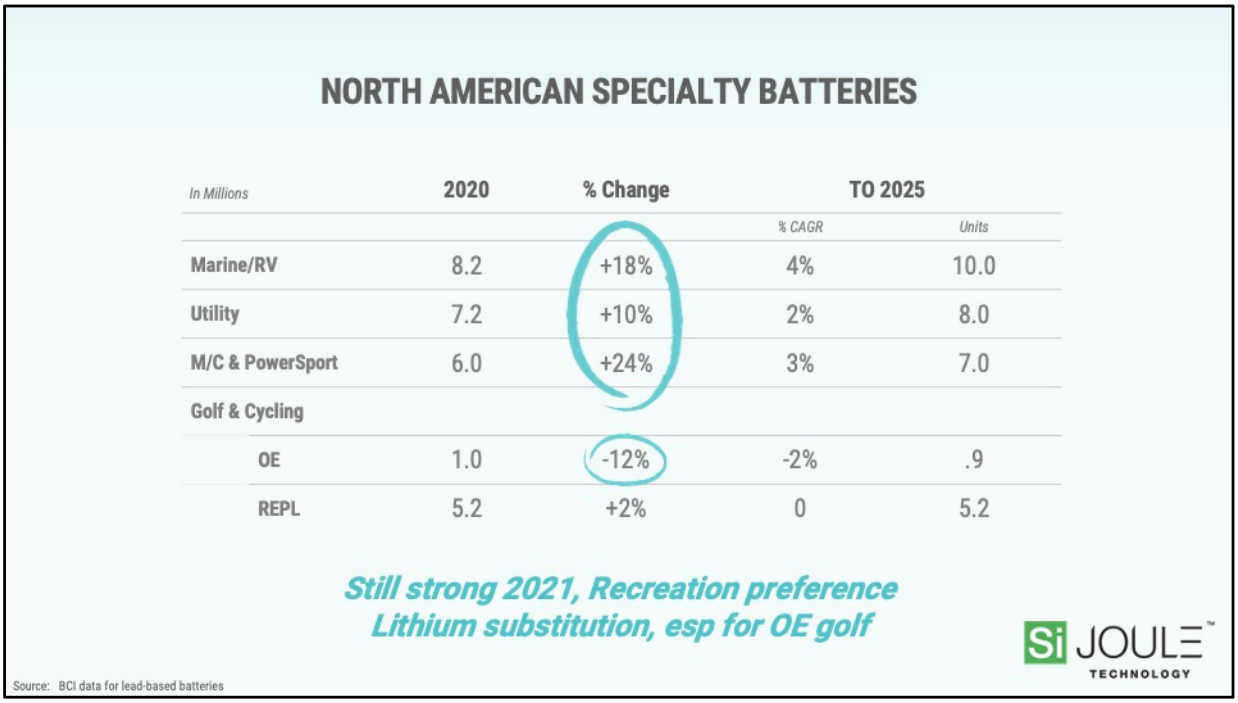
Combining the battery applications in the forecast, we have a compound growth of 15% or a doubling of the global demand by 2025 to over 1,500 GWhs or 1.5 terra watt hours. As you can see in the pie chart on the left, the actual capacity in energy will be split nearly 50/50, while the value of batteries sold will be about three times as high for lithium batteries at $166 Billion. However, lead-based batteries are still forecast at $52 Billion, as continued improvements in performance sustain many transportation applications.

I will now share some select regional insights into battery demand that aided the assessments and forecast.



Based on the statistics from BCI members, we have good historical information on transportation and specialty batteries in North America. As noted earlier, the replacement market increased by an above average rate of 5% in 2020. The best insight from industry members including Clarios, East Penn & Stryten was that it is likely we would return to more normalized growth of 2% for light vehicles and 3% for commercial vehicles to 2025.

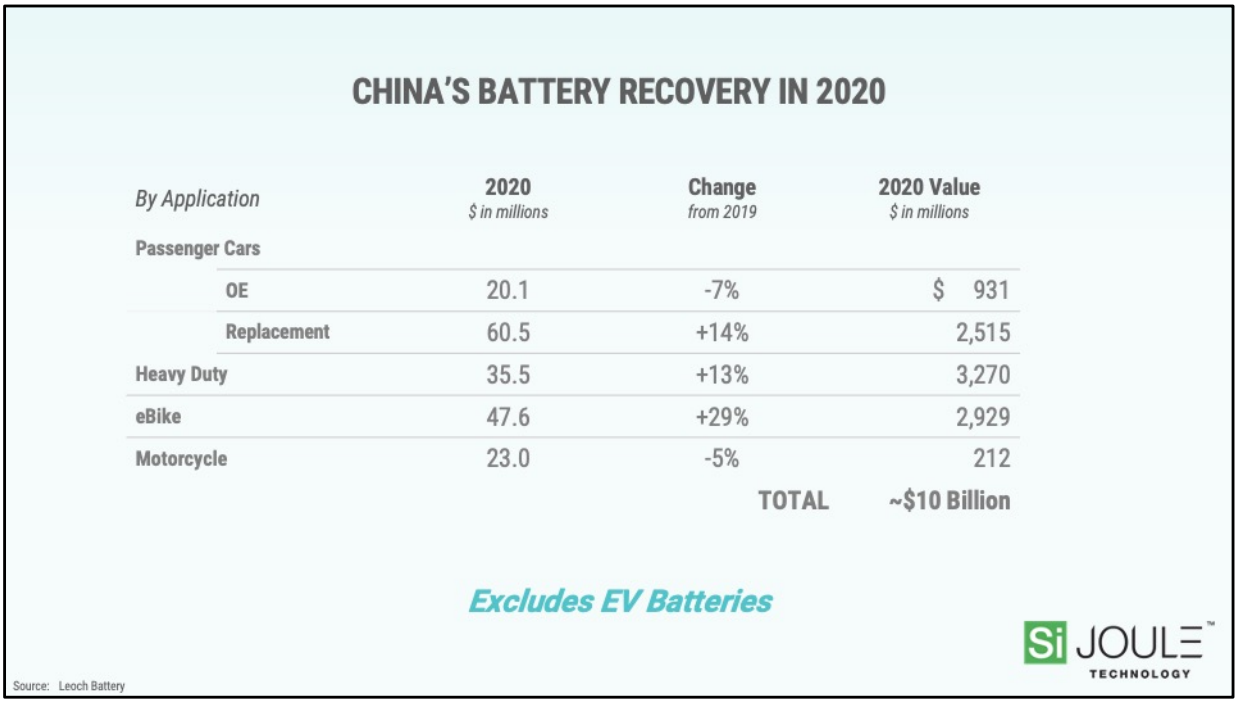
However, vehicles sold in recent years with the stop/start application will continue to drive rapid growth in the higher value AGM batteries, along with a higher share also of EFB batteries, preferred by some in particularly warm climates.



Across the specialty battery sectors, there was uniquely high growth in North America, reflecting the consumer activities in the midst of the pandemic. People working at home bought more powered garden tractors, bought batteries for new or existing RVs (recreational vehicles) and boats, and or put a new battery in their motorcycles and jet skis. As shown, shipments in these categories increased at 10 to 42%, which are rates I do not believe the industry has seen in the last 40 years.

Though the golfing industry saw a boom in North America in 2020 also, as a preferred outdoor activity, the actual mix of batteries shipped for new carts continued to shift to lithium batteries, particularly in warm climates, leading to a 12% decline in lead-based golf cart batteries for original equipment.

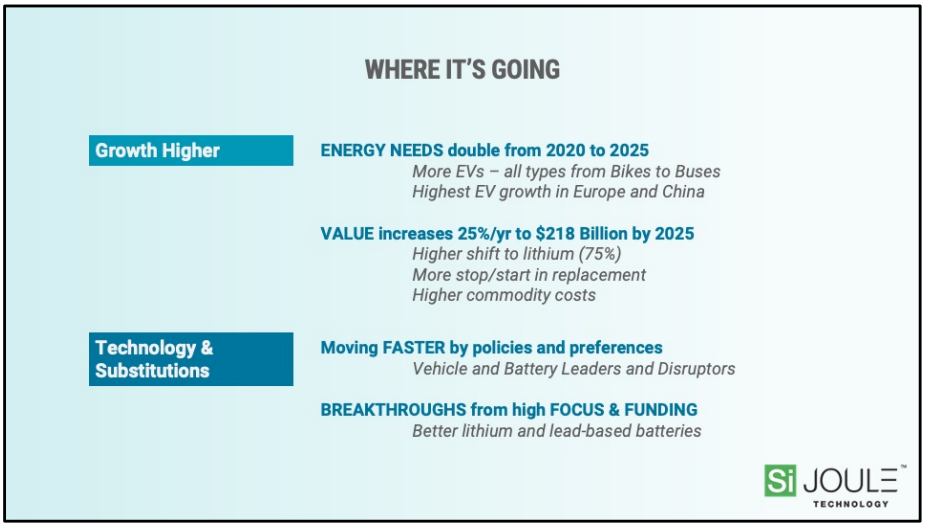
In Europe, these categories did not see the same increases as the usual vacation migration from Northern Europe to sunny Southern Europe was blocked by lockdowns in Italy, Spain and other countries striving to contain the spread of the virus.



We have good insight to the market evolution in China, thanks to the team at Leoch Battery. Classification differences can create some variation in the statistics, yet this summary gives you a good view of the recovery of the roughly $10 Billion Chinese transportation battery market, excluding the EV segments for light vehicles and buses.

Long parked cars with sulfated batteries was one explanation for the above average 14% replacement battery growth. Government stimulus lifted the heavy duty market to year / yr growth in 2020, and the preferences for safer/distanced travel vs. mass transit, led to a strong recovery in eBike battery shipments.

You may find it interesting to note that the three major Chinese markets of batteries for passenger cars, heavy duty apps. and eBikes are similar in value at $3 to $3.5 Billion each.



We have covered a lot of data, vehicles and issues impacting the transportation battery applications.

In summary, the Clean Energy Transition is driving a forecast doubling of the battery energy required from 2020 to 2025, and the value increasing by 3X to over $218 Billion worldwide based on the forecast model I have explained. This includes all the transportation battery uses from eBikes to eBuses and Stop/Start batteries and the rest.

The forecasts includes many assumptions on government policies and consumer interest, along with the cost of critical materials for batteries, which are generally increasing due to the higher demand.

Vehicle and Battery company leaders and their engineers at the same time are fighting to keep up with today's higher demands, and making critical decisions where to invest in technology advancements and capacity. Financial markets and governments are stepping up even more to support the energy transition to net zero emissions.

I believe it is broadly accepted that we will get safer and lower cost lithium batteries in the future. For advancing lead batteries, the work of many, including my company, with its Silicon Joule technology provides a tremendous opportunity to contribute to the efficiency of transportation in a sustainable, safe and low cost manner.

Regardless the progressing developments for lead-based batteries aided by the consortiums, and companies like mine, it is not yet broadly accepted as it is for lithium, that we can play a larger role in the clean energy transition. It is on us together with our leading technologists and executives to support the acceleration of the development, scaling and commercialization of the most promising technologies. I recognize how busy all your companies are addressing the business of today, yet we most move faster very soon not to be crowded out by the further progress of lithium batteries. My company and others can help you do that, helping you adapt your plants, and drive profitable growth.

Thank you, and best success in strengthening the future for your companies in delivering more and better lithium and lead-based batteries for the benefit of our planet.

I want to thank the companies and organizations listed here for the input supporting the forecast, and especially Dan Kubis from Roland Berger Consulting for his help in the forecast model.

For Full Disclosure, I have important personal investments in two companies referenced in this brief; most notably Gridtential, the provider of Silicon Joule (bi-pole) battery technology combining treated silicon wafers with lead-based chemistry, and also ChargePoint, the leader in EV Charging.

GRIDTENTIAL®

CONTACT

Ray Kubis
Chairman, Gridtential Energy LLC
ray.kubis@gridtential.com

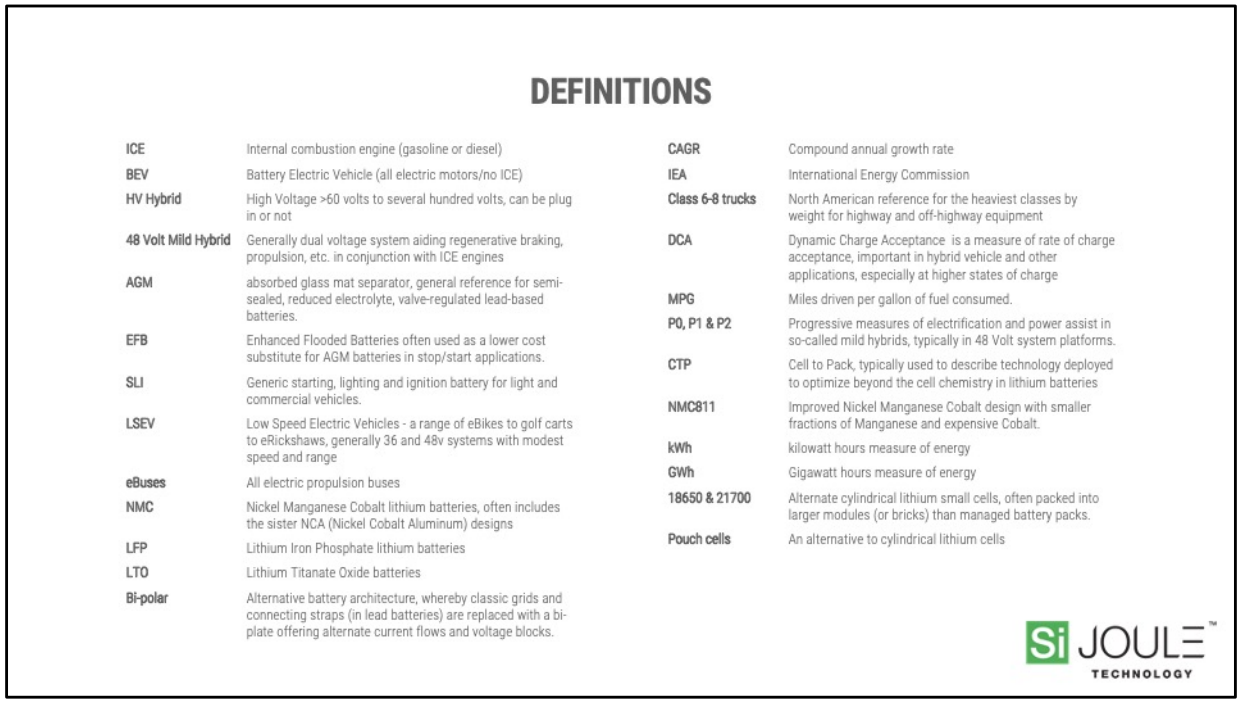
John Barton
CEO, Gridtential Energy LLC
john.barton@gridtential.com

gridtential.com

SiliconJoule™
12v Power

SiliconJoule™
24v Deep Cycle

Si JOULE™ TECHNOLOGY



ICE	Internal combustion engine (gasoline or diesel)
BEV	Battery Electric Vehicle (all electric motors/no ICE)
HV Hybrid	High Voltage >60 volts to several hundred volts, can be plug in or not
48 Volt Mild Hybrid	Generally dual voltage system aiding regenerative braking, propulsion, etc. in conjunction with ICE engines
AGM	Absorbed Glass Mat separator, general reference for semi-sealed, reduced electrolyte. valve-regulated lead-based batteries.
EFB	Enhanced Flooded Batteries often used as a lower cost substitute for AGM batteries in stop/start applications.
SLI	Generic starting, lighting and ignition battery for light and commercial vehicles.
LSEV	Low Speed Electric Vehicles - a range of eBikes to golf carts to eRickshaws, generally 36 and 48v systems with modest speed and range
eBuses	All electric propulsion buses
NMC	Nickel Manganese Cobalt lithium batteries, often includes the sister NCA (Nickel Cobalt Aluminum) designs
LFP	Lithium Iron Phosphate lithium batteries
LTO	Lithium Titanate Oxide batteries
Bi-polar	Alternative battery architecture, classic grids and connecting straps (in lead batteries) are replaced with a bi-plate offering alternate current flows and voltage blocks.
CAGR	Compound annual growth rate
IEA	International Energy Commission
Class 6-8 trucks	North American reference for the heaviest classes by weight for highway and off - highway equipment
DCA	Dynamic Charge Acceptance is a measure of rate of charge acceptance, important in hybrid vehicle and other applications, especially at higher states of charge
MPG	Miles driven per gallon of fuel consumed.
P0, P1 & P2	Progressive measures of electrification and power assist in “mild hybrids”, typically in 48 Volt system platforms.
CTP	Cell to Pack, used to describe technology deployed to optimize beyond the cell chemistry in lithium batteries
NMC811	Improved Nickel Manganese Cobalt design with smaller fractions of Manganese and expensive Cobalt.
KWh	kilowatt hours measure of energy
GWh	Gigawatt hours measure of energy
18650 & 21700	Alternate cylindrical lithium small cells, often packed into larger modules (or bricks) than managed battery packs.
Pouch cells	An alternative to cylindrical lithium cells