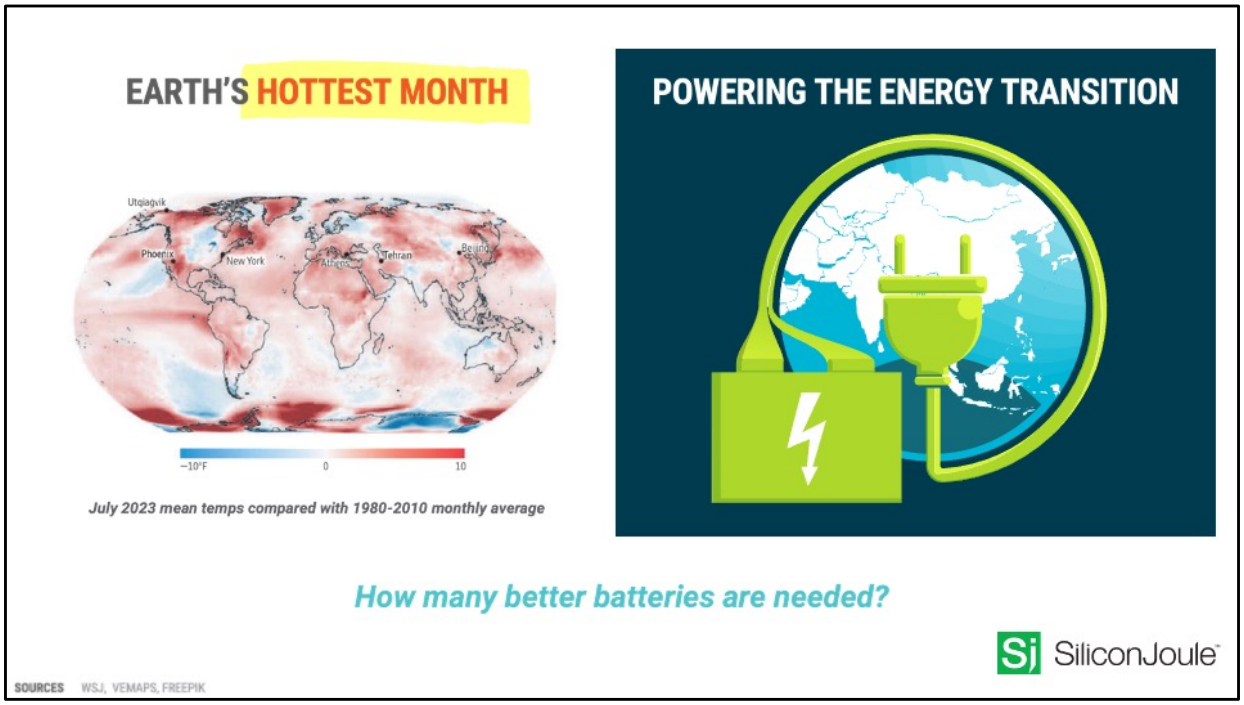
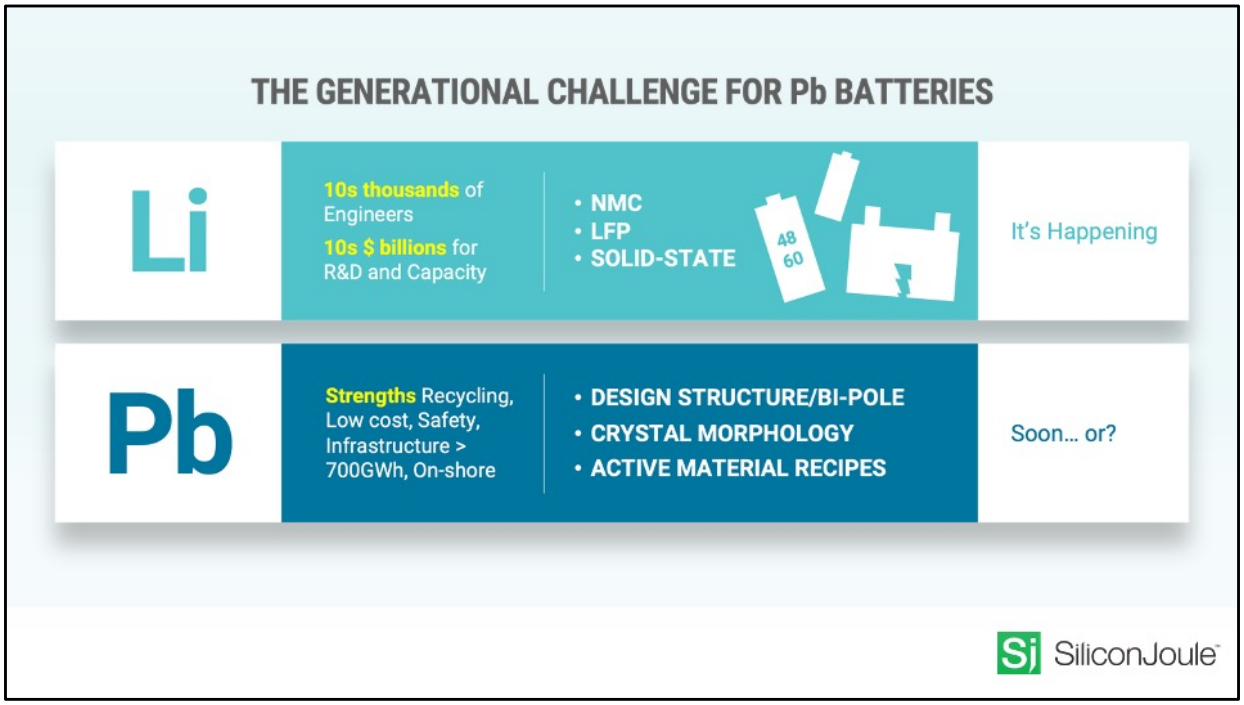
Though major battery investments are underway in Europe and the US, Asia remains the center of the global battery industry.

So, I am glad to be back to cover the forecast for battery usage across the diverse applications, and to add insight to the highest growth markets for advanced lead batteries.



Though some can debate the pace of warming, it is clear it is warmer worldwide.

For us, I believe it is most important to address what the powerful global transition to a cleaner energy future means for batteries and your business plans.



The batteries needed for the Clean Energy Transition is catalyzing 10s of thousands of engineers and 10s of billions of dollars of R&D and capacity investments to further advance lithium and potentially other technologies.

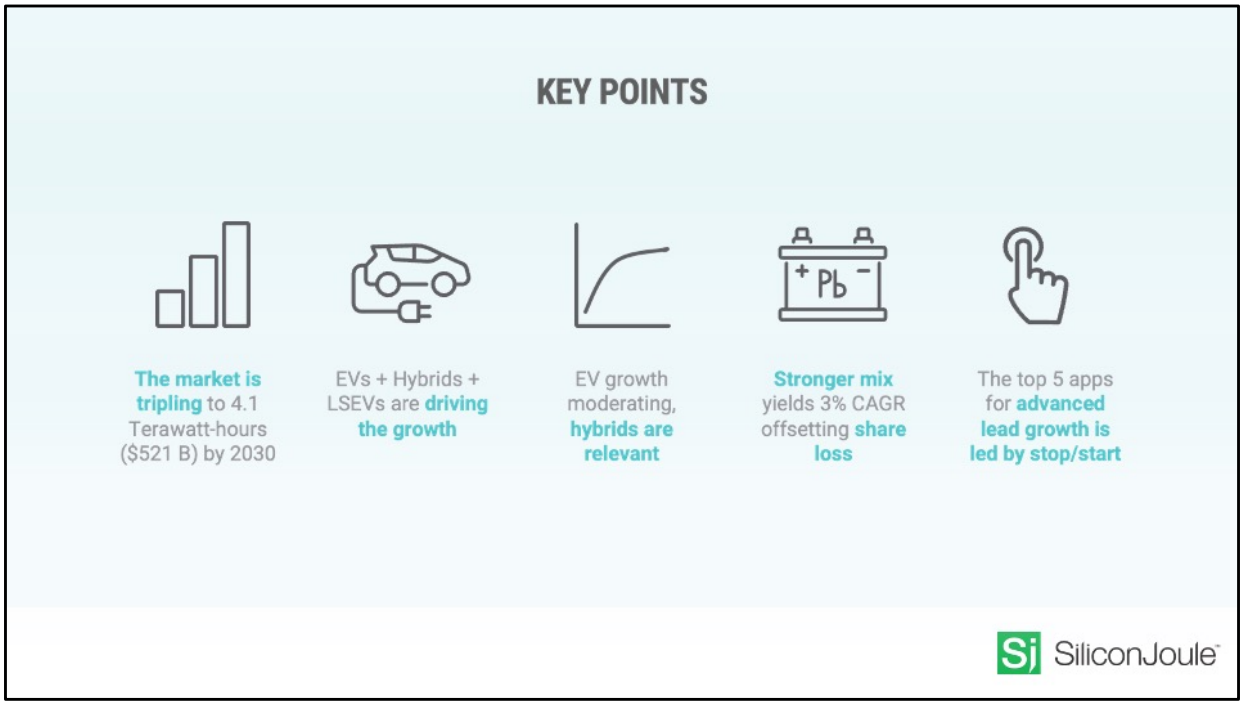
The global lead-based battery industry sits with a truly sustainable, localized, low-cost supply chain and over 700 GWhs of capacity. Yes, there have been incremental improvements with AGM and Pure Lead designs and carbon additives.

Yet only a handful of companies so far are accepting the Generational Challenge for the industry to stretch the performance and life to relevant levels needed to compete in the years ahead of us, even though battery demand growth is amazingly high contrasted to virtually all industries.

Lead batteries now deliver less than a third of the theoretical energy. And design structure alternatives now exist, and crystal morphology can be improved, etc.

My view is unless more companies move quickly to advance lead batteries, even many of our leading companies will show notable declines in future sales and earnings. This would be a huge opportunity missed to avoid the declines, and instead drive profitable growth.

Showing my bias, I am an investor in one lithium start-up driving for greater safety and density. And to help meet the Generational Challenge, I continue to invest in Gridtential, whose Silicon Joule technology combines treated silicon wafers with lead for a much higher performance and life.



Here are some key points to take away from today's brief.

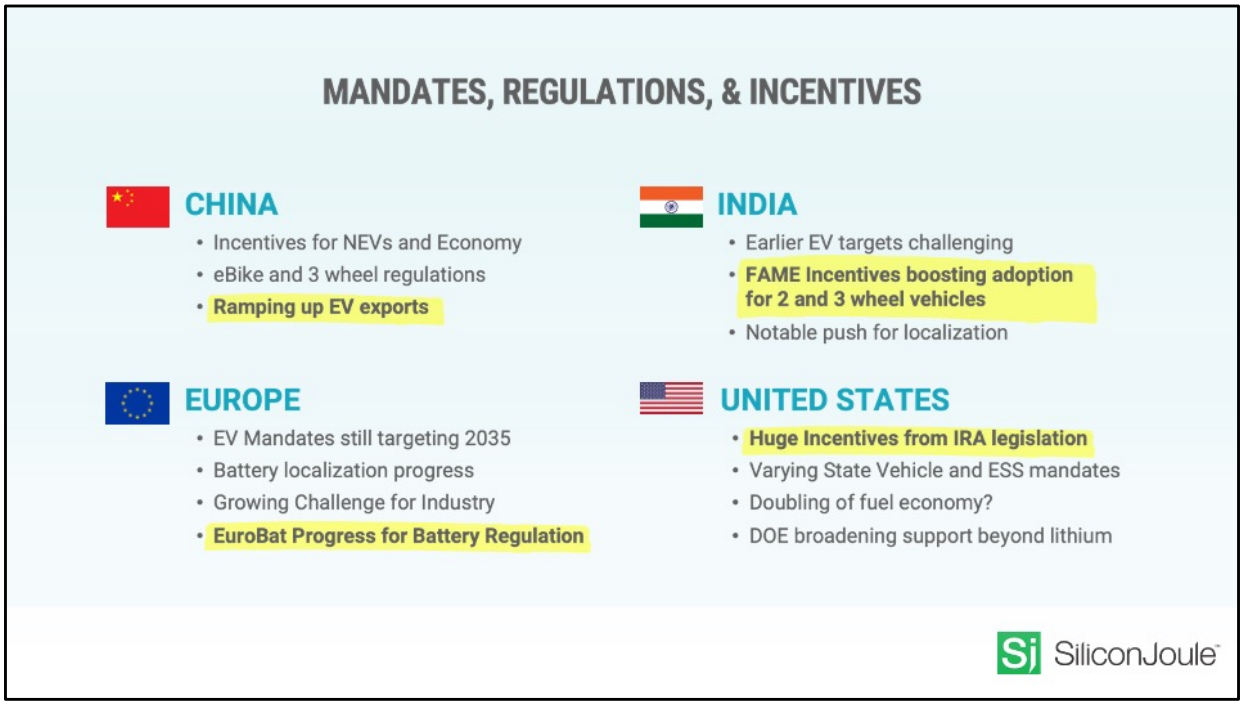
First, very high growth continues with the model showing the global transportation market for batteries to triple to 4.1 Terawatt hours per year and $521 Billion by 2030.

The big drivers are EVs, Hybrids, and Low Speed EVs (LSEV) worldwide with 2, 3 or 4 wheels.

We are starting to see EV demand growth rates moderate in some countries as consumers consider affordability, charging and convenience across the broader customer base following the early EV adopters.

Sales of lead batteries are forecast to grow at a 3% rate to $71 Billion by 2030 as the higher mix of better designs needed by today's vehicles to improve fuel efficiency and reduce emissions offsets some share loss in each transportation market segment to lithium batteries.

And based on the recent survey, those AGM-based batteries support the highest growth platform for lead batteries filling the stop/start function across the majority of OE (non-EV) new vehicles worldwide,and are now increasing in the much larger replacement market.



The mandates, regulations and incentives continue as a major driver for the electrification trends across transportation and other applications.

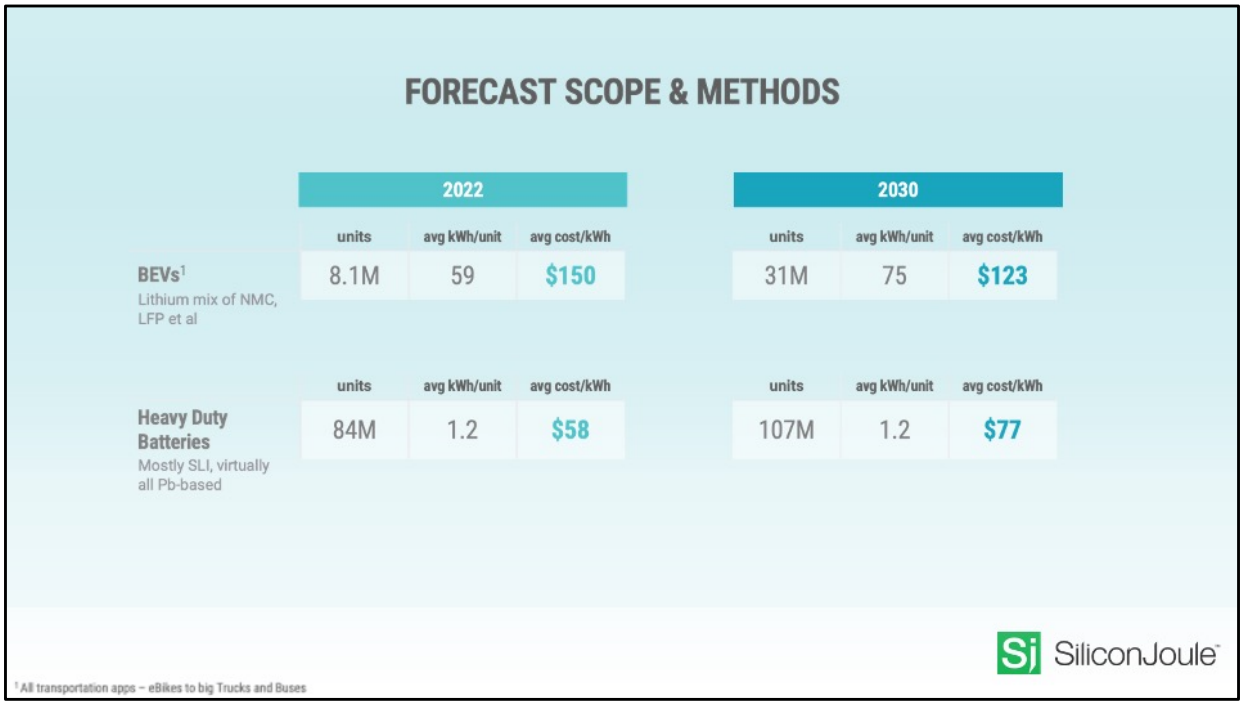
China's policies have supported dramatic growth in recent years for material processing, battery and vehicle production, and incentives were recently extended through 2025. With intense local competition, China's makers are now keen to export more batteries and EVs.

Europe's EV mandates remain in place, yet a recent update in the regulation has created an exemption for ICE vehicles that are powered by bio-fuels.

And we must complement the European Battery Association for a very positive development to prospectively achieve a common regulatory platform for all battery technologies which could remove one of the clouds over the lead battery industry.

India's EV market is largely about 2 and 3 wheel vehicles supporting the wider improvement in air quality across its very large cities. And its FAME incentives have led to an expanding deployment of locally made ebikes, larger eScooters and eRickshaws (or Tuk-Tuks).

For the US, the key development has been the incentives contained in the IRA act in 2022 which has catalyzed huge investments to localize battery supply chains and production.



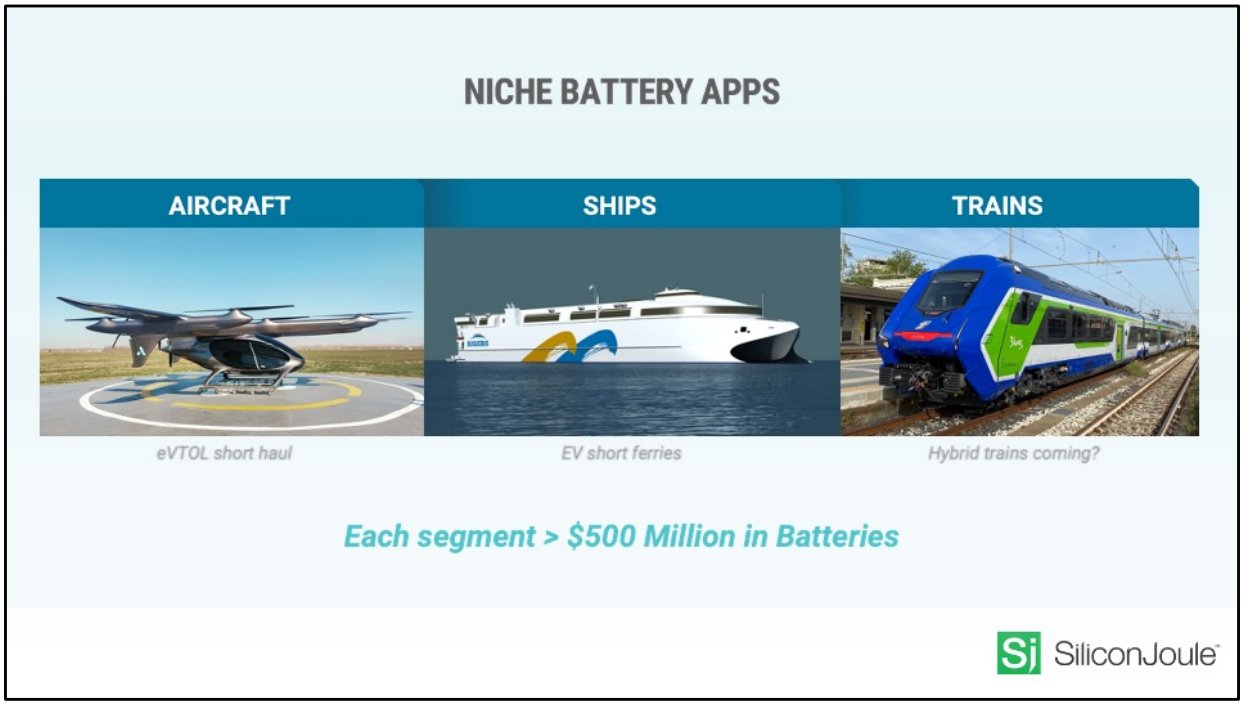
Let me explain how the forecast is built with two examples.

For EV light vehicles, you can see it starts with the 8.1 million EVs in 2022 and the average kWh battery content for the global sales that year, at an average estimated cost per kWh.

Then it is extended to the forecast 31m EVs by 2030, with now larger average battery packs and lower cost per kWh, following the huge surge in material costs in 2021, and the shift to lower cost, lower range LFP vs NMC batteries in the mix.

Also shown is an SLI type battery category, Heavy Duty Batteries for trucks, buses, et al, with the estimated battery units sold in 2022 worldwide along with a kWh content and cost, and then extended in the same way.

With this format with insight on all segments from eBikes to Buses we arrive to forecast battery demand in energy content and value by 2030.



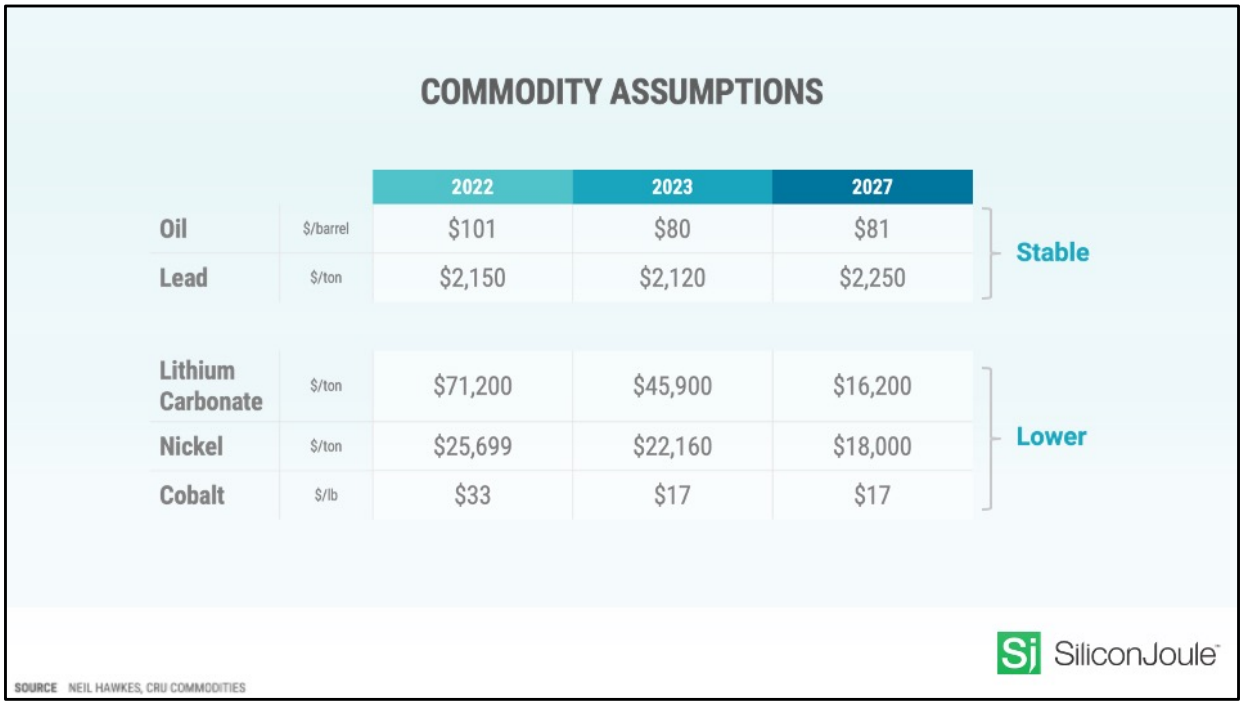
Here are three markets which I have not included in the forecast, yet worthy of some insight.

Each of these segments represent over $500m in batteries worldwide today, and likely heading toward $1 Billion by 2030 as each segment has an increasing trend to greater electrification in existing and new applications.

For aircraft, some companies have launched trial electric vertical take off and landing vehicles (eVTOL) suitable for short haul flights.

For ships, modest distance EV ferries can now re-charge often as quickly as the normal unload and reload cycles.

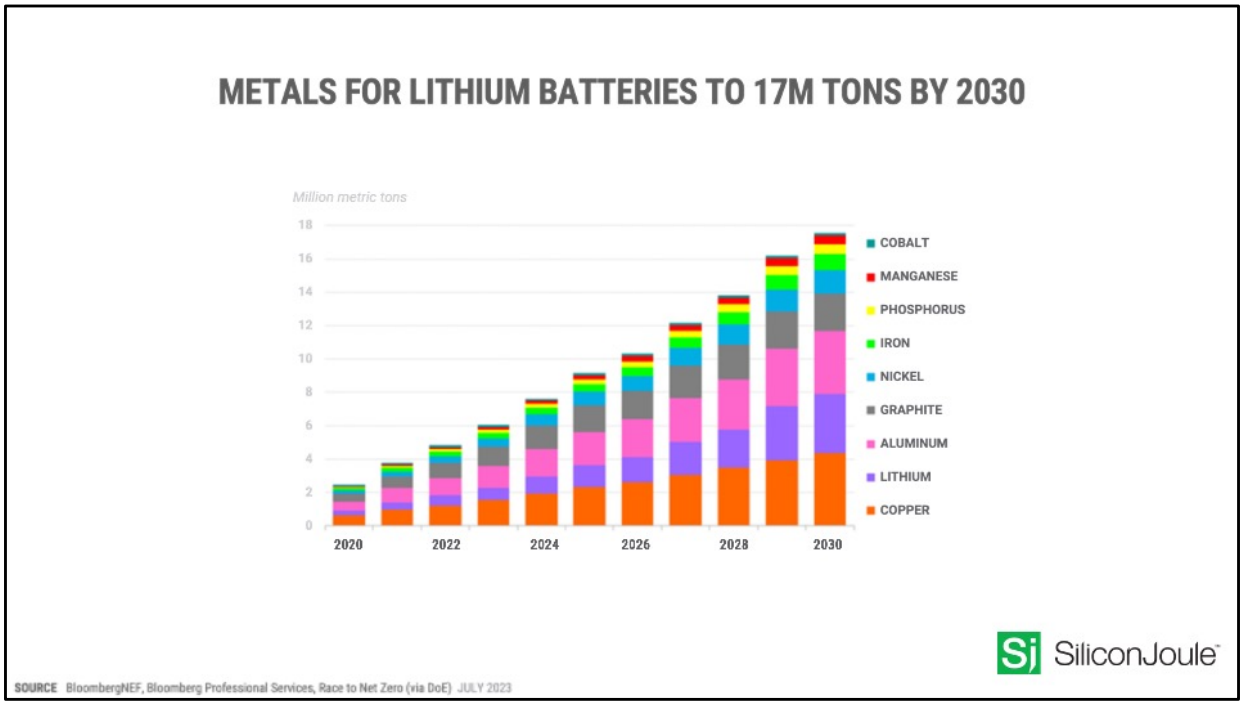
And Italy is taking initial hybrid electric trains where batteries can bridge the network of overhead electric cables.



Thanks to CRU, I am showing the assumptions for battery metals and oil which impact the mix and cost of vehicles and batteries.

The stability in lead costs is aided by the huge recycling content of the global 13+ million metric tons of lead consumed each year.

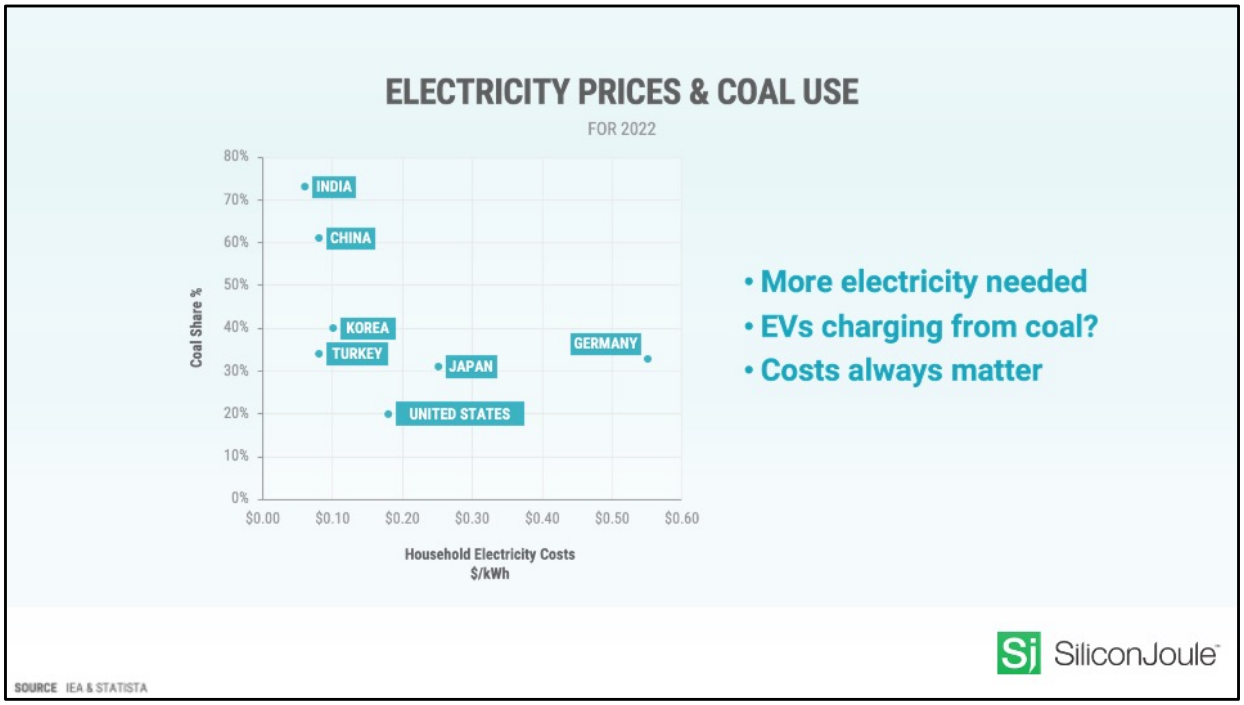
The lithium battery materials are now forecast lower following the earlier dramatic price surges.



This is a brief from Bloomberg profiling the huge demand for metals for lithium batteries through to 2030, which is 17 million tons of mostly mined materials.

Surely there will be some supply and demand variations in the short term, yet it appears there are sufficient materials in the ground and at the bottom of the Pacific Ocean, as some are targeting to collect.

It is important to recognize though that just like with oil, the reserves of these metals will be recovered with notably different costs depending on the location, geology, royalties and other factors.



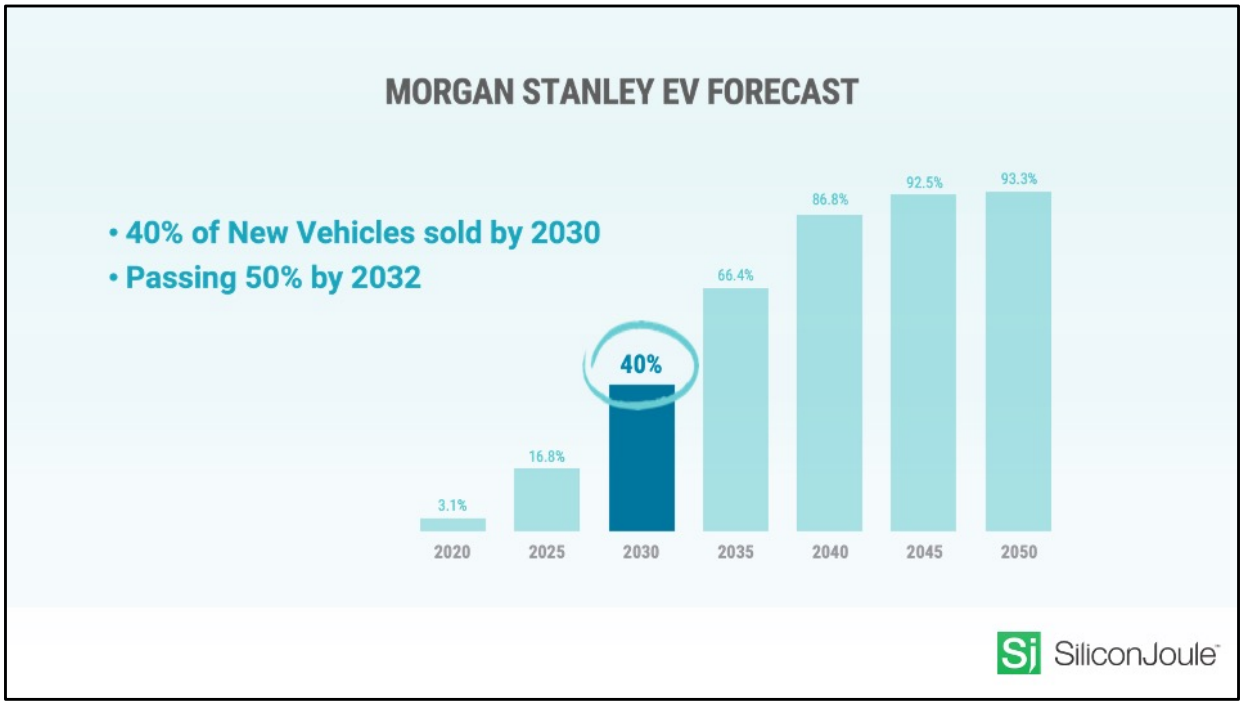
Electricity demand is increasing everywhere from the combination of economic growth and the huge push for electrification of transportation.

Though the growth of renewables is helping, a huge share of electricity generation is still from coal ranging from one-fifth in the US to over two-thirds in China and India. This graph illustrates the intensity of coal use in electricity generation along with the household costs of electricity ranging from $.06/kWh in China up to over $.50/kWh in Germany.

As costs will always matter to governments, businesses and households, I observe you have to be careful in assuming how much emission reductions will happen in this aspirational change away from low-cost baseload generation.

Many countries, including the US, are reducing the use of coal in generation, yet for many reasons the use of coal increased by 3.3% to 8.3 billion tonnes in 2022 according to the IEA.

To integrate even more renewables to reduce coal use and CO2 emissions, it is acknowledged we have to deploy many more, and lower cost of batteries to aide our grids and also EV charging.



Let's now focus on EVs & Hybrids.

This is a Morgan Stanley forecast for the all electric EV penetration, which they put at 40% of all new vehicles by 2030, and crossing the 50% mark in the 2032 / 2033 period.

Let's look at some details for New Energy Vehicles from markets large to small.

Starting with China, there is tough competition across vehicles from the very small $5,000 EVs from the Wuling mini, to BYD hybrids, and the larger vehicles including Tesla's.

Numerous price adjustments may lead to consolidation of the very high number of aspiring producers, concurrent with others' efforts to export aggressively.

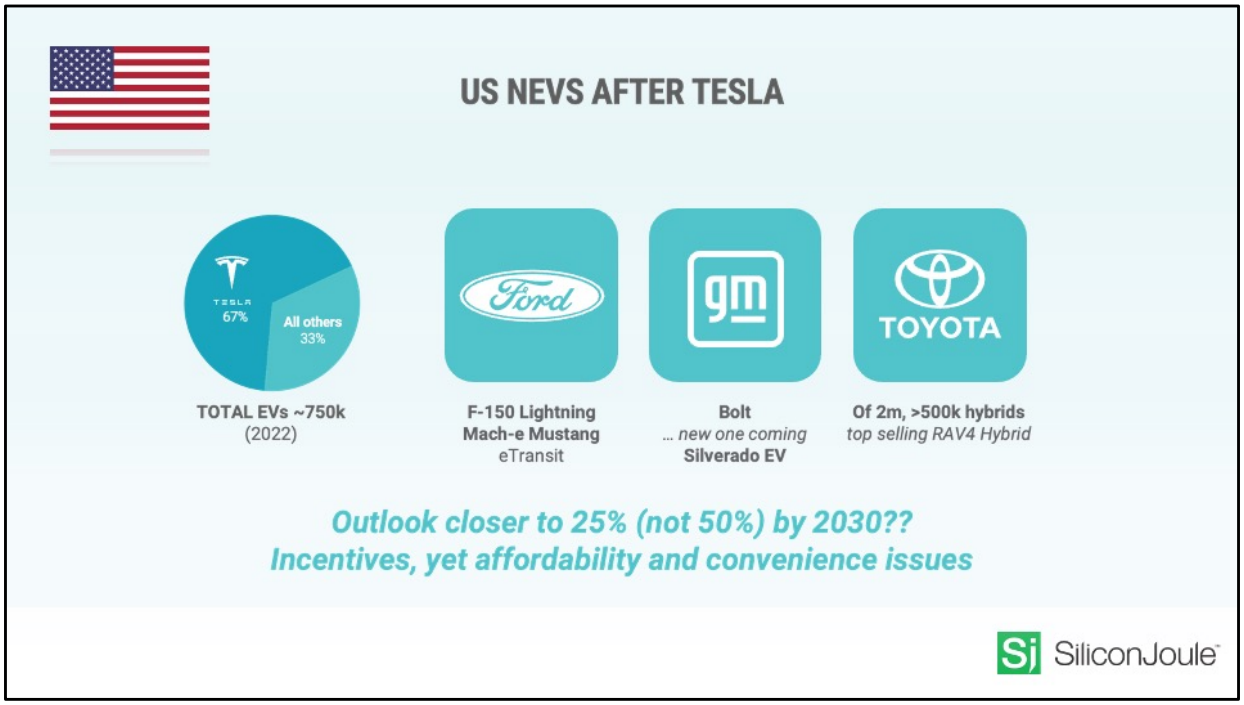
Current trends including small and large EVs and hybrids suggest China will be the first major country to exceed 50% of new energy vehicles by 2030.

In addition, with high forecast growth for exports, some forecast Chinese-made EVs will be over 50% of global EV sales by 2030.

Renault with its Dacia brand, VW with its ID platform, and Mercedes with its premium offering have all brought appealing vehicles to their customer base aiding the progress of electrification of new vehicle EV sales to over 15% in 2022 in Europe.

However, Tesla's Berlin plant, and the notable entry of Chinese EV imports is presenting a tremendous challenge not only to legacy European vehicle producers but also its suppliers and surrounding industries.

It is less clear how the EU carbon border tax will impact future vehicle imports. Yet, German industry's history as the early leader in advancing solar panel production, before being overwhelmed by imports, is potentially an interesting reference along the road to a cleaner energy future.

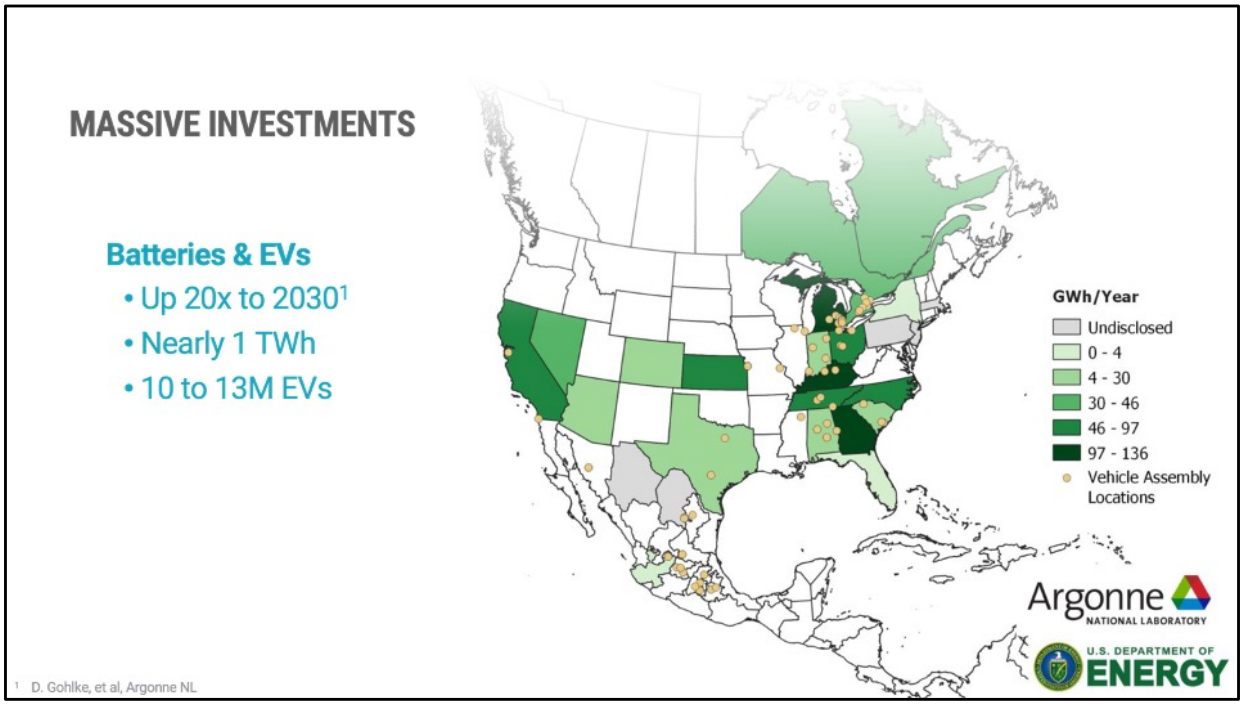


Tesla continues to lead the US market with about two-thirds EV market share of the 6% of new light vehicle sales in 2022.

FORD has successfully promoted its eMustang and F-150 Lightning pick-up truck, and

GM has launched their eSilverado, eHummer and eCadillac, all with large battery packs and premium pricing.

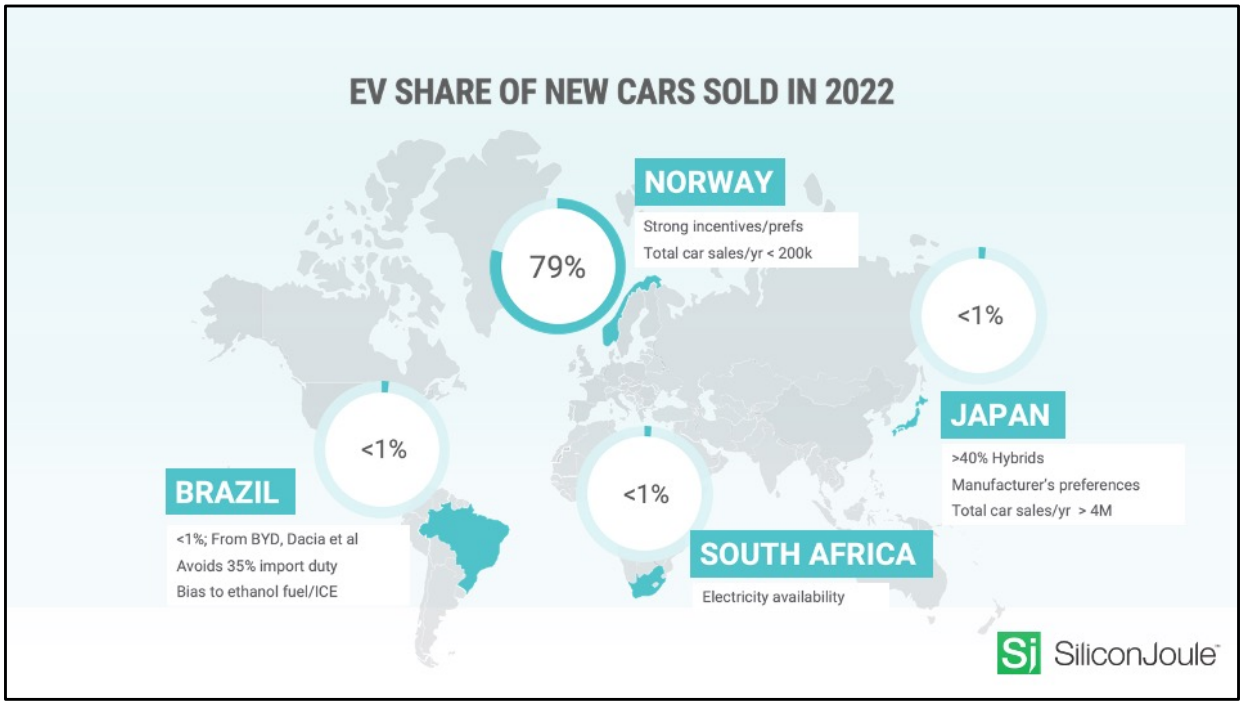
Toyota‘s major US presence continues to be led by its diverse hybrid solutions, which were over 500,000 of its 2m 2022 US shipments.



The IRA legislation passed in 2022 has catalyzed significant new battery and EV vehicle investments across the US

The investment tax credits and loans to support EV battery and supply chain localization, along with consumer EV incentives is a major part of the $1 Trillion plus in government support for climate change mitigation across the next 10 years.

Shown is a summary from Argonne, one of the US National labs, which puts the combined battery investment announcements increasing capacity by 20X to nearly 1 Terawatt hour by 2030, which could power 10 to 13 million all EV light vehicles.



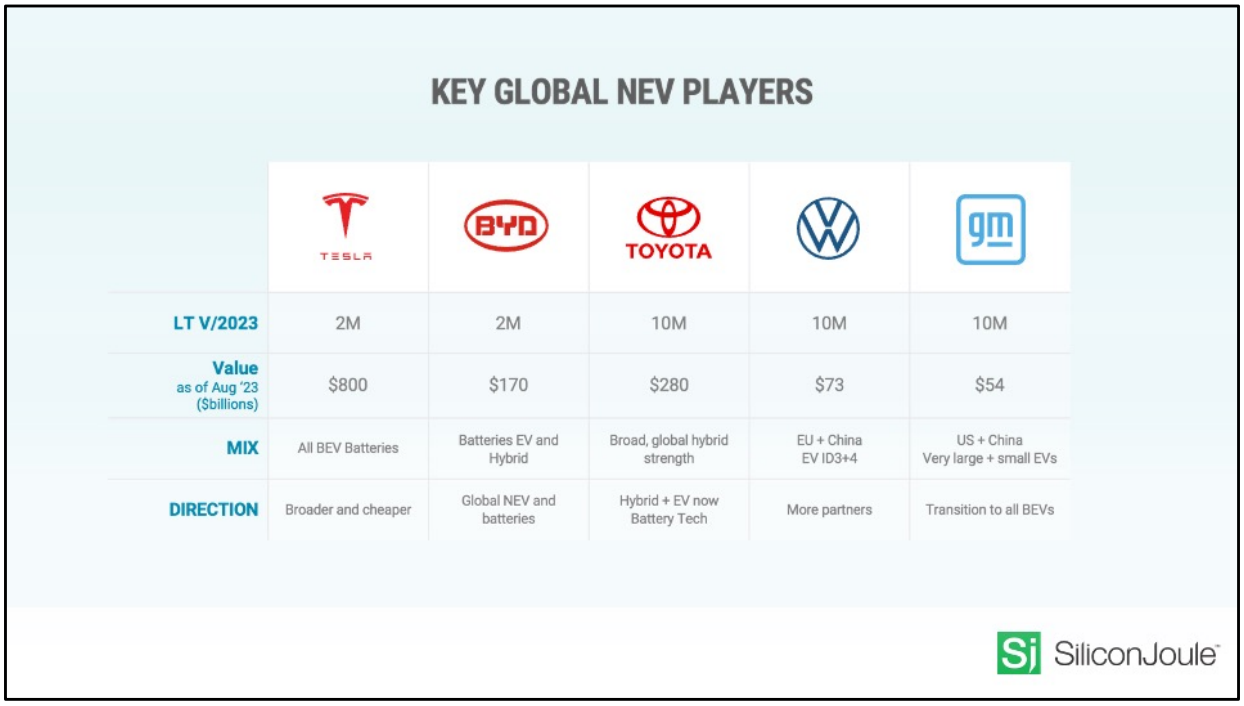
In assessing the prospects for global EV sales, it helps to look beyond the three largest markets.

Norway, one of the richest nations per capita, has led the world with EV penetration with a long list of EV preferences, and for 2022 EVs represented 79% of new vehicle sales.

By contrast three other important economies, Japan, Brazil and South Africa all had less than 1% EVs in 2022, with different influences on local EV adoption.

For Japan, one can argue they have led the world so far in CO2 vehicle-based emission reductions over the last 10 years with progressively higher penetration of very efficient hybrids, which reached 40% of vehicle sales in 2022.

With South Africa's continued challenges in electricity supply, it is understandable EV sales are quite low.



Stepping back from the by area EV analysis, shown here are five of the most influential companies in the electrification of the light vehicle industry.

I think it helps to focus on what we see these companies saying and doing.

Tesla is broadening its product range, increasing capacity, and reducing costs and prices on the way to its targeted 10 million EVs.

BYD's mix of EVs and Hybrids, aided by its strong battery background, is supporting its exports worldwide.

VW is adding vehicle and battery partners to protect its global market share, especially in its two largest markets in the EU and China.

Toyota keeps expanding its global hybrid leadership utilizing both lithium batteries and nickel-based bi-pole batteries, while announcing EV plans based partly around its progress with Solid State batteries.

GM's has promised an all EV future built around its Ultium battery pack.

India's electrification in transportation to date is best illustrated by Hero, the market leader in motorcycles, and Mahindra, who is the leading local light vehicle maker.

Hero has launched successful electric scooters and motorcycles.
And shown here is the 3 wheel, last mile delivery EV offering from Mahindra, which is built on the same platform as the eRickshaws for personal transportation.

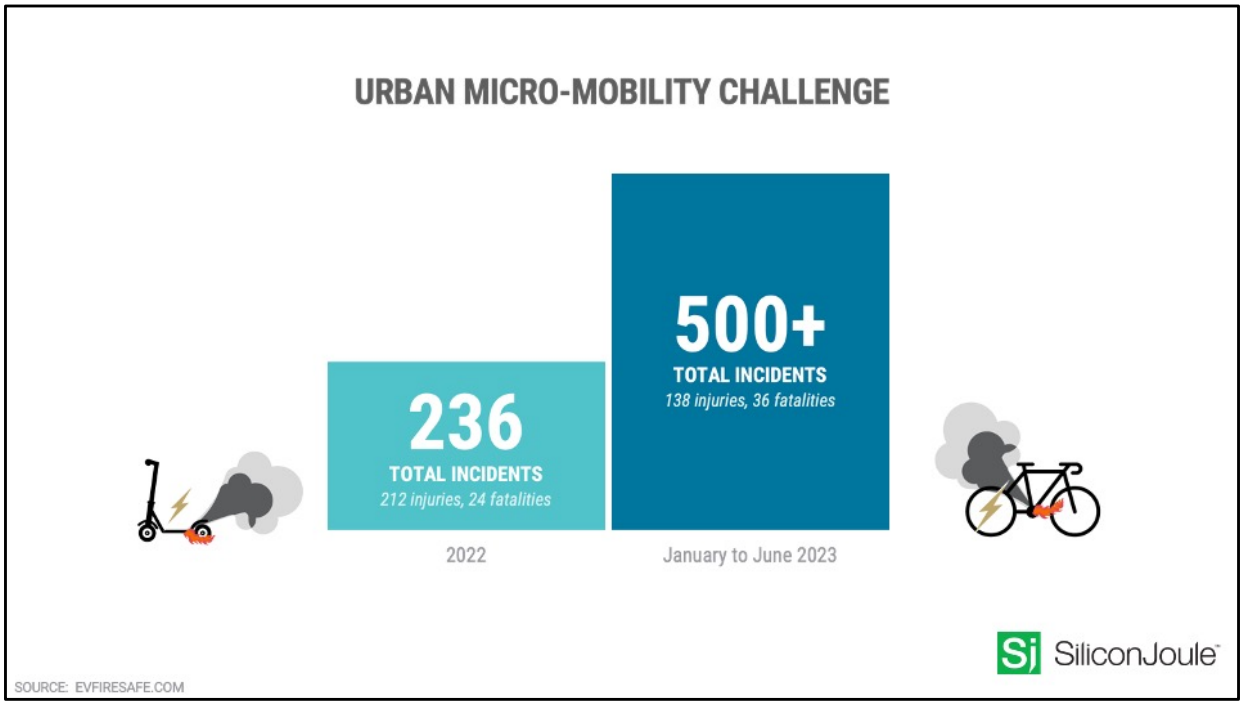
Ola has raised and invested a lot money to support its all-electric future of 2 and 4 wheel vehicles supported by its own giga-factory for lithium batteries.

India's FAME subsidies have aided the ramp in these diverse electric vehicle sales, which also aids local pollution reduction in their very busy large cities from legacy small engine rickshaws or tuk-tuks.

Given the size of the other battery and vehicle producing countries in Asia, Vietnam may not get a lot of recognition.

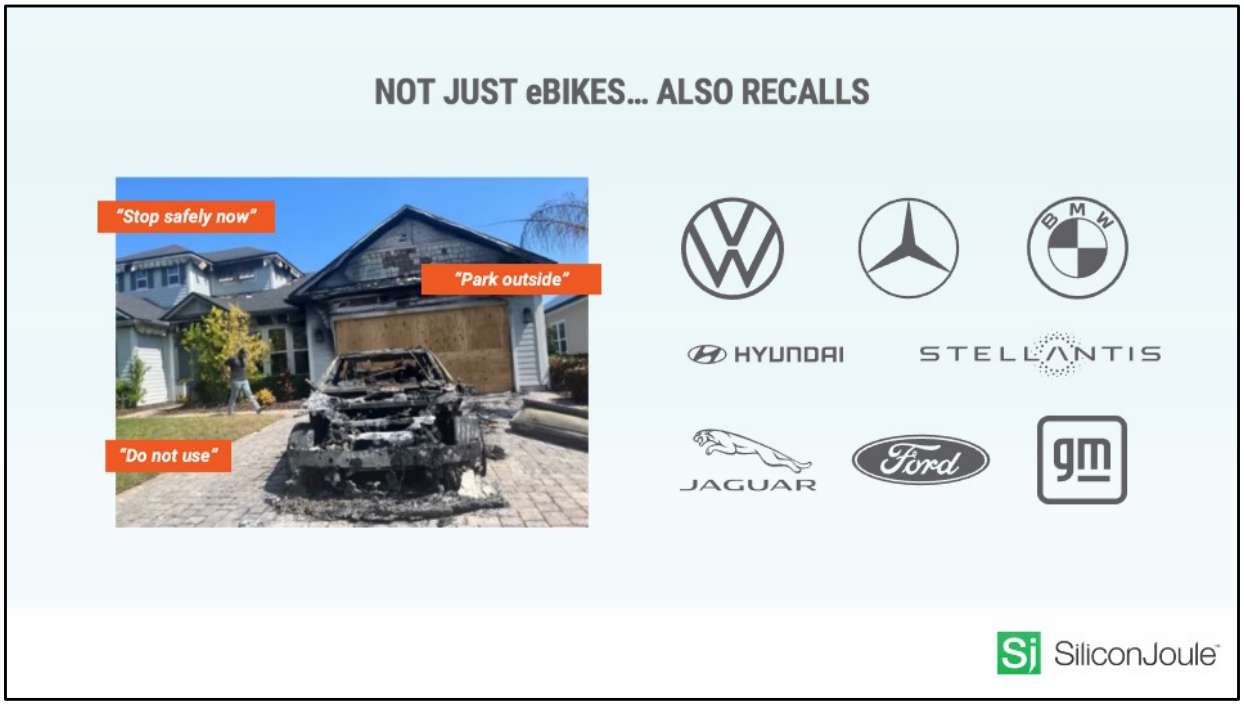
Shown here is just a partial list of the many battery makers who have grown to supply an important share of the global lead-based battery market.

And Vinfast, with its new EV vehicle platform and lithium battery production has aggressively entered into the crowded global market via export.



The growth of Urban Micro-Mobility vehicles, be they eBikes, or eScooters to ride or stand on have proliferated worldwide, with advocates claiming CO2 savings from less vehicles, congestion, parking etc, and especially young people in warmer climate cities increasingly use them in rental fleets or with personal ownership.

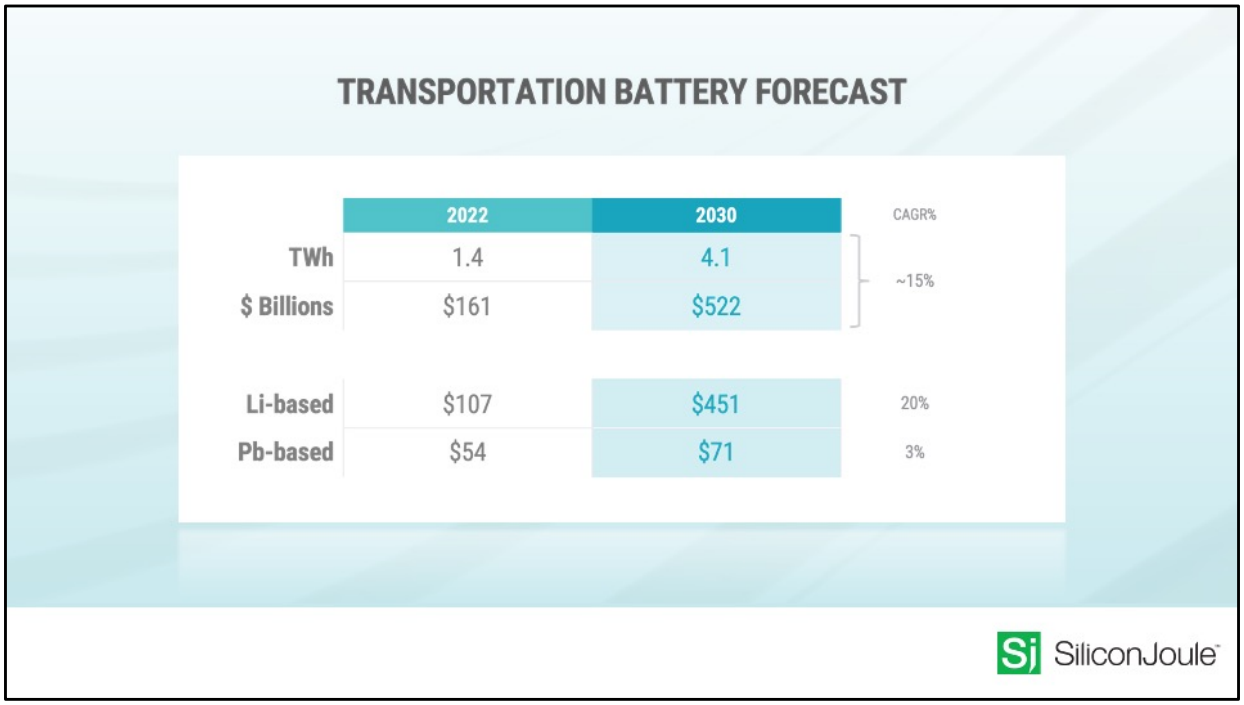
Yet the count and seriousness of fires keeps growing as illustrated in this summary, so industry must further improve on safety.



And the fire risk is not just with eBikes, the ever-larger high energy battery packs, and their controls are not easy, as almost all vehicle makers have experienced.

On the left is just one fire example this Summer from a Mercedes model, originally parked in a garage in the US.

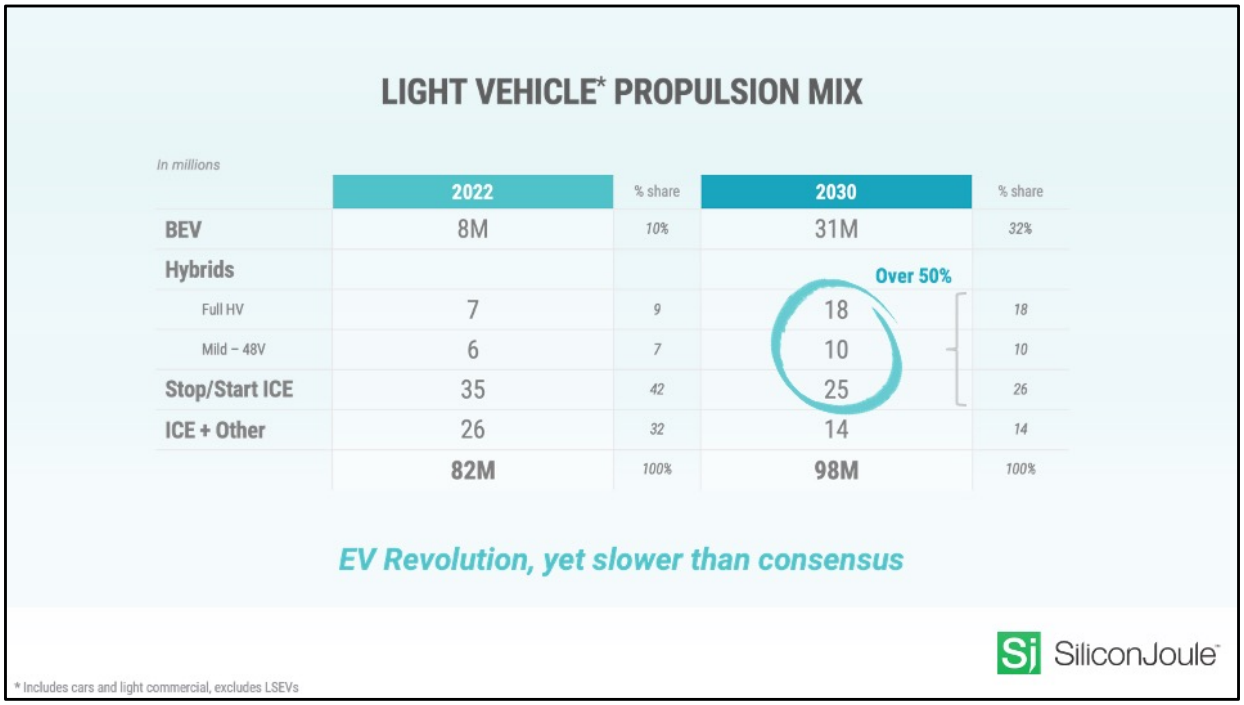
And virtually all the vehicle makers in the US and Europe have had at least one battery related recall, with interesting public warnings such as do not use or park outside.



Moving to the forecast, the total transportation battery market is forecast to triple by 2030, and this is about 15% compounded annually combining lithium and lead solutions.

However this splits to about 20% compound growth for lithium and 3% for revenue growth annually for lead based batteries.

For clarity, I have not included any fuel cell or sodium-based solutions, as I do not believe they will be significant in transportation applications to 2030, even though I acknowledge some at CATL and in Japan, Germany and elsewhere may believe differently.

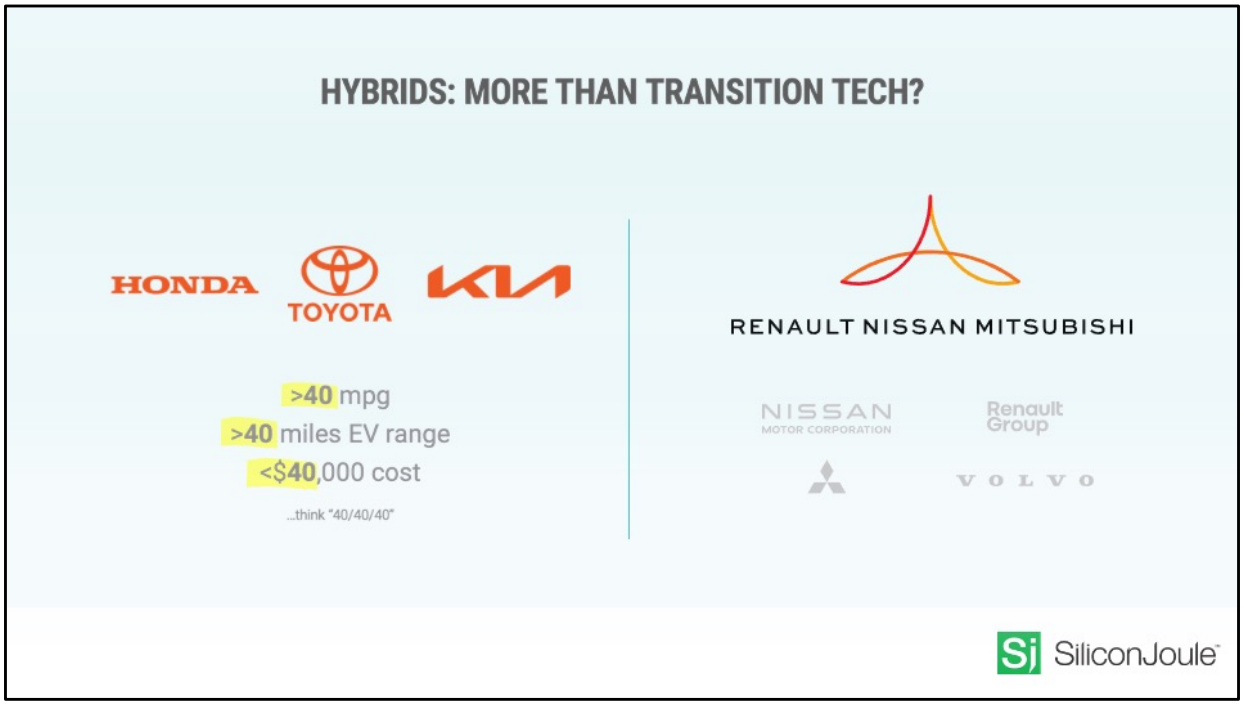


Within the propulsion mix forecast, I believe the 31 million all electric light vehicles by 2030 is about the middle of other forecasts I have seen.

The EV propulsion batteries are a mix of different lithium batteries, the low voltage auxiliary batteries required in EVs are still forecast to be mostly lead based solutions by 2030.

I have included the range of hybrids with also stop/start vehicles to be 53 million or over half all new vehicles sold by 2030.

The forecast noted for hybrids, especially the 48v so-called mild hybrids, represent another great opportunity for advanced lead batteries.



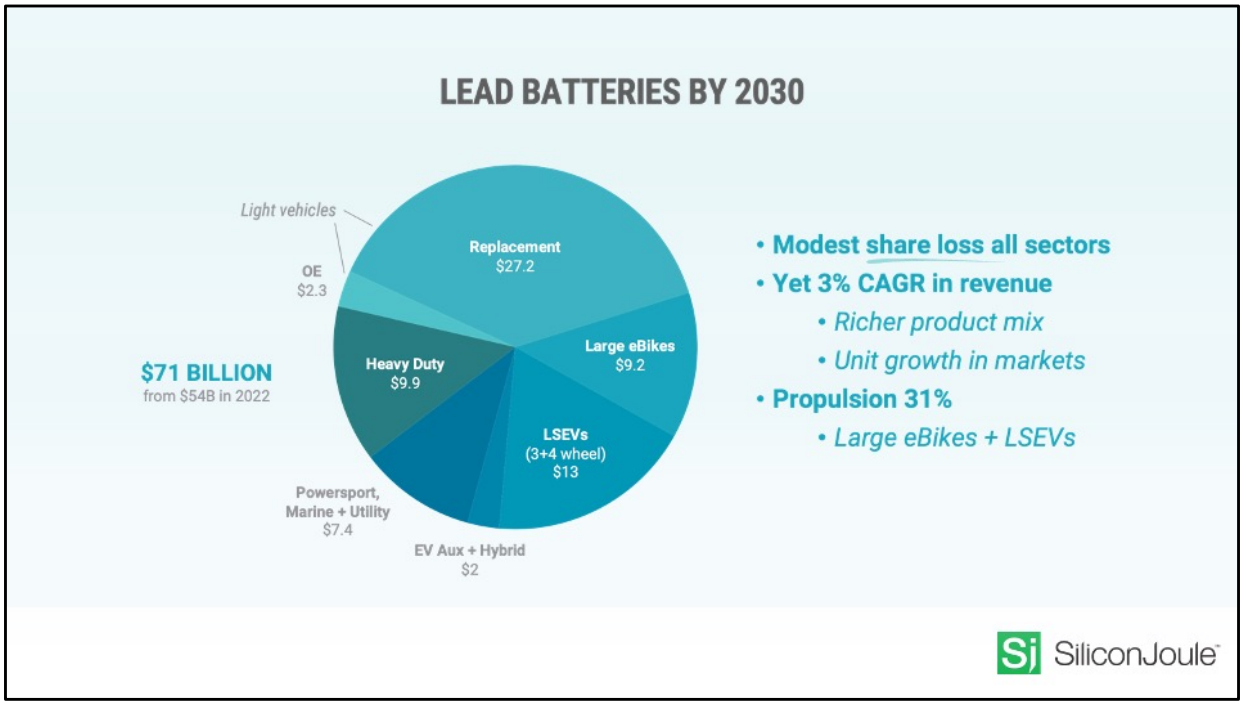
The perspective on high hybrid use to complement EVs is further illustrated by some examples and companies today.

Toyota, Kia and Honda lead with attractive hybrids today across many countries, and though there is a range of efficiency gains from different platforms, let's keep it simple and summarize the profile as 40/40/40……Over 40 mpg efficiency, 40+ miles of pure EV operation for 80% of most family trips, and <$40,000 cost.

And recently some companies are changing their structures and forecasts for vehicle technology and supply.

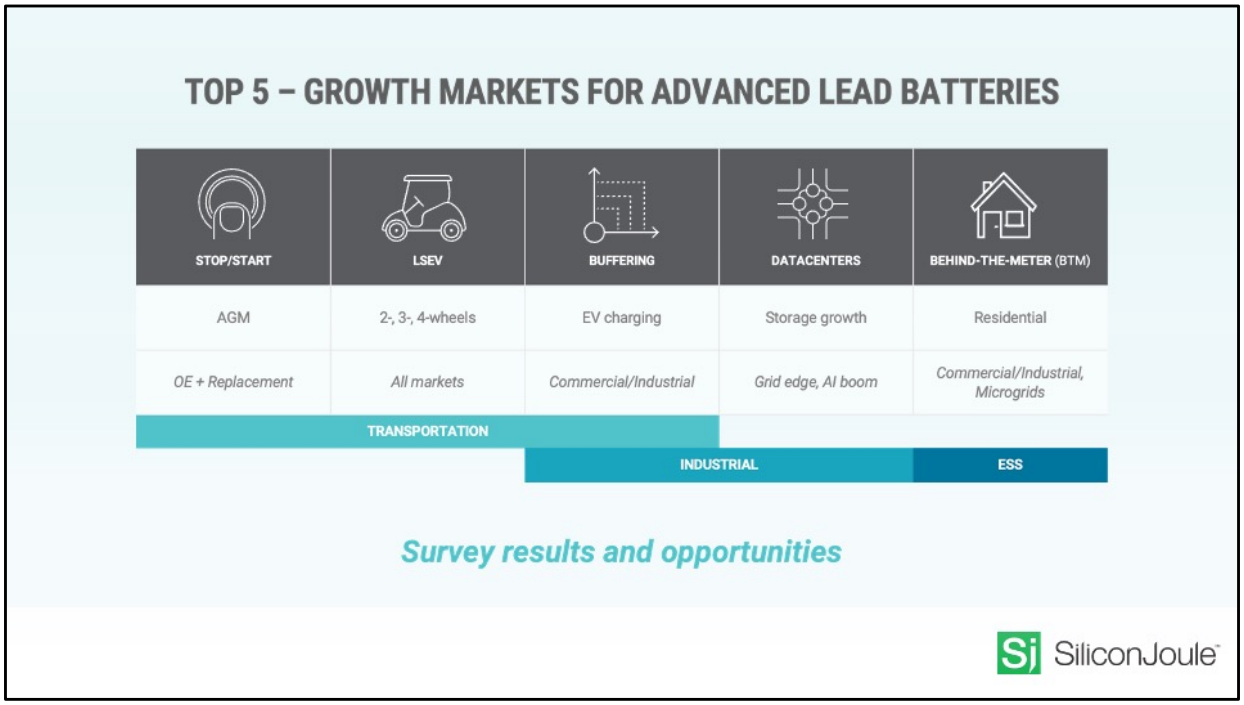
Four companies led by Renault have announced a new alliance to combine a major share of their vehicle and R&D efforts arounds more efficient ICE and hybrid vehicles globally.

Ford also recently announced a reduction of its mid-term EV output and explained a strengthening of their hybrid offering to give customers a broader choice for electrified vehicles.



One takeaway from the split of the lead-based transportation battery market by 2030 is the significance of the propulsion applications in eBikes and other LSEVs at 31%.

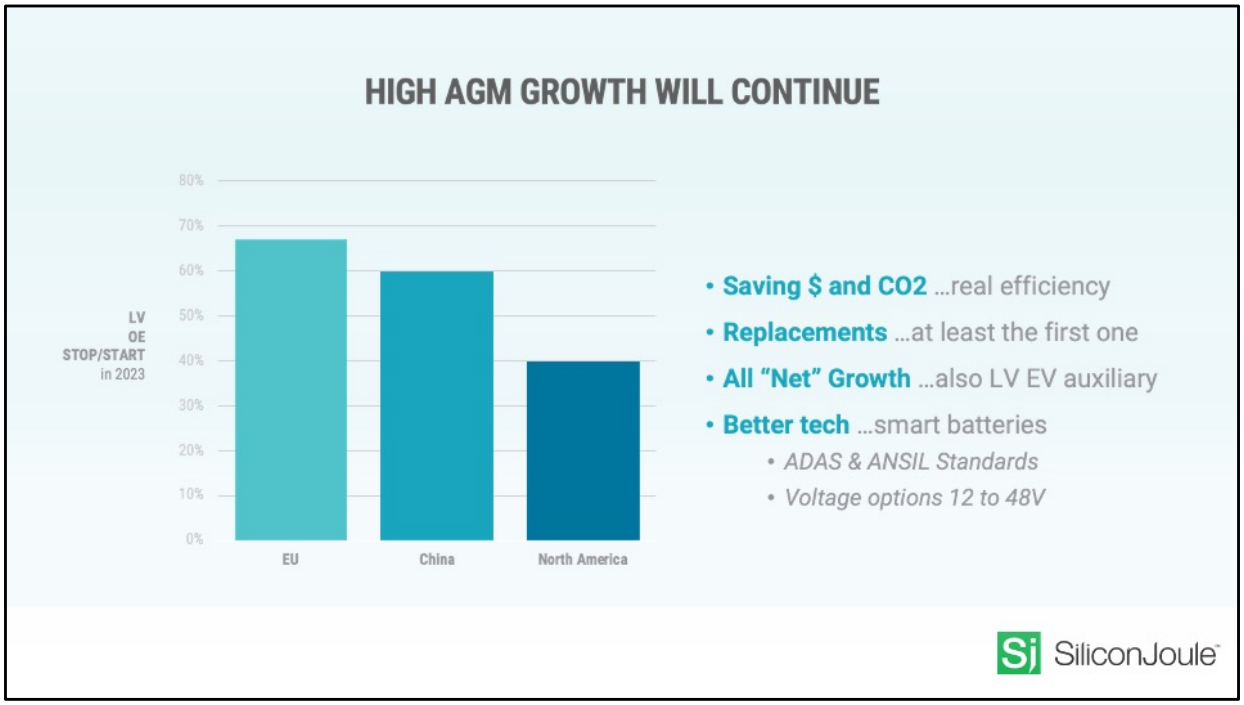
Technology progress with lithium or lead batteries may change this, yet battery makers especially across Asia have a real opportunity for significant and/or expanding sales if they provide economical and better performing lead-based solutions.



Gridtential recently took a global survey to better understand what participants in the lead battery business thought would be the best markets for growth to 2030.

Even by application there was a range from optimism to pessimism for relative growth, yet these five were the top areas for growth of lead batteries across all applications from transportation to so-called industrial markets, and the developing ESS markets.

Beyond the stop/start market and LSEVs briefly covered already, the three others listed are buffering, data centers and Behind the Meter (BTM) ESS applications. BTM ESS apps were either renewable, generally solar paired solutions for businesses and homes, or the so-called micro-grids for communities.



Vehicle makers keep increasing the utilization of stop/start technology. Shown here are the shares of stop-start technology at the OE level currently, mostly using AGM batteries across the EU, China and the US.

Though higher cost batteries, they clearly reduce fuel consumption and emissions, and the demand is now increasing in the replacement market.

Considering these trends for stop/start, and other applications, I believe it is fair to summarize that at a global level ALL the net growth is for AGM batteries, with flooded capacity moving to excess, needing to be re-purposed or closed in the years ahead.

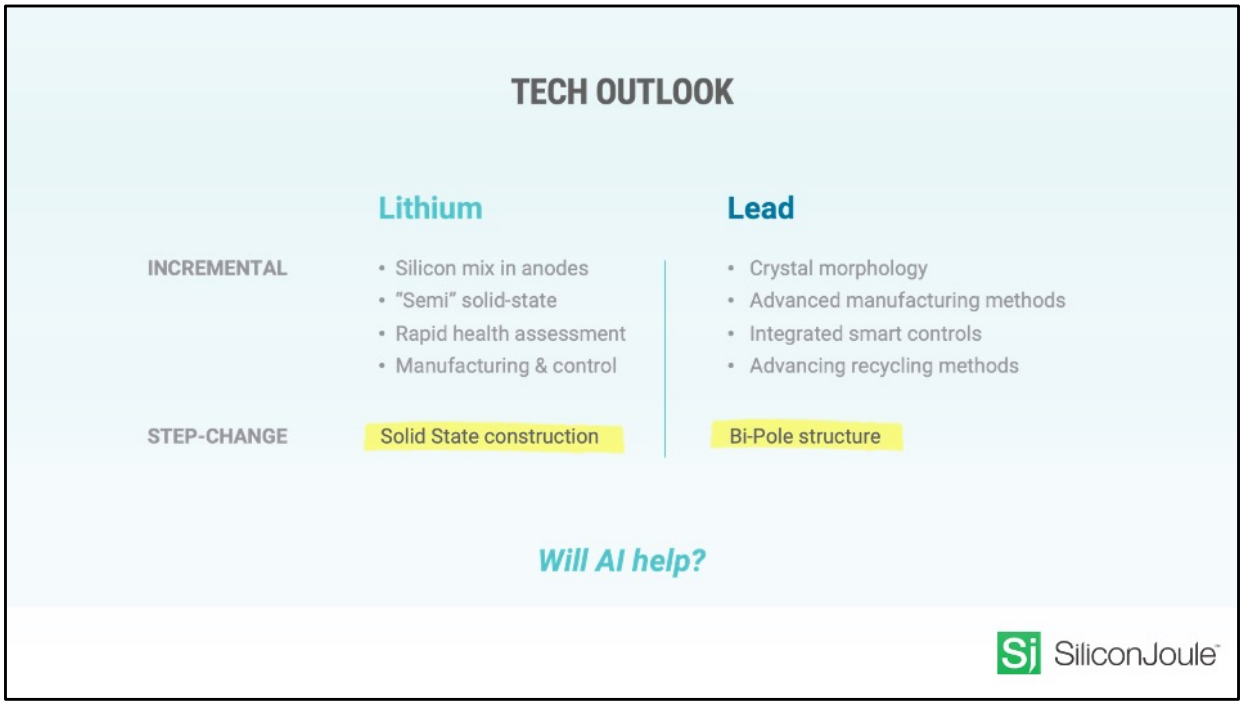
In, addition, OE vehicle makers have told us at Gridtential they would like both smarter batteries with individual cell monitoring, and voltage flexibility to 12, 14 to 48 volts for the increasing demands across their vehicle designs. This includes supporting the requirements for Advanced Driver Assistance (ADAS) and Safety (ANSIL) applications and standards.

Here is an example of the EV charge ‘buffering’ pilot for a fleet supported by a GS Yuasa lead battery at an installation in the Central US.

Buffering is a function where batteries can help EV fast chargers or commercial businesses use batteries to help avoid the generally expensive, or unavailable peak or high current needs.

Data centers keep growing in size and number as growing demands for data processing and storage, and now booming AI applications, demand secure power.

Here is an example of an installation by East Penn in the US with their VRLA based lead batteries.



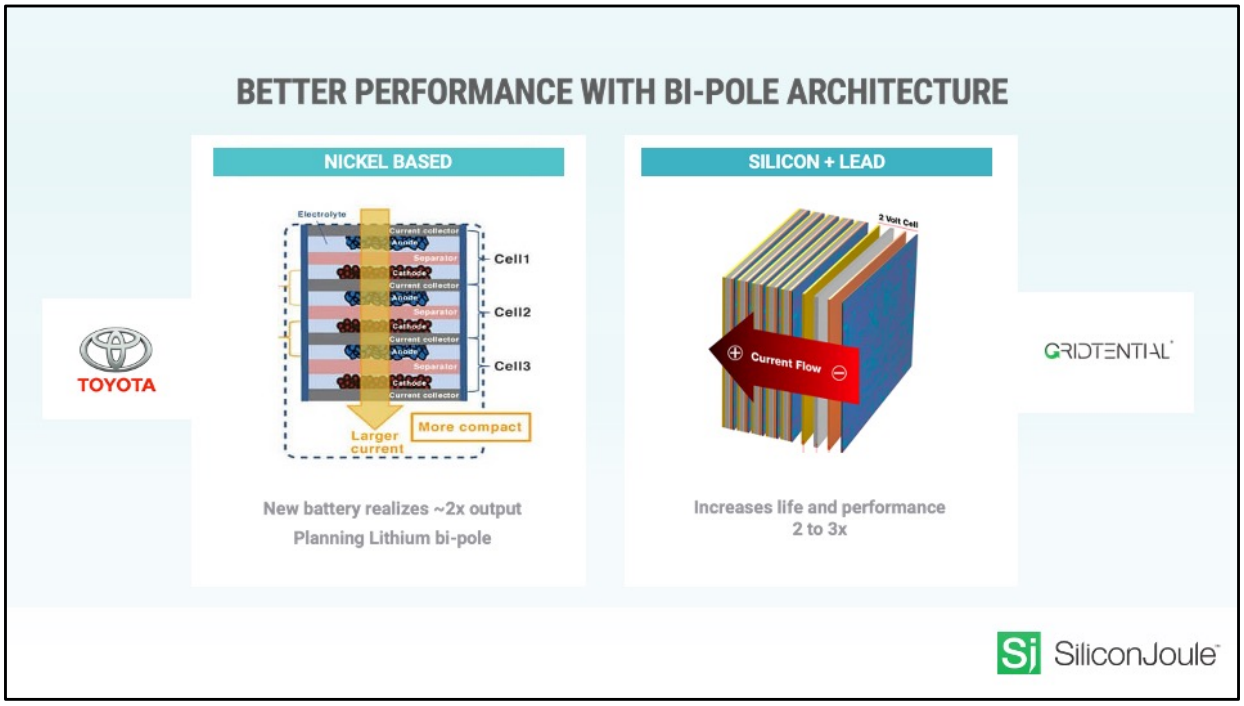
There are a lot of technology specialists here this week, and elsewhere with great insights into lead and lithium-based technologies, yet I will summarize my view from the best listening I have done over the last few years.

It is helpful also to split the incremental-type from the step-change improvements prospect.

There are many credible pathways for incremental improvements in lithium and lead based batteries, with many of them reflecting the cocktail mix for the electrodes with silicon for lithium and carbons for lead, among others.

For lithium, true solid-state designs for a large energy pack is recognized by most as the best chance to notably improve both safety and energy density in lithium batteries.

And for lead based, bi-pole designs which by structure notably changes the performance, weight and life possibilities for lead electro-chemistry is the best opportunity recognized by many.

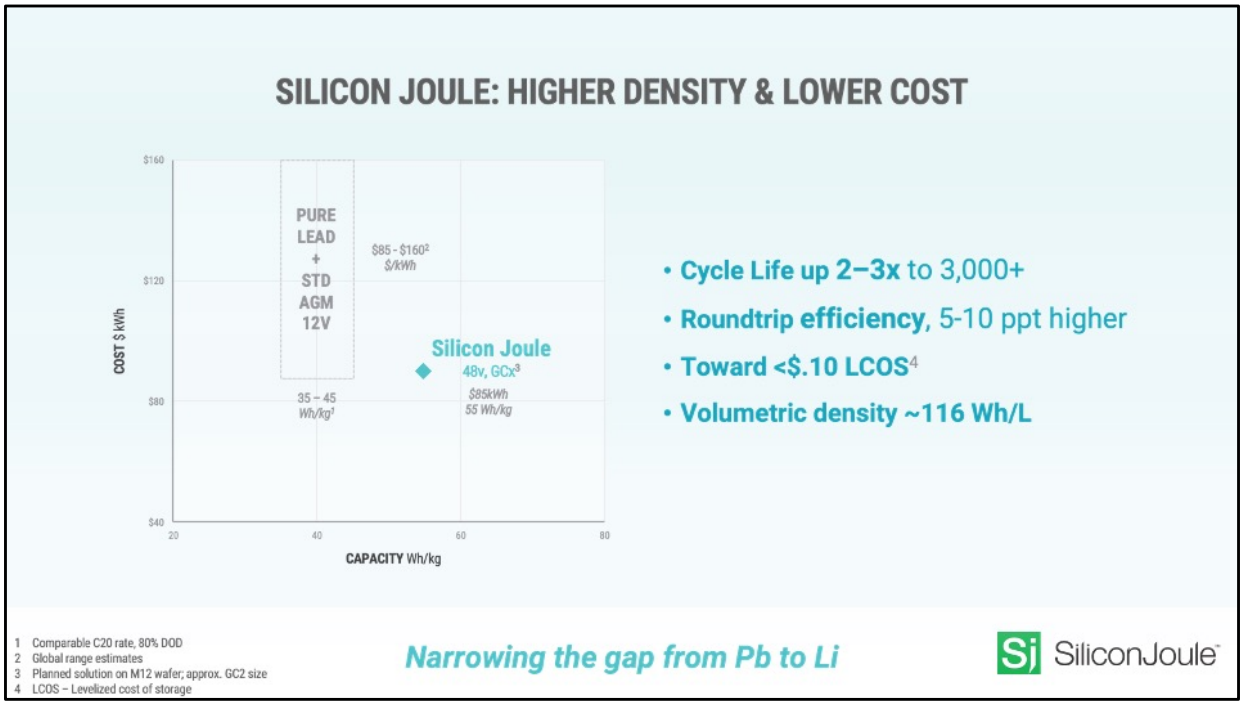


Here is some insight on bi-pole technology progress across chemistries.

Toyota was the first to commercialize bi-pole technology at scale with their nickel based bipole battery referenced here, now being used across many of its hybrids.

Just recently, they also confirmed their plans to integrate a bi-pole lithium-based design.

We at Gridtential have notably progressed this last year with advanced electrode processing to open up even higher targets for power, energy density and life with our low-cost design integrating silicon based bi-poles.



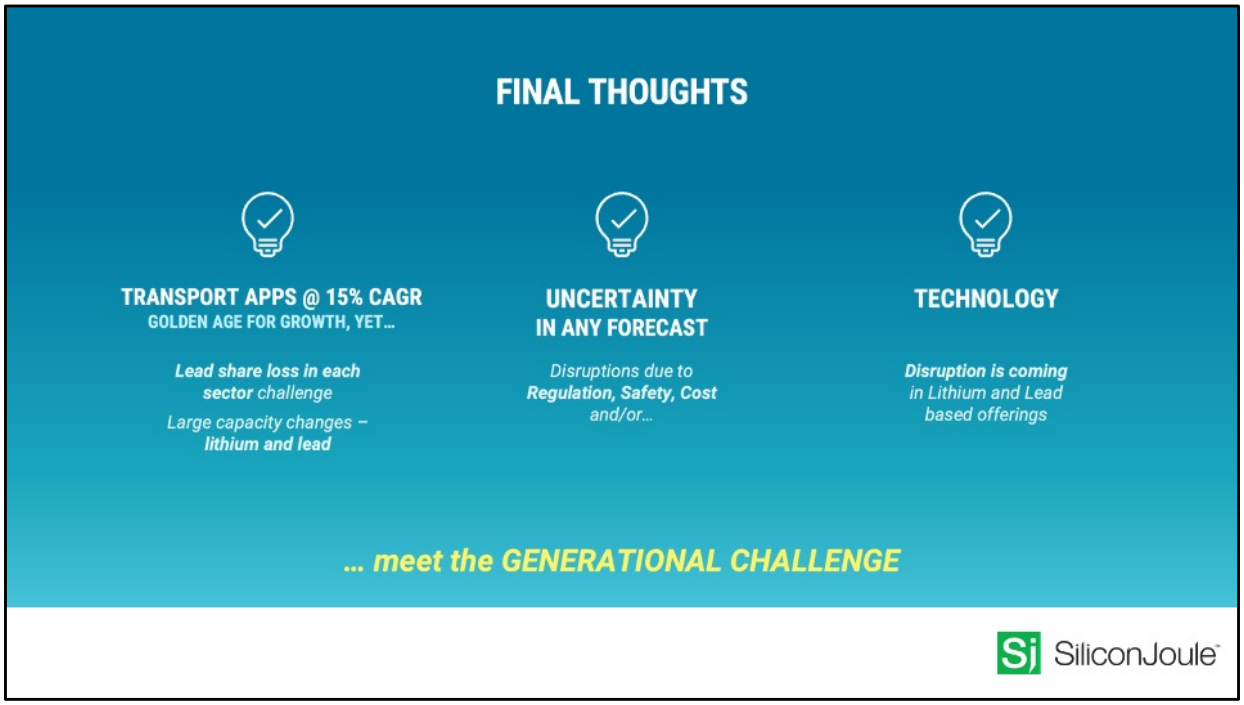
Current premium AGM and pure lead variants available worldwide today are delivering higher value across many applications in the US, Europe, China and India.

For those designs on this graph, I have profiled the global range of energy density at 35-45 Wh/kg, and costs from $80 to $160 per Wh/kg for deep cycle applications with a balanced discharge rate (C20) and voltage cut-off limit.

And I have included the Silicon Joule design of a 48-volt deep cycle GCx we are working on following the successful smaller format battery blocks with partners worldwide.

At costs comparable to standard AGM designs we expect to already deliver 56 Wh/kg, with much longer cycle life, higher energy efficiency, and further improvements are likely, before even adding the other great incremental improvements the industry is driving for with paste recipes et al.

Silicon Joule is narrowing the gap from lead to lithium based electro-chemistry.



The global battery industry is dealing with very high growth in demand and lithium battery capacity, and also a notable shift within the lead-based industry for AGM type batteries.

None of us can say for sure if we will have too little or too much capacity for lithium batteries, yet surely the scale and investments represent a challenge the lead-based industry.

I highly encourage you to invest to meet the Generational Challenge for faster technology advancement of lead batteries to strengthen your company's prospects in this period of significant growth and change for the global battery industry.

All the best to you and your businesses.

Thank you.

Also, I want to thank the sources listed here whose insights have significantly aided me in preparing this brief for you.