

QUANTUMSCAPE (NYSE: QS)

A Pump and Dump SPAC Scam By Silicon Valley Celebrities, That Makes Theranos Look Like Amateurs

\$15B market cap | \$40.85/share | ADV 17mm shares, 3mo avg | Short interest 4% of float per Capital IQ

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Senior member of Volkswagen's EV battery effort

"The main issues our engineers and experts are raising are **trust in the data, a lack of transparency. Behavior in certain situations like extreme temperatures and so on.** This is a big question mark where they're saying that we are having a lot of issues and a lot of risk. Those are [some of the] core questions that are circling around. **They don't trust that you can charge it in 15 minutes, for example.**"

Former employee #1

"I wouldn't say that nothing that we tried worked. I've been on a number of calls with people, a lot of them are into the hype, and they hear a hesitation in my voice, and **they just can't believe that it's not real** for whatever reason. But this is an extraordinarily hard thing to do to the point that most people can't really understand how hard it is...**Most people who have not done some kind of industrial work in the past just have no idea how difficult this stuff is, how uncertain it is...** **This is a super-difficult problem like, basically, Nobel-Prize-winning work needs to be done to make solid-state batteries real.**"

Former employee #2

"A lot of the upper management have very good backgrounds, a lot of Stanford grads there. **They absolutely wouldn't falsify data or fudge things.** But the CEO, his [pause]...his [pause]...he's a different [pause]...he's different. He's different from the rest of their team, and he is totally in charge...Dissenting views have no place at the company...different interpretations of the science. You're picking up on it [the discrepancies]. I'm sure a lot of the science team there would do it differently, but it's all up to the CEO. Jagdeep is picking every slide, every picture, what the colors are...[he's] selling this vision on Jim Cramer's show and **he hopes the data catches up to him...It's taking a long time, taking longer than Jagdeep wanted and his backers wanted.**"

Former employee #3

"I mean, this seems almost like a sudden discovery. Until about a year back, they couldn't solve the problem, and all of a sudden, it's just solved and not just solved but stabilized and now scalable as well? That's something that I would pause to look at and seriously evaluate from a materials perspective... The core team was extremely strong. Having said that, some of the claims just do not sit well with me because I feel like, like some of the materials, there are certain problems that they just could not have solved...And high-energy-density...That's where the problem is. If they really had a solid-state battery, their claims would be much different..."

Former employee #4

"Jagdeep is a great seller. When I was there, I was amazed that he was able to raise so much capital with such little data. I agree with whoever you talked to that said he goes to the edge of the line. I've worked for many CEO's, and I'm more in the camp of being honest with your investors. That's not the QuantumScape way."

Former employee #5

Q: "Do you think they're lying?"

A: "[Chuckles] Your question is too straightforward. I can't comment."

Former employee #1

Q: "Have they solved the problems that have impeded solid state batteries for the last 50 years, which is what they're representing?"

A: "***Absolutely not. That much I can tell you for sure. The answer to that is absolutely not.***" [...]

Q: "Is QuantumScape going to have a product in a car in the next 10 years?"

A: "***Absolutely not.***"

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1) Introduction to Quantumscape

Quantumscape recently went public through the backdoor mechanism of a SPAC. The company claims to have a “magic material” that’s led to a breakthrough solid-state battery for electric vehicles. Even amidst the current mania of retail gambling on vaporous SPAC promotions, QS stands out for its reckless, nosebleed valuation of \$15B – or roughly ~\$80MM per employee, a mere 188 per LinkedIn.

Quantumscape, across its investor materials, has only released about 7 key “data” slides with a few scraps of information. This leads us to pen a new valuation metric - “Market Cap per Powerpoint Slide” – in this case, about \$2B for each tantalizing crumb.



Source: Barchart.com

1) Introduction to Quantumscape

With an early lockup expiration that we believe is fast approaching and insiders so achingly close to the final lap, the CEO seems to be furiously pumping the stock on TV at every chance.

April 1, 2021



<https://www.cnbc.com/video/2021/04/01/quantumscape-ceo-on-volkswagen-partnership-biden-ev-spending-plans.html>

Feb 17, 2021



<https://www.cnbc.com/video/2021/02/17/watch-cnbcs-full-interview-with-quantumscape-ceo-on-earnings-outlook-and-more.html>

Jan 4, 2021



Source: <https://www.youtube.com/watch?v=ZISi0HoN6ME>

Feb 25, 2021



Source: <https://finance.yahoo.com/video/quantumscape-ceo-shares-two-exciting-151621348.html>

1) Introduction to Quantumscape

The blitz, we believe, reflects a fear of the stock's fragility when the lock-up expires. On two consecutive trading days - Dec 31 and Jan 4 - the stock crashed ~50%. The sudden move was a mystery to most, including the financial media. The reason, we believe, was simple: holders of 50MM SPAC "PIPE Shares" became eligible on Dec 31 to dump their stock, which we believe they did with haste at the next open. The CEO played dumb on CNBC. Shares haven't recovered.

The CEO appeared on CNBC on Jan 4th where he was grilled on why the stock crashed. He vaguely alluded to a registration statement being made effective regarding resale of the "PIPE Shares" but otherwise played dumb by using a legalistic interpretation of "lockup."

Video: <https://www.youtube.com/watch?v=ZISi0HoN6ME>



CEO appears to mislead CNBC's audience by saying no lockups have expired. The PIPE shares were not technically under a "lockup" but the company was required to register them for re-sale, which it did effective Dec 31, prior to which they couldn't be sold – in reality identical to a lockup expiry.

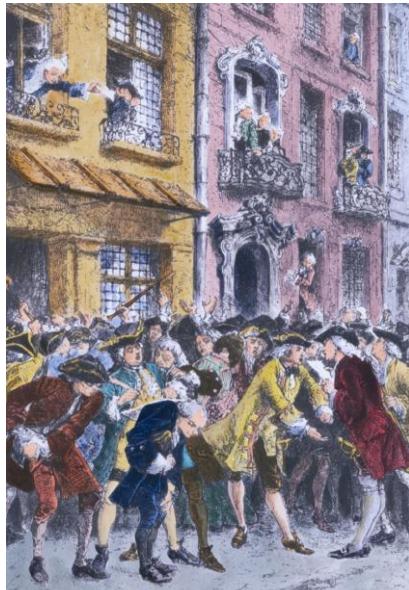
"There are no lockups have expired. Everybody is still locked up the way they were supposed to be." – QS CEO, Jan 4

1) Introduction to Quantumscape

The company was founded in 2010 and is known for its secrecy, saying little for a decade until the SPAC. Now suddenly hungry for airtime, it still refuses to say much about its actual underlying technology – even appearing to get testy when asked for details. We recall a similar, famous blank-check stock promotion at the peak of the 1700's South Sea Bubble - “A Company For Carrying Out An Undertaking of Great Advantage, But Nobody To Know What It Is”

SPAC's are also known as blank-check companies. Blank-check stock bubbles have come and gone for hundreds of years.

Blank-check stock promotion circa 1700's



Blank-check stock promotion circa 2020's – Quantumscape CEO comments

'No offense, but we don't really care what you think'

“Asked why journalists should have confidence in the company’s results without the benefit of independent findings, Singh stressed that he’s sharing as much of the data as he can to be transparent. But he adds that QuantumScape isn’t “in the business of academic research.” “No offense, but we don’t really care what you think,” he says.” – *MIT Technology Review, Dec 8, 2020*

Source: <https://www.technologyreview.com/2020/12/08/1013357/quantumscape-vw-lithium-metal-battery/>

“Disclosure, [Singh] suggested, reflects weakness”

“I raised the subject of disclosure multiple times with Singh....He pointed me to QuantumScape’s history. Disclosure, he suggested, reflects weakness.” – *Marker/Medium article, Sep 21, 2020*

Source: <https://marker.medium.com/an-ultra-secret-battery-startup-hints-that-its-blown-past-tesla-but-won-t-show-the-goods-2ed31173610d>

1) Introduction to QuantumScape

A key feature of the largest frauds is often the backing of a famous investor or corporate partner, in this case VW – “the smart money” - that lends credibility to the scam. Without “validation,” a fraud can’t super-scale in the first place. The largest investor in Sino-Forest was billionaire John Paulson; in Luckin Coffee, it was a famed hedge fund; Walgreens, Safeway, and the who’s who backed Theranos; JP Morgan vouched for Madoff; GM blessed Nikola, an epic hoax.

The EV battery space - especially within solid-state - is particularly known for the number of frauds and flops that once made audacious claims similar to QS, as we later detail - such as Sakti3, Envia, A123, Seeo, Pellion, etc. A common trait of once-hyped battery scams is the presence of a major automaker who lent credibility by partnering or investing.

GM Ventures Makes Strategic Investment in Sakti3

Nikola and General Motors Form Strategic Partnership; Nikola Badger to be Engineered and Manufactured by General Motors

Battery startup Seeo finds a backer in Samsung

Source: <https://media.gm.com/media/us/en/gm/home.detail.html/content/Pages/news/us/en/2020/sep/0908-gen2fcs.html> ; <https://eepower.com/news/gm-ventures-makes-strategic-investment-in-sakti3/#>; <https://www.yahoo.com/news/weather/battery-startup-seeo-finds-backer-110021883.html>

1) Introduction to QuantumScape

Given the secrecy around QS, the entire “science is real” story is based on VW’s validation. After Dieselgate and the recent “Voltswagen” prank that backfired, we’re not sure “smart money” is the best term. We spoke to two members of their EV battery team, who stated that the leadership has Tesla-envy and wants press releases, but that the engineers and experts are highly skeptical of QuantumScape’s claims.

QuantumScape is a “black box” and investors are assuming that if a major automaker is involved, it must have seen and blessed the science as real. VW is QuantumScape’s largest investor. Investors appear buoyed by VW’s ongoing investments in QS. VW employees we spoke to explained the dynamic: the leadership is desperate for media wins in the aftermath of Dieselgate and want to show investors they have an EV plan – “pressure in Germany” for “nice Powerpoint slides” - but internal battery experts are highly skeptical of QS.

“The main issues our engineers and experts are raising are **trust in the data, a lack of transparency. Behavior in certain situations like extreme temperatures and so on.** This is a big question mark where they’re saying that we are having a lot of issues and a lot of risk. Those are [some of the] core questions that are circling around. **They don’t trust that you can charge it in 15 minutes, for example.**” – VW employee

“**The data we have received in this early stage cannot be compared to an established supplier,** where the testing and validation we’re normally doing is on a completely different level. That’s why there are so many question marks and **not everybody is supporting it 100%** because it’s really early stage and not all the facts and figures are on the table, and sometimes **there’s also a lack of transparency.**” – VW employee

Besides VW, a key part of the QS “trust us” story hinges on billionaire venture capitalist Vinod Khosla and the purported validation from Bill Gates, who we suspect is a minor indirect investor as Khosla’s friend. Khosla’s track record is legendary – just not in cleantech or EV batteries, where an unusual number of his investments made bold QS-like claims of a breakthrough, only to be exposed as frauds.

One of the case studies that we detail is Sakti3, another secretive and hyped solid state play that purported a breakthrough battery for the EV market. Sakti3 red flags then are identical to QuantumScape red flags today.

“There was no one in the battery R&D community that did not think that Sakti 3 was a fraud and was not angered by it. Everyone knew. GM invested, and I think, thanks to Khosla, found a greater fool in Dyson to dump it on. They had very, very small cells. They never really showed any performance data. It seemed to be a manufacturing process that would be expensive or impossible to scale up, and it never scaled.” – Solid-state expert

Secretive Company Claims Battery Breakthrough

The Michigan start-up Sakti3 says its solid-state cells more than double the energy density of today's best Li-Ion batteries

1) Introduction to QuantumScape

Khosla once tweeted that his 3 EV battery plays are Sakti3, Seeo, and QuantumScape. All three are/were solid-state plays with nearly identical claims. As we detail later, Seeo was a flop. Sakti3 appears to be an outright scam. For those who think that QuantumScape is the one outlier where the science is real, we note comments by a Sakti3 co-founder on the level of diligence Khosla's firm did before investing.



Vinod Khosla

@vkhosla

...

Replies to @ACNicolet and @rohanmanchanda

I was slower in predicting their adoption as I did not anticipate Tesla & no existing player was adopting EV's. But we did invest back then in 3 EV battery plays: Seeo (sold to Bosch profitably), Sakti3 (sold to Dyson profitably) & QuantumScape which just raised >\$100m from VW

12:28 AM · Jun 25, 2018 · Twitter Web Client

**Sakti3's quest for a better battery:
Hype, funding, promises, and then a
surprise sale**

Khosla's firm demanded little hard data, Albano said, and that fit Sastry's strategy. "We were after the higher-risk-tolerant VCs who didn't demand a lot of detail," Albano said. **"We got the \$2 million with no questions asked."**

1) Introduction to QuantumScape

A battery expert's opinion two pages earlier – that Khosla found “a greater fool” to “dump” Sakti3 on – is also an apt description for Infinera (INFN), which the QS CEO founded and took public in 2007. Khosla’s firm was the lead investor. INFN is a zombie company that has lost money almost every year since inception – nearly ~\$1B burned, with the stock flat for a decade. It soared briefly similar to QS, but those who followed Khosla and Singh got crushed within 5 months when the lock up expired

We actually went long INFN stock for a short time in 2009. We did an IR call with the CEO, which we vividly recall for its level of promotionalism. We were taken aback when he announced his resignation a few weeks later and began to sell his stock. We realized we had been played and sold our position.



1) Introduction to QuantumScape

Infinera strikes us as a classic VC pump and dump, and it appears the band is back together for an encore. Khosla's firm and other key INFN holders at IPO - venture capitalists who got in early - appear to have aggressively dumped 100% of their stock within 5 months at lockup expiration, driving the stock down 50%. We believe the same pattern is imminent at QS.

The largest holders of QuantumScape's stock are its venture capital/private equity backers and insiders – sitting on ~120MM shares or ~30% of the company. At a \$15B market cap, we expect they will be trigger happy to cash in when the lock up expires – much like the PIPE holders on Jan 4th.

INFN stock chart for 2007/2008 – lock up expired Dec 2007



Source: Yahoo finance stock chart; CapitalIQ data

QS holders by type - ~30% are insiders and VC/PE firms sitting on massive gains

Ownership Summary ¹			
Type	Common Stock Equivalent Held	% of Total Shares Outstanding	Market Value (USD in mm) ²
Institutions ⁵	109,030,469	28.80	5,167.0
Corporations (Public)	86,216,539	22.78	4,085.8
Corporations (Private)	1,340,582	0.35	63.5
Individuals/Insiders	47,630,500	12.58	2,257.2
VC/PE Firms (>5% stake)	55,722,534	14.72	2,640.7
Public and Other ³	78,585,646	20.76	3,724.2
Total	378,526,270	100.00 ⁶	17,938.4

QuantumScape was founded by two Stanford grads and their professor, Fritz Prinz. Their initial, ill-fated plan was based on Prinz's concept of an "All Electron Battery." Ex-employees and leading researchers we interviewed indicate the notion "violated the laws of physics," was a crackpot idea, and one of the reasons the company doesn't "have the world's greatest reputation" in the battery space.

Prinz remains a Board member and strikes us as an original thinker with bold ideas, such as harnessing algae for electricity. His current stake in QS is worth ~\$500MM. A 2013 patent for an "All-Electron Battery" lists QS Chief Technology Officer and Prinz as co-inventors.

"They do not have the world's greatest reputation...Their origin, and if you're asking my opinion, Fritz Prinz came up with an idea that **violated the laws of physics**. The original idea behind QuantumScape was published in an ARPA-E funding opportunity. Everyone was like, "What the hell is with the all-electron battery? It doesn't make any sense." It makes no sense. There are a lot of very serious people who I think never got over that." – Solid-state battery expert

Stealing Electricity From Algae

"We have shown that we can steal an electrical current from algae," said Fritz Prinz, a scientist from Stanford University and co-author of the ACS Nano Letters article.

1) Introduction to QuantumScape

The All-Electron Battery “would create a completely new class” of EV batteries that “could be charged 1000’s of times without showing a significant drop in performance.” When that failed, QS did mass layoffs and pivoted to solid-state batteries. In the few years since, QS claims to have solved scientific problems that have stumped others for a century – a spurt that makes Liz Holmes look like a sloth.

QS CEO on Mad Money, Apr 1, 2021, where he's a regular guest



Source: <https://www.cnbc.com/video/2021/04/01/quantumscape-ceo-on-volkswagen-partnership-biden-ev-spending-plans.html>; ARPA-E/Stanford page on all electron battery <https://bit.ly/3uPVgzH>

“Pretty amazing data, if we say so ourselves”

“A blockbuster assertion by QuantumScape, not verified by outside scientists, that it was on a short path to a solid state EV battery using pure metallic lithium, a prized material that has been the subject of a decades-long global technology race.”

<https://marker.medium.com/an-ultra-secret-battery-startup-hints-that-its-blown-past-tesla-but-won-t-show-the-goods-2ed31173610d>

“Singh says the battery resolved all of the core challenges that have plagued solid-state batteries in the past, such as incredibly short lifetimes and slow charging rate.”

Source: <https://www.wired.com/story/quantumscape-solid-state-battery/>

“As far as he's concerned, the company has solved the hard basic-science problems that have stymied the commercialization of a solid-state battery.”

Source: <https://www.wired.com/story/quantumscape-solid-state-battery/>

1) Introduction to QuantumScape

In a typical Li-ion battery, ions move between the anode (negative electrode) and cathode (positive electrode) through a liquid called an electrolyte. The QS battery replaces the liquid material with a solid-state ceramic separator. A decades-long obstacle: how does one possibly move ions through a solid as easily as through a liquid?

A simple analogy explains one of the many reasons why no one has solved the challenges of solid-state batteries, except under highly artificial and manipulated conditions on tiny samples in a lab. Imagine a battery as a swimming pool with the anode at one end and cathode at the other. Lithium ions “swim” from the anode to cathode during discharge, and reverse direction when charged. Now replace the water with a solid ceramic material. How does one swim through a rock in the same manner as through a liquid? A ex-employee of QuantumScape explained the problem: “Nobel Prize-winning work needs to be done.”

“I wouldn’t say that nothing that we tried worked. I’ve been on a number of calls with people, a lot of them are into the hype, and they hear a hesitation in my voice, and **they just can’t believe that it’s not real** for whatever reason. But this is an extraordinarily hard thing to do to the point that most people can’t really understand how hard it is... Most people who have not done some kind of industrial work in the past just have no idea how difficult this stuff is, how uncertain it is... **This is a super-difficult problem like, basically, Nobel-Prize-winning work needs to be done to make solid-state batteries real.**” – Former employee of QuantumScape

Source: Scorpion Capital consultation calls with experts

1) Introduction to QuantumScape

As we began our research, we noticed a number of articles by investigative journalists in the space, indicating near-universal skepticism of the company's claims among solid-state academics and researchers. We are reminded of similar under-the-radar but prescient articles on Theranos by some academics, well before it was widely exposed.

“Experts question the claim by QuantumScape...”

An Ultra-Secret Battery Startup Hints That It's Blown Past Tesla — But Won't Show the Goods

Experts question the claim by QuantumScape, backed by \$500 million from Bill Gates, Silicon Valley venture capitalists, and VW

Source: <https://marker.medium.com/an-ultra-secret-battery-startup-hints-that-its-blown-past-tesla-but-won-t-show-the-goods-2ed31173610d>

“But some observers aren't convinced...”

This super-energy-dense battery could nearly double the range of electric vehicles

But some observers aren't convinced that QuantumScape's lithium-metal batteries will power cars and trucks on the road as soon as the company claims.

Source: <https://www.technologyreview.com/2020/12/08/1013357/quantumscape-vw-lithium-metal-battery/>

“But most battery researchers don't believe it”

If True, QuantumScape Has Made the Biggest Leap in Batteries Since the Debut of Lithium-Ion

But most battery researchers don't believe it

Source: <https://themobilist.medium.com/if-true-quantumscape-has-made-the-biggest-leap-in-batteries-since-the-debut-of-lithium-ion-5feb85c7e15d>

Did QuantumScape Just Solve a 40-Year-Old Battery Problem?

Source: <https://www.wired.com/story/quantumscape-solid-state-battery/>

QuantumScape: can battery pioneer live up to the hype?

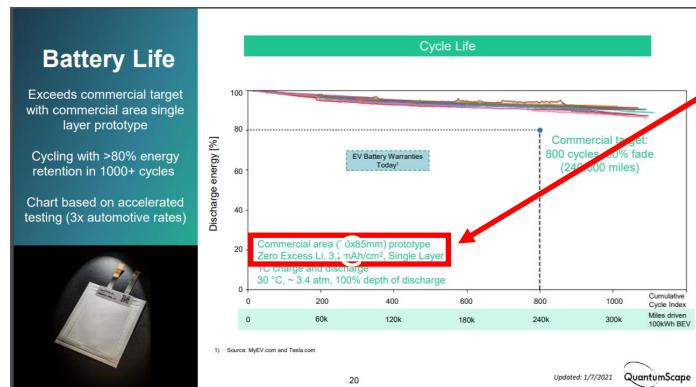
Source: <https://www.ft.com/content/c31ca3ce-5e83-452c-86cb-3d1646490c7a>

1) Introduction to QuantumScape

As we analyzed the few scraps of data QS has shared with investors, we noticed numerous red flags. In particular, the company goes to great lengths to conceal the capacity of the prototype cells that are the basis of its far-reaching claims. We consulted a leading academic, who concluded the cells are less than 200mAh – that is, less than 1/3rd the capacity of a common hearing aid battery.

"The y-axis is discharged energy percentage because you know they have only one layer, so it's 70x85-millimeter, so it's about 56 or 60 centimeters square. **So, for the entire pouch cell, the total energy is about 200 milliamp-hour.**" - Leading solid-state battery researcher

Slide #20 from QS December 8th "Battery Showcase"



Solid-state expert uses the fine print on QS slide to calculate the actual capacity of the prototype cell used for the battery life test

- 1) Area of prototype cell is 70x85mm, or 7x8.5cm, which is 59.5 square cm
- 2) Capacity of the cell is stated as 3.2mAh/cm squared
- 3) Therefore, actual capacity = surface area of 59.5 cm² x capacity of 3.2mAh/cm² = 190.4 mAh

Source: Scorpion Capital consultation calls with experts; https://s26.q4cdn.com/263384136/files/doc_presentation/2021/1/Data-Launch-Updated-Post-Presentation-20210107-2.pdf;

1) Introduction to QuantumScape

Leading experts indicated that one of the most common tricks in battery research is using tiny cells with no useful capacity to claim a “breakthrough.” The battery field is a graveyard of companies that made far-reaching claims with single-layer cells the size of a coin or credit card, that never worked outside the lab. QS is worth \$15B because investors expect it to dominate batteries for electric vehicles – off a prototype with 5% of an iPhone battery’s capacity.

200 mAh

*per battery expert estimate

QuantumScape single-layer pouch cell (7 x 8.5 cm)



650 mAh

Duracell hearing aid battery



3,400 mAh

AA-size lithium ion 18650 cell



3,687 mAh

iPhone 12 Max Pro battery



1) Introduction to QuantumScape

Solid-state researchers pointed us to an industry checklist to prevent data fraud. As we went through it, it became apparent that QS has shown almost none of the items required for a credible claim – that is, their data doesn't even meet the minimum smell test for publication.

The problem of data fraud and lack of reproducibility is so common that one battery journal has proposed a checklist with “standardized battery reporting guidelines” – basically an “oath of honesty” that anyone making claims about battery performance must sign. The editors decried the lack of transparency and cherry-picked information when researchers report battery performance. The checklist is short and lists the bare minimum of data for a claim to be credible and considered for publication. QS has shown almost none of this data.

Joule Battery Checklist: [https://www.cell.com/pb-assets/journals/research/joule/Checklist_Batteries_v1_\(006\)-1608320062.pdf](https://www.cell.com/pb-assets/journals/research/joule/Checklist_Batteries_v1_(006)-1608320062.pdf)

Standardized data reporting
for batteries



Revision 1.0, Last updated: Nov 10, 2020

Standardized data reporting for batteries

CellPress

If a figure in your paper is of a battery, complete the below form

Authors are encouraged to include this completed document as supplemental information at the time of submission. Not doing so may cause delay if your paper is selected for peer review.

Please note that this form is intended for use in the manuscript or supplemental information; it is not intended for the editorial team and reviewers to consider.

For any items that are not present, please provide details in the text box for the editorial team and reviewers to consider.

Battery assembly reporting

Ratio or mass percent of active material, conductive additive, and binder on electrode

Thickness of battery components

Calendula pressures when applicable

Amount of electrolyte (either volume or weight) used to wet the electrodes (conducting additives, binders, etc.)

Mass of all components of the battery (binding, additives, electrolytes etc.) as well as the total mass of the cell

Anode mass (mg/cm²) loading of active material

Net mass of cells, the amount of excess lithium being lithiated and capacity of the cell

Diagram of battery architecture or reference to architecture being used

Electrochemical reporting

Temperature at which electrochemical tests are run

Indicate whether full-cells or half-cells are preferred when possible. Full-cells are preferred when possible

First cycle or any pre-cycling

Average charge and discharge voltage are reported for the primary cycling rate

Explain exception if line item is not present in manuscript

Volumetric and gravimetric stack energy densities with calculation methodology

Theoretical capacity used to calculate C-rate

C-rate clearly reported on the figure or in the figure caption for every cycle

Capacity for at least 3 cycles with the capacity of each cell reported individually along with the standard deviation reported

The basis for capacity measurements should be clearly stated. While electrode-level capacities are preferred, active material level capacities are acceptable when the active material fraction is provided

Coulombic efficiency for at least 30% with the Coulombic efficiency of each cell reported individually and the average capacity reported for the cell

Coulombic efficiency and capacity in cycle graphs should use reasonable y-axis scales. Capacity values for the first cycle should not be reported on a y-axis scale of 0-100% but rather 90-100% etc.

I verify that this form is completed accurately in agreement with all co-authors, to the best of my knowledge.

Submitting author name: _____

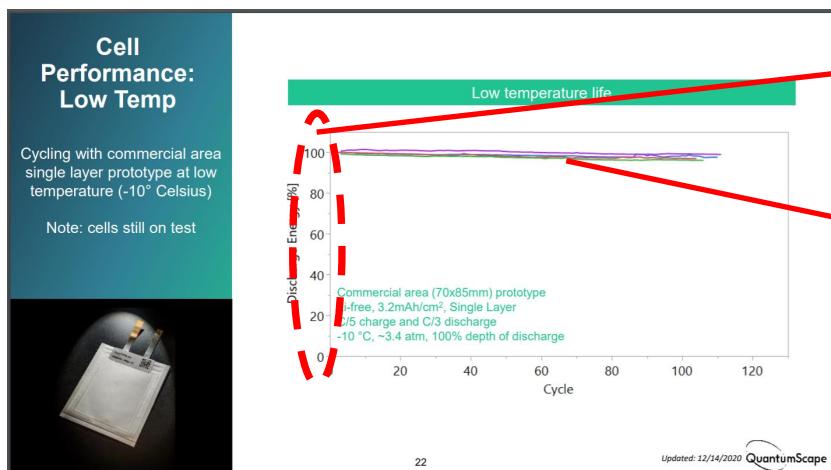
For general queries or feedback regarding this form please email joule@cell.com

1) Introduction to QuantumScape

The “battery fraud” checklist even warns against specific tricks prevalent in QuantumScape’s data presentation, such as using misleading Y-axis scales for key metrics.

For example, one of the key criteria for a solid-state battery to be commercially viable is its lifespan and operability in cold weather conditions. The data slide that QuantumScape uses for this parameter uses the exact trick that the checklist cautions against. We discuss this in more detail in a later section.

Slide #22 from QS December 8th “Battery Showcase”



Y-axis is scaled from 0-100%, even though the 4 test cells shown are all between 95-100%

This creates the misleading impression that the cycle life trend is flat – that is, battery life is stable and barely degrades over time, under low temperature conditions

Joule checklist warns against the trick above



Note: Red arrows, lines, and text ours for emphasis

“Coulombic efficiency and capacity vs cycle graphs should use reasonable y-axis scales. For instance, Coulombic efficiency should not be reported on a y-axis scale of 0-100% but rather 90-100% etc.”

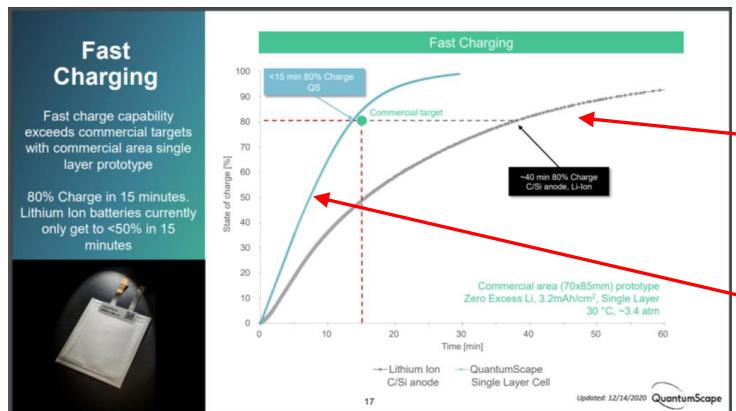
1) Introduction to QuantumScape

Even more alarming, key data slides in QuantumScape's presentation appear to be fabricated, in the opinion of well-known solid-state academics and researchers – as well as former employees - who we asked to analyze the data. A highly published researcher on a key graph showing fast charge capability in 15 minutes: "It's not real."

We asked one of the world's leading solid-state battery researchers to scrutinize QuantumScape's fast charge data, and in the expert's opinion, the data points are fake.

"The gray line is something every lab can produce, and I would say it's the real data because you can clearly see the data points. The blue line, I think, is wishful. It's not real. There's no variation in the data. I cannot see any data points. It's just a randomly drawn line. It's not actual data. That's my interpretation for slide 17. If they were going to peer review like in science journals or publications, a reviewer like me would definitely ask for the original data set." – Leading solid-state expert

Slide #17 from Dec 8th "Battery Showcase"

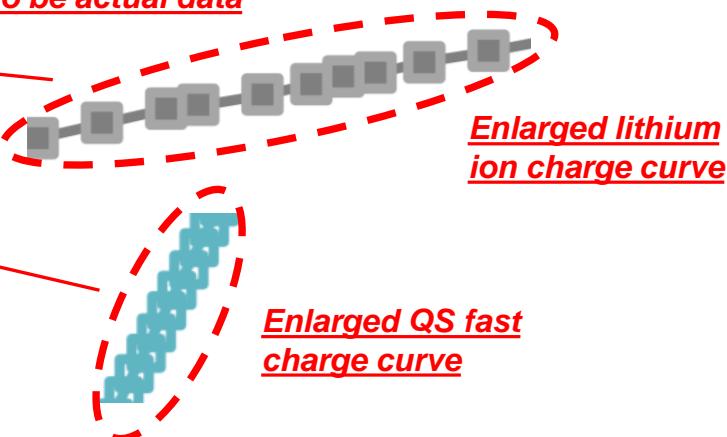


Note: Red circles and arrows ours for emphasis

Source: Scorpion Capital consultation calls with experts;

https://s26.q4cdn.com/263384136/files/doc_presentation/2021/1/Data-Launch-Updated-Post-Presentation-20210107-2.pdf;

We enlarged the QS fast charge curve (blue) and the lithium ion one (gray) – blue QS data points are perfectly, evenly spaced which suggests they are fabricated, while gray data points appear to be actual data



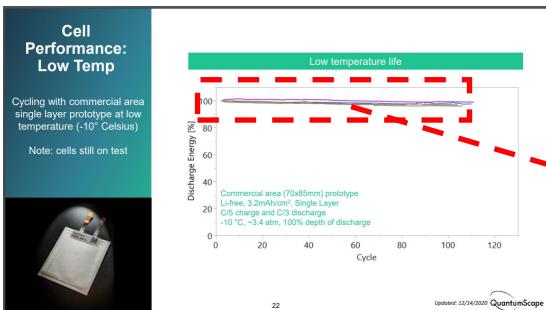
Another troubling discrepancy appears in the graph purporting to show battery life in low temperatures, a key automaker criteria. The chart appears to be fake, as it shows a cell being discharged at over 100% of its energy, which common sense indicates is impossible. The number of similar tricks and red flags makes us doubt it's an error.

We double-checked with a solid-state researcher, who confirmed that either what the graph shows is impossible – or it's using another trick with a misleading Y-axis, which is labeled with a made-up, undefined, and non-industry standard term in battery research.

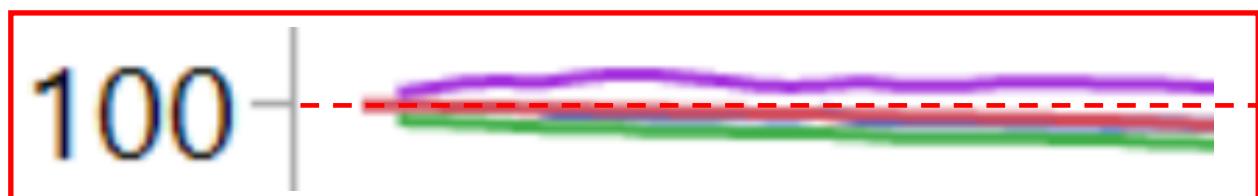
Q: "Is there ever a situation where a cell can exhibit more than 100% of its discharge energy, or is that impossible by definition, in a typical cycle life test (such 80% DoD)?"

A: **"Yes. Of course.** This all depends on what one defines as the 100% depth of discharge (DoD). Imagine that the cell is capable of doing 122mAh, but one only define 61mAh as 100% depth of discharge (utilization rate 50%) - **such tricks are entirely possible."** – Solid-state expert

Slide #22 from Dec 8th "Battery Showcase"



Y-axis is "Discharge Energy [%]" from 0 to 100% - purple line below shows a cell cycled at more than 100% of its energy. We overlaid a dashed line at the tick mark for 100% to make it clear.



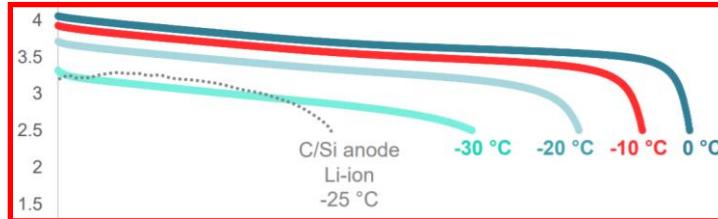
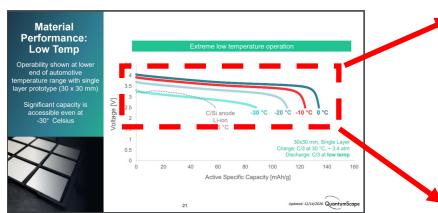
Note: Red boxes, arrows, dashed lines ours for emphasis

Source: Scorpion Capital consultation calls with experts; https://s26.q4cdn.com/263384136/files/doc_presentation/2021/1/Data-Launch-Updated-Post-Presentation-20210107-2.pdf;

1) Introduction to Quantumscape

On another crucial chart, Quantumscape shows cell performance in low temperatures. A former employee implied fraud: the slide data “is just not true”; “just picked some data” for the deck; “not something I’m going to buy”

A key slide shows that the QS battery does better in cold temperature than conventional liquid electrolyte-based Li-ion. A former employee analyzed the data in the chart and explained why it simply cannot be true. We analyze the slide in more detail in later pages.



Key data slide (#21) from QS December 8th “Battery Showcase” – referenced in comments below

Former employee explains why the data shown in the QS chart “is just not true”

A: “The number 140 that you see at 0°C - just a little bit of technicalities here - so 4,000 is a normal value. The active specific capacity should be ideally around like 3,500-4,000 because they are using lithium metal and at -30°C, you would have exactly 1%, if that, which is usable. This graph should be all the way where your carbon-silicon anode would be. The dotted lines and the -30 should sort of be coincidental, and the rest of them would be like marginal improvements over what you see. But again, you would expect the same trend for a conventional battery as well.”

Q: “You’re saying the data on this graph - the line should be different, like this is not the behavior you expect?”

A: “Look at all the color lines - shrink and move them such that the -30 coincides with the dotted line. That is exactly what the trend would be. **This shows that your conventional battery performance is inferior to your solid-state battery, which is just not true.”**

1) Introduction to QuantumScape

Ex-employees slammed each key claim as misleading, exaggerated, or fraudulent. Dendrites are one of the most stubborn obstacles to solid-state batteries. QS claims to have a “magic material” that’s solved it. Six ex-employees suggested the claim is false, made up, or “definitely bullshit,” implying that QS still struggles with dendrites: “hype,” “science is not there yet.”

Former employee #1: Dendrites are a showstopper and a “Herculean task”

“Dendrites are a real problem, and that's basically where we were at when I left - **trying to solve dendrites. It's a showstopper.**”

Former employee #2: The prototype used for the dendrites test isn't even a “real battery cell”

“A lithium-lithium symmetric cell is not a real battery cell...**I don't believe that they have solved dendrite formation** in a real battery. A single layer is nothing.”

Former employee #3: Dendrites are “very difficult problem,” QS struggles even with coin-size cells

“You're balancing thickness versus number of defects; the defects are the ones with the dendrites.... **They were having problems at the coin cell level**...it is a very difficult problem.”

Former employee #4 answers affirmatively to our question: “They're struggling with a dendrite issue in the transition from single-layer to multi-layer cells?”

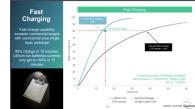
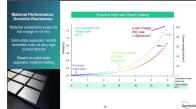
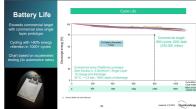
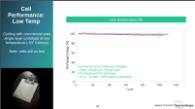
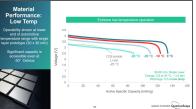
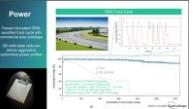
“I don't know that they've completely nailed this. I wouldn't say that they've completely nailed it because **there are definitely some issues with what they've put out.**”

Former employee #5: Painted the claim as fraudulent, called it as absurd as claiming 200 MPG

“[The CEO's dendrites claim] is a **bunch of bullshit** ...**That's definitely bullshit**...it's not going to be representative of what you will see in an actual cell...this is just not going to hold good at all.”

1) Introduction to Quantumscape

The QS data is remarkable for its statistical gimmicks and sleight-of-hand, glaring omissions, as well as cherry-picking across lab tests. A single battery must meet various criteria to be viable: fast charge, dendrite-resistance, cycle life, power, low temperature operation and lifespan. Rather than use the same prototype for each test, the QS fine print shows a mishmash of cell types, sizes, temperatures, and charge rates – or omits key info entirely.

	Fast charge	Dendrite resistance	Battery life	Low temp cycle life	Low temp operation	Power
						
Prototype size	70x85mm	Omitted	70x85mm	70x85mm	30x30mm	30x30mm
Configuration	Single layer pouch cell	Li/li symmetric cell	Single layer pouch cell	Single layer pouch cell	Single layer, pouch cell?	Single layer, pouch cell?
Charge/discharge rate	15 min charge	Varies	1 hr/1 hr	5 hr/3 hr	3 hr/3 hr	15 min charge
Temperature	30 C	45 C	30 C	-10 C	30 C charge, discharge varies	45 C
Pressure	3.4 atm	Omitted	3.4 atm	3.4 atm	3.4 atm	3.4 atm

We note concerns that 3 former employees shared on the use of cherry-picked lab tests. One pointed out another type of cherry-picking – “nefarious” - that’s not disclosed in the fine print: different permutations of cell components such as separator thickness, cathode type, and anode - “Their graphs are not consistent”; “That’s weird to me”; “very easy to tweak” the knobs to manipulate results.

Former employee says lack of consistency from test to test is “weird”

“**Their graphs are not consistent**. You should be consistent with the cells, same size, from the same batch, or from a different batch with the same size. **That's weird to me.**”

A second ex-employee indicates it's “very easy” to vary test parameters to produce certain data

“Let me put it this way, when you're testing the battery, there are so many different specs that you can have for the battery. **It's very easy to tweak each of those specs in order to get a good result**. It's easy to change the pressure of the battery, change the temperature the battery's performing at, and you can get different cycle results, depending on which one you're showing...”

A third questioned how different cell components may be mixed and matched for different tests

“If you've got it all working together, **are you cherry-picking different elements?** You're trying the separator in one; you're trying the anode in another; you're trying the cathode in another.”

1) Introduction to QuantumScape

A number of solid-state battery experts have questioned whether QuantumScape's battery is even solid-state. A key diagram includes a mystery component labeled "catholyte," which experts deduce to be a liquid that comprises the bulk of the cell. One expert explained why "it's impossible" for the QS battery to not have liquid – negating the purported advantages of solid-state even if the "science" was real.

A number of key QS data slides state “~3.4 atm” in the fine print, which experts interpret as atmospheric pressure. At that pressure, a solid-state researcher explained that it's impossible for a solid electrolyte to work, which requires 20 atmospheres.

*“The pressure, 3.4 atmospheres - **for sure they have liquid in their battery. It's not all solid-state.** Because in solid-state, it cannot work [at 3.4]. We have many, many scientists that worked on this pressure control problem. At room temperature with 3 or 4-atmosphere pressure, there has to be liquid. It's impossible, **without high pressure like 20 atmospheres - they cannot ensure contact between the electrolyte and the lithium metal.** As you can imagine, liquid can flow. For a solid, if you don't establish very tight contact, if there's any gap, like an air gap, the performance will be terrible.” – Solid-state batteries expert*

Slide #10 from Dec 8th “Battery Showcase”

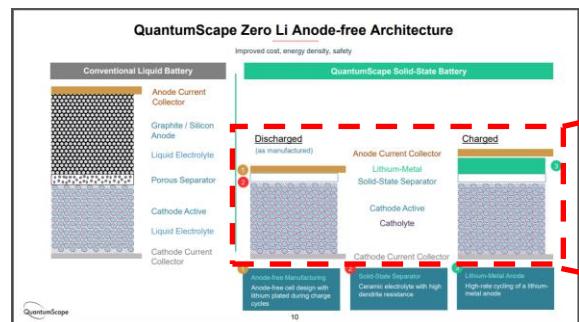


Diagram shows an undefined component -“Catholyte”

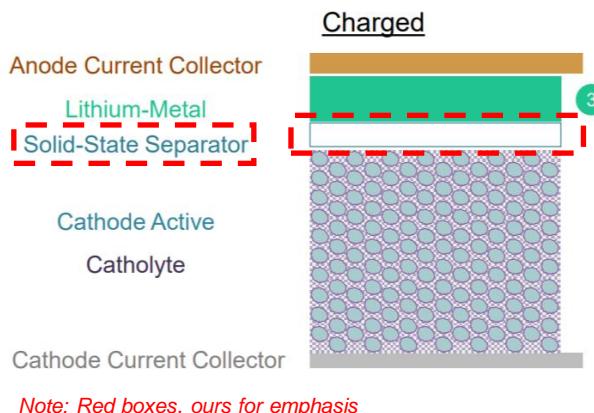


1) Introduction to QuantumScape

Aside from liquid, we note red flags around the thickness of the solid-state separator – a key element of the cell and essential to it being “solid-state.” The separator must be ultra-thin to have a viable energy density – so thin that it’s a super-human, unsolved problem. Ex-employees suggest that QS is struggling with a separator so thick that it’s dead on arrival. Thickness negates the entire rationale for a solid-state cell – without it, all key QS claims go out the window.

QuantumScape’s SEC filings vaguely allude to unsolved separator thickness as a risk factor but otherwise bury the struggle .

QS cell diagram showing “Solid State Separator” – Slide 10 from Dec 8th “Battery Showcase”



QS 10K – “our business could fail” with a thick separator

*“We are likely to encounter engineering challenges as we increase the dimensions, **reduce the thickness** and increase the volume of our solid-state separators.”*

Experts, ex-employees indicate failure to disclose separator thickness is a massive red flag

*“The other thing that they’re **not showing is separator thickness** across the board...I mean, if they reported separator thickness, that would go a long way toward answering these questions.” – **Solid-state expert***

*“One of the solutions was to make the separator thicker, and that typically reduces the performance of the cell, and it quickly negates a lot of the advantages that solid-state gives ...If they say they can make a separator that works, but they **won’t tell us how thick it is...**” – **Ex-employee***

Given the sheer number of red flags, we are not surprised that QS struggles to reliably make small-scale test samples that work, according to ex-employees, much less cells that are commercially relevant: “We built 300 cells a day, a few of them were ok to test”; “it was really hard to get a full cell that was repeatedly performing for a long period”; lab samples are so brittle they break at “astronomically high” rates with manual handling.

Our research indicates that manufacturability is as much an unsolved and daunting problem as the science. To illustrate the mammoth difficulty in manufacturing solid-state cells, we preview comments from ex-employees on the company’s inability to produce even small numbers of working cells reliably and consistently.

Q: “What about repeatability? Did they make 20 cells and found one where they could do this?”

A: “I would say that’s almost certainly the case. It certainly was the case when I worked there. **We built 300 cells a day, and a few of them were okay to test.”** – Former employee

“The chances of this getting broken are probably astronomically high. For sure it was high in what I saw. **The separator itself would break for manual labor reasons.”** – Former employee

“I believe them for a sample or two or maybe three or maybe four or maybe 10, but **I don’t believe that they can do that pretty consistently. It’s not a robust process at the moment.** So, even with a non-robust process, you will probably get some good cells. I don’t doubt that part. It’s just, can you do it robustly? **And from the people that I still talk to, they can’t.”** – Another former employee

2. Volkswagen employees indicate that engineers and battery experts internally are highly skeptical of QuantumScape's claims, getting "nice Powerpoint slides" and little else

2) VW employees indicate internal skepticism of QuantumScape's claims

Given QuantumScape's secrecy and scant details, investors appear to be leaning on Volkswagen's involvement as "validation" that the science is real. We spoke with two current employees involved in VW's EV battery efforts, both of whom noted their interactions with QS staff/leadership and involvement with the partnership.

QuantumScape is a “black box” to investors, and investors appear to have turned to VW for validation, assuming that if a major automaker is involved, it must have seen and blessed the science as real. VW is QuantumScape’s largest investor.

Slide #7 from hr. QS December 8th “Battery Showcase”

Volkswagen Committed to QuantumScape Technology →

Volkswagen Group Overview

- ~11 million vehicles produced in FY2019
- ~\$38 billion investment in electric mobility by 2024
- Plans to launch ~70 electric vehicle models and produce 22 million electric vehicles by 2029

Selected Brands

Volkswagen Partners with QuantumScape

- Corporate funding commitment of \$300+ million
- Strong relationship since 2012, including development collaboration, testing of prototype cells and representation on the QS board of directors
- Founded a JV to prepare for the mass production of solid-state batteries for Volkswagen

Source: Volkswagen AG Half-Yearly Financial Report published July-2020, 2019 Annual Report published Mar-2020, press releases published Mar-2019, Nov-2019 and Jun-2020, Half-year press conference published Aug-2018; Porsche Annual Press Conference published Mar-2019. Page 18 based on Volkswagen AG press release published Sep-2018.

7

QuantumScape logo

QuantumScape hypes VW's involvement at every opportunity.

2) VW employees indicate internal skepticism of QuantumScape's claims

QuantumScape's CEO uses purported VW “validation” as an excuse for secrecy - we’re not “in the business of academic research” – and aggressively promotes their blessing the science as sufficient: “they’ve seen the data,” “they’ve seen it works,” “VW has gone all in”

We note the tone the CEO took in a recent interview.

No offense, but we don’t really care what you think

MIT Technology Review article, Dec 8, 2020

Asked why journalists should have confidence in the company’s results without the benefit of independent findings, Singh stressed that he’s sharing as much of the data as he can to be transparent. But he adds that QuantumScape isn’t “in the business of academic research.”

“No offense, but we don’t really care what you think,” he says. “The people we care about are our customers. They’ve seen the data, they’ve run the tests in their own lab, they’ve seen it works, and as a result they’re putting in massive bets on this company. VW has gone all in.”

2) VW employees indicate internal skepticism of QuantumScape's claims

A sharp-eyed battery journalist, who has written a series of investigative articles probing QuantumScape's claims, as well as on previous battery frauds with the same investors, notes subtle wording changes in VW press releases suggesting the opposite: “Only, it wasn't clear VW had validated QuantumScape's cells” (italics his)

The journalist, Steve LeVine, analyzed VW's press releases to note a shift – their statements no longer appeared to vouch for QS' technology. When he emailed VW to give them an opportunity to re-iterate their earlier validation, he indicates they declined and referred him to QuantumScape: “Again, VW seemed to be backing away from any concrete assurances about when or if QuantumScape's material will find itself into a VW Group vehicle.”

An Ultra-Secret Battery Startup → Hints That It's Blown Past Tesla — But Won't Show the Goods

Experts question the claim by QuantumScape, backed by \$500 million from Bill Gates, Silicon Valley venture capitalists, and VW

 Steve LeVine Sep 21, 2020 · 15 min read ★



This version omits the words “successfully” and “an industry first,” and merely notes that the cells had been tested, a non-committal and thus meaningless bit of wording.

2) VW employees indicate internal skepticism of QuantumScape's claims

Nonetheless, investors appear buoyed by VW's ongoing investments in QS. VW employees we spoke to explained the dynamic: VW leadership is desperate for media wins in the aftermath of Dieselgate and has Elon Musk-envy – “pressure in Germany” for “nice Powerpoint slides” - but internal VW battery experts are “quite skeptical” of QS.

A VW employee explained that “there’s a lot of pressure internally” to “have something in the pipeline for our investors.” He indicated the QS partnership is “a lot of marketing and PR” but that the actual battery experts inside the company have “a lot of question marks” and are “quite skeptical.”

“There’s also a lot of pressure in Germany to make all those nice PowerPoint slides and press releases real, so **there’s a lot of pressure internally, But when you’re talking with the experts, with the battery experts [at VW], there are still a lot of question marks. The experts on our side were quite skeptical.** They’ve been working with the current technology for years, with pouch cells, prismatic cells, and they know what kinds of challenges and problems they had to go through.” – vw employee

“We are getting a lot of pressure from Tesla, and Musk is making huge announcements of his supercell and his super factory and a much higher density, lower cost, and so on. And **we also just need to have something in the pipeline for our investors** to say that we are also working on something similar and have a strategic plan....**It's a lot of marketing and PR out there on both sides [VW and QuantumScape]** because we also need to show something like what Elon Musk is talking about, that something big will come in the future.” – vw employee

2) VW employees indicate internal skepticism of QuantumScape's claims

In contrast to the QS CEO's claims that VW has “seen the data” and “they've seen it works,” both VW employees indicated that VW has seen little: “the main issues our engineers and experts are raising are trust in the data, a lack of transparency”; “there are so many questions”

VW employees indicated that the little that QS has shared “cannot be compared to an established supplier where the testing and validation we’re doing is on a completely different level.” Engineers at VW apparently don’t trust key claims that QuantumScape has made – “They don’t trust that you can charge it in 15 minutes, for example” -

“The main issues our engineers and experts are raising are **trust in the data, a lack of transparency.** **Behavior in certain situations like extreme temperatures and so on.** This is a big question mark where they’re saying that we are having a lot of issues and a lot of risk. Those are [some of the] core questions that are circling around. **They don’t trust that you can charge it in 15 minutes, for example.**” – VW employee

“The data we have received in this early stage cannot be compared to an established supplier, where the testing and validation we’re normally doing is on a completely different level. That’s why there are so many question marks and **not everybody is supporting it 100%** because it’s really early stage and not all the facts and figures are on the table, and sometimes there’s also a lack of transparency.” – vw employee

2) VW employees indicate internal skepticism of QuantumScape's claims

VW indicates “there is nothing real we have seen on the table” and “analyzed on our side in specific detail”; “quite dependent on what is being presented to us,” which is just slide-ware; “mixed opinions from our engineers” who say they’re fed cherry-picked results from the 2 test cells out of 100 that may work.

VW feedback suggests QS is feeding them scraps of cherry-picked information, which fuels skepticism among VW’s engineers – test cells are behaving in an unstable manner; internal commentary that test results they see are not representative.

“There is nothing real we have seen on the table and investigated deeper and taken and analyzed on our side in specific detail. [We’re getting it] from QuantumScape’s side. The data, facts and figures are aggregated on a level which seems perfectly nice.” – vw employee

“When you have test results and each cell is behaving differently most of the time, of course there are people [at VW] saying, they tested 100 cells and two performed quite well, and those are the results we see, just to give you an example. With our current suppliers who are actually equipping our cars, we get live data. This is not where we are currently. It’s also that there’s a lot of marketing involved. As I mentioned before, we are quite dependent on what is being presented to us.” – vw employee

“I’ve gotten mixed opinions from our engineers. Everybody says it’s a long journey to goal...” – vw employee

2) VW employees indicate internal skepticism of QuantumScape's claims

Former employees of QuantumScape confirmed the color we received directly from VW, suggesting that VW was kept in the dark and that the QS CEO and Chief Sales Officer “just had it nailed” as far how to play the VW bureaucracy.

Our research interviews indicate that VW didn't “have as much transparency” as the company would like investors to believe.

*“I don't know if Volkswagen have as much transparency into what's going on in there. I don't think people questioned it, to be honest. **They were very limited in getting access.** It was a very controlled environment. I don't think they got the full picture. I'm pretty sure they didn't.” – Former employee*

*“Jagdeep and Howard Lukens [Chief Sales Officer] essentially **broke down the VW organization and figured out where all the decisions were made**, and allocated a guy from QuantumScape to each of these key points. They just had it nailed. Everything was scripted down to practicing everything after the introduction.” – Ex-employee*

2) VW employees indicate internal skepticism of QuantumScape's claims

The lack of transparency from QuantumScape was a key theme of our research calls with both VW employees, which suggested major tension in the relationship with QS “blocking us from time to time”; lack of “cooperation”; just “nice Powerpoint slides” but “we don’t see exact raw data”

VW suggests there is “big drama” in the relationship with QuantumScape, due to a lack of cooperation and withholding of information.

Q&A during our research consultation call

Q: “Is there some tension in the partnership because QuantumScape is withholding some information?”

A: “[Laughs] It’s a big drama, I would say. We don’t want to buy into something that we don’t trust and have not tested 100 times, especially where Volkswagen is now coming from. We want to be double-sure that everything is correct and is compliant. **We are asking many, many questions, and they’re blocking us from time to time.** They say we need to do our homework, that we don’t know.”

“We are not sitting in the same laboratory where we are looking at exactly the same test results. We are getting nice reports, nice PowerPoint slides, but, for example, **we never see the exact composition of the raw materials. We don’t see exact raw data** from the test institute, and so on. It’s all nicely prepared and aggregated. It’s not like that our battery expert goes there saying, let’s work together for four weeks and let’s have a look at the books and show me your facts and figures. This kind of cooperation, we don’t have right now.” – vw employee

2) VW employees indicate internal skepticism of QuantumScape's claims

A lack of “trust” in QuantumScape’s data by VW engineers was emphasized a number of times during our consultations: “really difficult” to interpret; “reliability of the data and of QuantumScape”; “hasn’t created trust”

The actual dynamic within VW’s battery group does not suggest any validation or blessing of QuantumScape’s technology.

Q&A during our research consultation call

A: **“It’s really difficult [to interpret QuantumScape’s data]. I think it’s basically the reliability of the data and of QuantumScape.** They don’t have a well-known institute standing behind them or real customer tests, so this is really, really early stage. It’s back and forth, back and forth [between VW and QuantumScape]. **This hasn’t created trust, when I speak to the engineers.”**

Q: “You’re saying there’s not a lot of trust among the engineers in VW at QuantumScape’s data?

A: “Yes, because they are only seeing nice PowerPoint slides and hearing big stories from the CEO meets saying this is great. They say, let’s see, let’s find out, let’s dig deeper into it and let’s see how it really behaves under certain types of tests, under certain test conditions and so on, and under a mass production standard, **not just in a laboratory where everything is perfectly designed.”**

“When you produce this battery in a factory you’re producing millions of batteries a day. This is also something where our people are saying - it’s nice to design something in the laboratory and make it work, but when it comes to scale, this needs to be proven and no one has done yet.” – vw employee

2) VW employees indicate internal skepticism of QuantumScape's claims

Even with the trust and transparency issues, we were surprised when VW employees dismissed the QS relationship as not “a real partnership or joint venture”; “nor really a commercial relationship”; “no real R&D relationship or exchange or joint lab or whatever”; just a stock investment; “quite challenging” to work with QS

VW employees painted the QuantumScape “partnership” as just a passive equity investment without any real R&D component or even proper access to their data.

“Currently, it’s only financial support. R&D collaboration isn’t really established yet. Of course, we have shares and have some power because we are one of the biggest investors, but there is **no real R&D relationship or exchange or a joint lab or whatever.**” – vw employee

“We don’t have a real partnership or joint venture. Of course, we are one of the biggest investors, but they’re also kind of scared to share intellectual property, so it’s not like we have an open book policy. This is **quite challenging.** They are quite protective. This is making the current working mode **quite challenging.** Volkswagen as a mass manufacturer is also probably not the one willing to pay the most for batteries.” – vw employee

“We have no real commercial contract and obligation from QuantumScape to open all the books and to make everything transparent to us, because **it’s not a real partnership nor really a commercial relationship.** That’s why we have far more data from established suppliers” – vw employee

2) VW employees indicate internal skepticism of QuantumScape's claims

VW states that they don't even know the chemistry or materials in QuantumScape's prototype, describing it as a black box: technology is “unknown to everybody”; they want to “keep their recipe in their kitchen”

We note the sharp contrast between VW's perspective versus what the CEO has represented.

“I think QuantumScape **wants to keep their recipe in their kitchen**. That's my feeling. They open up the black box to say here are the specs you requested, and this is our testing result.” – vw employee

“**VW doesn't know the chemistry** and the core processing of the manufacturing and industrialization. **By chemistry, I mean the structure of the cells and also the material in the cell.** We treat that as a kind of black box. In the meantime, they are developing the industrialization process based on **this technology, which is actually unknown to everybody.**” – vw employee

Q&A during our research consultation call

Q: “Volkswagen knows what the chemistry is here?”

A: “**Not in detail.**” – vw employee

2) VW employees indicate internal skepticism of QuantumScape's claims

Internal experts at VW appear to doubt key QS claims, such as 15 minute fast charging. Questions about battery lifespan, low temperature behavior: "we have no clue"; "we don't know how the technology behaves"; "how stable are those KPI's"; "why we are so cautious"

We find it interesting that VW appears to agree with the skepticism of QuantumScape's claims in recent investigative articles, tweets by battery researchers and experts, etc.

"We have **a big question when it comes to the battery's lifespan. How stable are those KPI's** and results we're seeing? And secondly, when it comes to how to produce such a cell in a mass market, no one has experience in this. It's all in a micro laboratory." – VW employee

"That's the reason why we are so cautious, saying we need to investigate further. Nothing has really been produced or tested to scale up the production. There are still a lot of question marks, where we don't know how the technology behaves. **Many of the question marks you can find on websites and forums and whatever, I would say they're mostly true.**" – VW employee

"Behavior in certain situations like extreme temperatures and so on. This is a big question mark where they're saying that we are having a lot of issues and a lot of risk. Those are [some of the] core questions that are circling around. **They don't trust that you can charge it in 15 minutes**, for example." – VW employee

„,,there are so many questions also when it comes to the lifetime and other aspects of solid state batteries. **We have no clue how solid state technology behaves** in extreme temperatures, in crash situations, over a longer period of time, and this needs to be tested and evaluated." – VW employee

2) VW employees indicate internal skepticism of QuantumScape's claims

Both VW employees were dismissive of QuantumScape's data as not real world: “easy to do it in the laboratory” with “a small scale” and “low-capacity cell”; “we have only seen simulations under perfect test conditions”; suggest the “battery business” is full of such claims

VW indicates they have yet to see cells “under real-life conditions” versus “a small-scale, gentle test, perfect in the laboratory.”

“**It’s easy to have a battery perform well in the laboratory** and meet the specs and to show feasibility, but come to industrialization, that’s another story. The **battery business is just like that**. It’s easy to demonstrate, but it’s difficult for industrialization.” – VW employee

“First of all, it’s **easy to do it in the laboratory and in a small scale and with a low-capacity cell**. You can do it perfect actually. You can control the material so precisely, and also you can pick a good sample when you do it in the laboratory. But when you come to industrialization, and you have a machine that may produce hundreds or thousands or ten-thousand cells a day on a big scale, how are you going to control this kind of process to make sure that it still reaches the quality level? That’s the challenge. It’s nice to have a small-scale, gentle test, perfect in the laboratory. When you come to industrialization, all kinds of issues pop up.” – VW employee

“**We have only seen simulations under perfect test conditions**. What needs to be seen is taking the single cell into a bigger pack, into a battery system with all the requirements we have, and then it needs to be tested to see if it’s still behaving the same, not just looking at a pure testing environment in an institute, but under real-life conditions.” – VW employee

2) VW employees indicate internal skepticism of QuantumScape's claims

VW indicated strong concern that QS test cells aren't even in the required dimensions for a car. Concerns about cells with "more layers, bigger size": "It's gambling, as far as how those questions will turn out"; "just nice slides"; questions about cost.

QuantumScape's claims are based on small, single-layer prototypes. VW appears keenly aware of the risks of relying on lab samples different than what goes in a car.

"It's kind of tricky - we don't know how their cells will perform later on, and with the lack of transparency, it's kind of difficult. **The core issue is that the cells which we have are not in the dimension which will be used in vehicles.** What we have right now is like a cell phone with only 4 to 5 layers of cells, and it's just one cell, and this is basically the foundation of all of our tests...But the thing is, it's not in the dimension where you would see them in the cars, and we don't have tests at a module level, which gives us a big question mark. How do those cells behave when you put them into a model or into a battery pack? This is basically just nice slides because these are just assumptions." – vw employee

"All the discussions are based on **samples in quite small dimensions**, and they are not manufactured on industrialized lines. They are just prototype lines. There are several questions. The first is how does it look when the cells are bigger and put into an automotive environment? And what's the performance of those cells when you produce them in scaled-up production factories. This is a big question mark. **It's gambling, as far as how those questions will turn out.**" – vw employee

"There are two major questions. First of all, how do the test results and behavior look in an automotive dimension? **More layers, bigger size, in a module or a pack, how is the performance then?** And secondly, how will you scale it up, what are the process parameters? No one has any experience in this and you need to meet a certain cost target - those are the two biggest question marks our engineers have." - vw employee

2) VW employees indicate internal skepticism of QuantumScape's claims

In contrast to the CEO's claim that "VW has gone all in," VW comments strike us as ambivalent and noncommittal at best - indicating any orders/commitments would be a decade away; that they're evaluating other solid-state players; and that it's unclear who they'll select, assuming that hurdles to solid-state batteries can be overcome.

In our assessment, the tone of the comments does not suggest "VW has gone all in."

"VW has teams for early-stage battery technology and they are dealing with QuantumScape, but also getting tests and next-generation batteries from many other suppliers. They are **evaluating, testing, and discussing not only QuantumScape but other suppliers as well.**" – VW employee

"We are discussing **what is the right path to continue and with whom**. There, of course, we are discussing with QuantumScape, established players as well and as our joint venture partner." – VW employee

Q: "I think you said earlier that Volkswagen **hasn't given QuantumScape any orders, commitments, or purchase commitments because it's too many years out, right? It's like a decade away, is that correct?**"

A: "**Yes, that's correct.**" – VW employee

Q: "Is there a possibility that you end up working with Solid Power or another company for solid state batteries instead of QuantumScape at some point?"

A: "I think so. **We have many partnerships where we thought they were great partnerships, but then we stopped the partnership.** In the past, we thought Panasonic was a great partner for batteries, but it turned out not to be." - VW employee

2) VW employees indicate internal skepticism of QuantumScape's claims

As one might expect of a corporate partner that is ambivalent and noncommittal, both VW employees we consulted indicated that “a lot of players” in solid-state batteries are at parity or ahead of QS, based on VW “scouting results”; “who knows” if VW selects QS.

A VW employee replied “Who knows” when we asked if it was a forgone conclusion that QS would be their solid-state battery supplier.

“Solid State is at the same level or even further advanced than QuantumScape, I would say. When I spoke with [redacted], they also have the same opinions of Solid Power, that it’s at least on the same level as QuantumScape.... It’s a head-to-head race.’ – vw employee

“There are quite a lot of players like QuantumScape, Solid Power and Solid Energy. I think SDI and Toyota are also on it. I think they’re quite close from laboratory results. At this moment, only based on the laboratory results, I would say there’s not a big difference.” – VW employee

“Solid Power and QuantumScape are close, frankly speaking, although it’s a different and not a purely apples-to-apples comparison of their chemistry, but I think they’re quite close. Based on our scouting results they are close.” – VW employee

Q: “Is it a forgone conclusion that QuantumScape is going to be the solid-state battery provider to Volkswagen? Or it’s just who knows at this point?”

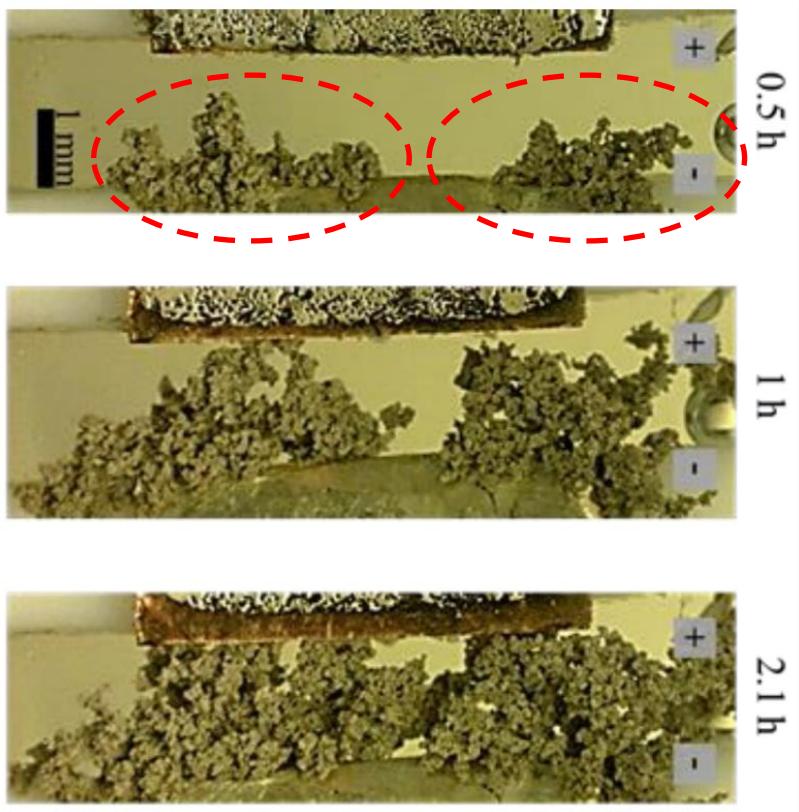
A: “Who knows, I would say.” - VW employee

3. Phony claim A: Solid-state material resists dendrites

3) Phony claim A: Solid-state material resists dendrites

Dendrites are one of the biggest obstacles in making solid state lithium metal batteries, preventing progress for >50 years. QS claims to have a breakthrough solution.

Scientists have tried to make batteries with solid lithium metal since the 1800's, but failed because lithium quickly develops dendrites, which are metallic growths and deposits that resemble a tree, roots, or a fungus. Once a dendrite develops, it quickly grows out of control and the battery shorts and fails. QuantumScape's CEO describes dendrites as a "monster that's lurking" and that "with enough cycles it will just burst out" like "that monster in Alien in the '80's...."



Dendrite layer after 30 minutes of current

At one hour, dendrites almost reach the other end of the battery, which will instantly short the cell

At two hours, they grow enough to short and kill the battery

3) Phony claim A: Solid-state material resists dendrites

In a recent interview, the CEO claimed to have basically solved the industry's long-standing dendrites problem. The article noted widespread skepticism among experts.

The interview and article focused on the company's claim of a breakthrough solution to dendrites. The CEO explained that dendrites "had turned out to be the single greatest challenge" and that "those were some dark times" as "every one of the systems we looked at was dendriting." He claimed they then found a magical material that prevents dendrites, and his "personal depression started to lift."

If True, QuantumScape Has Made the Biggest Leap in Batteries Since the Debut of Lithium-Ion

But most battery researchers don't believe it



"But most battery researchers don't believe it"

"...in an hour-long interview last week, two of QuantumScape's founders were most interested in talking about a single thing: How they had beaten dendrites."

Dendrites are a "dreaded," "nightmarish growth" that have long stumped battery researchers

The scourge was a sort of cancer — a nightmarish growth that tends to bloom from pure lithium metal while the battery is in use and trigger the device's death. The dreaded growth is called dendrites, and researchers have failed to rid batteries of them, and even to discover what precisely

QS CEO/CTO claim to have discovered the cause and a special material that prevents them

CEO Jagdeep Singh and CTO Tim Holme said the company had discovered what precisely causes lithium dendrites, and that they had also developed a material that suppresses them before they grow. If validated, their breakthrough would be the biggest in batteries since the commercialization of lithium-ion itself in 1991. "We're lucky that in the end nature had a

3) Phony claim A: Solid-state material resists dendrites

Small problem with the CEO's claim: six ex-employees imply it's false, made up, or “total bullshit”, implying that QS is still struggling with dendrites and slamming the data as “useless,” “crude,” “immature”

We begin by quoting two former R&D employees whose comments are representative of the skepticism we encountered. Others are quoted in the pages that follow.

Former employee #1: Dendrites are a showstopper and a “Herculean task” that needs to be solved 100%; the company was still “trying to solve” it “when I left”; former employee remains current with QuantumScape’s progress and is extremely skeptical

“Dendrites are a real problem, and **that's basically where we were at when I left—trying to solve dendrites. It's a showstopper.** It's not like paint chips or something like if it happens, you have a few unhappy customers, and you can repaint their car or make them happy. It's a showstopper. The battery's not even safe if you have a short risk. Therefore, it has to be solved 100%. And therefore, the ceramic separator needs to be produced flawlessly. **They need to produce hundreds of square meters per vehicle of flawless 5-micron thick separator material. That's a Herculean task**. – Former R&D employee

Former employee #2: The prototype used for the dendrites test isn't even a “real battery cell” and that “I don't believe they have solved dendrite formation in a real battery”

“A lithium-lithium symmetric cell is not a real battery cell...**I don't believe that they have solved dendrite formation in a real battery. A single layer is nothing.** Show me a multiple-layer battery, a one AH, two AH, a commercial-level battery - then I'll believe it. Their data is useless...From a commercial application point-of-view, it's too crude, too immature. .– Former R&D employee

3) Phony claim A: Solid-state material resists dendrites

Multiple former employees detail QuantumScape's ongoing problems with dendrites and imply the CEO is misleading investors with "hype": "twisted the knobs," "science is not there yet," problems even at coin cell size

We quote two more former employees who indicated the company has not solved the dendrites issue – an ominous sign as even the CEO indicates it's a showstopper.

Former employee #3: Dendrites are “very difficult problem,” QS struggles even with dime-size cells

“A ceramic electrolyte was the main mechanism when I was there. It’s easy to make well as a bulk powder. But when you put it into a film, which is the form factor for a battery, that’s where things become harder. You’re balancing thickness versus number of defects; **the defects are the ones with the dendrites....**

They were having problems at the coin cell level...it is a very difficult problem because they’re grinding ceramic down to little particles. They’re creating this formulation, and they’re casting it into a thin film, and you have to have zero defects. One way to combat a defect is to make it thicker, but making it thicker has its consequences, so there’s a fine balance.” – *Former R&D employee*

Former employee #4 answers affirmatively to our question: “They’re struggling with a dendrite issue in the transition from single-layer to multi-layer cells?”

“Right. Let me explain some things about just how these batteries work [...] **Obviously you’re always going to hype up whatever you’re doing. I don’t know that they’ve completely nailed this. I wouldn’t say that they’ve completely nailed it because there are definitely some issues with what they’ve put out...I think there’s some truth to what he’s saying. I just think that... I wouldn’t hold my breath because there’s definitely more that he needs to show that this is ready for a commercial vehicle...There are a lot of things you can do to reduce dendrites, like charging at a slower rate or changing the battery’s temperature or pressure. I’m sure that they had to have done some tapering with the specs to get to this level that they thought was optimal enough to release data. They probably just twisted the knobs and engineered a process to produce this set of results.** **The science is just not there yet.”** – *Former R&D employee*

3) Phony claim A: Solid-state material resists dendrites

One former employee painted the dendrites claims/data as fraudulent: “definitely bullshit,” “I don’t buy this, for sure,” and replied “Absolutely” when we asked if he was saying that the key slide is “made up, fiction or garbage”

He stated that at best the dendrites claim could be “possible” for a coin-size single-layer cell, but not representative of “an actual cell” and explained his reasoning in detail.

*[The CEO’s dendrites claim] is a **bunch of bullshit** because even if you did have a ceramic separator, the kind of synthesis that you would have to do on it just to make sure—here is the deal. You want lithium-ions to flow through this separator or the electrolyte; in this case, the solid-state separator and electrolyte is kind of like a combination here. So, you want lithium-ions to flow through it from cathode to anode and vice-versa, but then you’re not allowing the dendrites, which is essentially lithium metal again, to pass through the ceramic separator.. **That’s definitely bullshit.** If it’s a tiny one-inch diameter coin cell, then yeah, it’s entirely possible, and it has to be single-layer as well but **it’s not going to be representative of what you will see in an actual cell, especially when it comes to a dual-electrode multi-layer cell, this is just not going to hold good at all.**” – Former R&D employee*

We then asked, “You’re saying, it’s just not going to hold true at all?” and he explained his reasoning for why he believes the claim is “bullshit”

No. This is a symmetric cell that they are talking about. So, there’s a bidirectional current. Going slightly into technicalities—the activation energy for the process is going to be symmetric between the cathode and the anode because both of them are the same anyway, and it’s a single-layer. The assumptions that go into such a graph would be that the activation energy for the forward and the backward reaction are going to be exactly the same. Second, **it’s going to be a single-layer coin cell which means that the area of cross-section is not going to be enough to even promote the dendriting.** Third, at this level, you could probably nanostructure the hell out of your separator, in which case, it just wouldn’t allow the lithium plating to happen on the other side, anode or cathode.” - Former R&D employee

3) Phony claim A: Solid-state material resists dendrites

The former employee characterized the claim as believable as someone declaring 200 miles per gallon for a gasoline-fueled car, and explained in detail why the CEO's statements are not credible

Similar to other research interviews we conducted, we find the former employee's answers to our questions to be notable for their high level of skepticism as well as their technical knowledge/credibility.

Q: "You're saying this slide is basically made-up, fiction, that it's garbage?"

A: "Absolutely. It's kind of like a body certifying a gasoline car to have 200 miles per gallon on a test strip. Yeah, it's possible. You don't have drag; you don't have rolling friction, you don't have anything at all, you don't have the A/C on. It's theoretically possible. But then when you take the car out on the road, you'd realize it's less than 50 mpg. That's essentially what I expect out of this as well. The disclaimer is that they've already said that it's a lithium-lithium symmetric cell, so it's only for coin cell for testing purposes at a coin cell level, and it's single-layer, and it's 45°C, which is also good because the cell is happiest at higher temperatures and not lower temperatures. I'm just not sure this would translate into a commercial product."

Q: "So, you don't buy what the CEO is saying?"

A: "Yeah, I don't buy this, for sure." – Former R&D employee

3) Phony claim A: Solid-state material resists dendrites

A solid-state battery expert slammed the CEO's claim of a miracle dendrite-resistant material as "a ridiculous statement" and "disingenuous: "I don't understand how you can say that and have a straight face."

Our interviews with solid-state battery experts who have studied the company's patents and with former employees lead us to believe that its supposedly breakthrough material is a ceramic compound known as LLZO, which we discuss in a separate section. An expert who is highly knowledgeable about LLZO cited a key MIT research paper that proves that it is not immune to dendrites.

"That's a ridiculous statement. I do not believe that they have solved the issue and one of the reasons why I don't believe it is because a researcher under Yet Ming Chiang's lab at MIT has shown a single crystal LLZO material. it shows that even a single crystal material is not immune to dendrites. He had a pure LLZO crystal, and the reason why that's important is because there are no grain boundaries, so the lithium dendrites are thought to potentially move through the bulk and the grain boundaries. LLZO has had very good compatibility with lithium metal, but he showed that you can push a dendrite, a single crystal LLZO and why a single crystal is important is because there's no grain boundary; it has to go through the bulk. So **for QuantumScape to say we've solved this is disingenuous**. Saying, like sulfides, they have dendrites, yeah sure, you can push dendrites, but I guarantee you, like send your separator to some lab and they push even current density through, you're going to have a dendrite form. **I don't understand how you can say that and have a straight face.**" – Solid-state expert

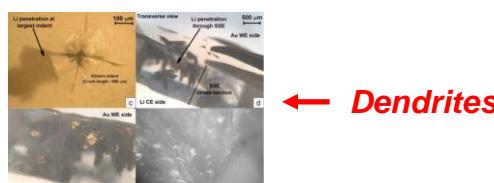
MIT paper the expert cites on dendrite formation in a single-crystal solid-state ceramic material

Lithium Metal Penetration Induced by Electrodeposition through Solid Electrolytes: Example in Single-Crystal Li₆La₃ZrTaO₁₂ Garnet

Tushar Swamy^{8,1}, Richard Park^{8,2}, Brian W. Sheldon³ , Daniel Rettenwander⁴ , Lukas Porz⁵,

Stefan Berndts⁶, Reinhard Uecker⁷, W. Craig Carter^{9,2} and Yet-Ming Chiang^{9,10,2} 

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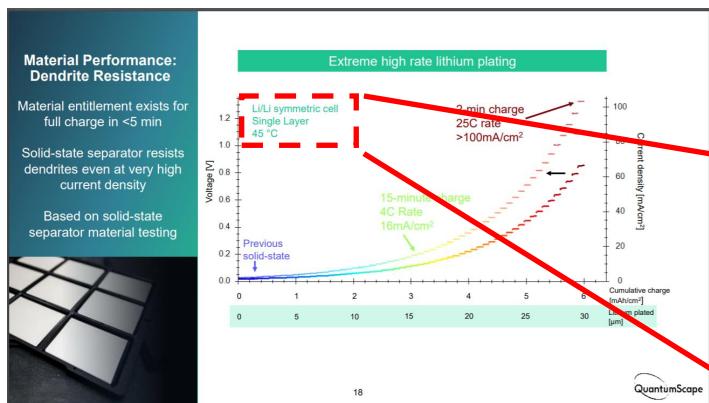
3) Phony claim A: Solid-state material resists dendrites

Red flag 1: Lab test used to prove “dendrite resistance” doesn’t even use a real battery cell. Leading solid state experts: “It’s not a battery”; practically “useless”

QuantumScape’s dendrite breakthrough claim rests on a single test shown at their Dec 8th Battery Showcase event: “solid-state separator resists dendrites even at very high current density.” The presentation is already troubling as it cherry-picks different lab prototypes for each slide. However, the dendrites data takes the mixing and matching to an even more audacious level, using what’s called a “Li/Li symmetric cell” – which is not even a real-world solid-state battery. The other slides used 30/x30mm or 70x70mm lab samples – which are at least battery cells, albeit single-layer and commercially irrelevant.

“This is lithium/lithium. It’s not a battery. You just have a thick lithium foil on both sides, and you’ve got your fancy solid-state separator between the two pieces of lithium foil, probably just some pressure on it, and you’ve warmed it up to 45°C and then you’re driving a small amount of current.” - Solid state battery expert, with extensive experience with ceramic separators

Dendrites data slide from QS December 8th “Battery Showcase” – slide #18



A second expert – Prof. Jeff Dahn, a world-respected solid state researcher – states that symmetric cells have zero average voltage and are “useless from a practical point of view,” although they can provide other significant information.

**Li/Li symmetric cell
Single Layer
45 °C**

Note: Red box and arrows ours for emphasis

3) Phony claim A: Solid-state material resists dendrites

Red flag 1 (cont'd): Ex-employees echo experts and ridicule the prototype in the dendrite test as “not a real battery”; “doesn’t tell you too much about the battery.”

Former employees explained why the particular prototype used – which lacks the basic anode-separator-cathode structure of a battery – isn’t a real cell and why the data is therefore meaningless.

Dendrite test doesn’t use a “normal cell”; “really doesn’t tell you too much about the battery”

“In a normal cell, they have a lithium metal-plated anode, and then they have a cathode—but this doesn’t have that. With this lithium-lithium symmetric cell testing, they’re putting lithium on both sides and passing electricity back and forth. This is giving you the max capability of the separator, the max speed at which it can cycle without destroying the separator. **That actually really doesn’t tell you too much about the battery.** It’s telling you the max capability if there is no other restriction, so you just put lithium on both sides and see how fast you can pass it from one side to the other. **Of course, when you put it into an actual battery, you’re going to have a cathode on the other side and not just a lithium-plated side, or else the battery is not going to hold a real charge.** That’s what passes electricity back and forth. By doing that, you’re not going to get that type of speed. It’s like when you do a Wi-Fi speed test to see the max speed . You’re never actually going to get that if you start downloading, because it’s just showing you the fastest signal step if you tried.” – Former employee

A single-layer prototype “that has two anode layers” is just “academic” and not a real battery

“If you want to say you have solved the dendrites problem, you have to show you solved the problem in a real product, in a multiple-layer battery. It’s just a single layer. **A prototype that has two anode layers, that’s not enough. That’s academic.** That still stays at a university, it’s not industry.” – Second ex-employee

Lithium/lithium symmetric cell used for dendrite test “is not a real battery cell”

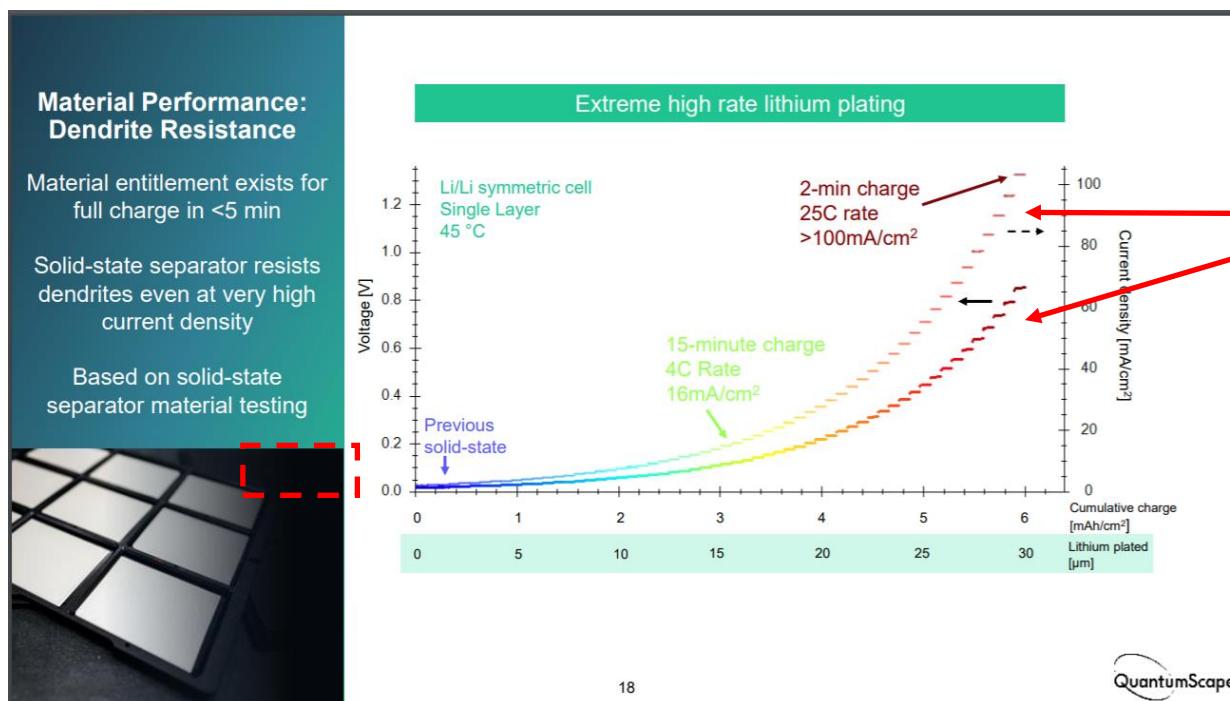
“A lithium-lithium symmetric cell is not a real battery cell...**I don’t believe that they have solved dendrite formation in a real battery.**” – Second ex-employee

3) Phony claim A: Solid-state material resists dendrites

Red flag 2: QuantumScape used a “pulse test” to claim dendrite resistance. Former R&D employees and leading experts label it deceptive and a trick that proves nothing.

Dendrites form as lithium is subjected to a continuous current over a period of time – and of course batteries must operate for continuous periods to do useful things like power a car. The graph that shows QuantumScape’s purported dendrite breakthrough cheated by “pulsing” the current – applying current, stopping, applying current, stopping again – which is not how batteries operate in the real world.

Dendrites data slide from QS December 8th “Battery Showcase”



One of the world's leading solid-state battery researchers stated the chart clearly shows a “pulse test”

“The lines are broken. The line is not continuous. It's break, break, break. Look at the short lines - each duration is very short. **They apply some current and then pulse – apply current, wait, apply current, wait, versus continuously increasing the current.**” – Leading expert

Note: Red arrows ours for emphasis

Source: https://s26.q4cdn.com/263384136/files/doc_presentation/2021/1/Data-Launch-Updated-Post-Presentation-20210107-2.pdf;

3) Phony claim A: Solid-state material resists dendrites

Red flag 2 (cont'd): Leading solid-state battery researcher who's conducted similar pulse tests explain why it's a trick, and notes another discrepancy in the dendrite data

One of the experts we asked to analyze the QS data has conducted similar experiments and explained why it's cheating: lithium has a low melting temperature, and pulsing creates electrical resistance that heats the lithium, which causes dendrites to smooth out in the rest period between pulses – which "is not how batteries are operated in the field." The expert further noted the lack of a voltage spike in the pulsing data as another red flag in the chart, and wondered what "other tricks they played during the resting period."

Anyone can "prevent" dendrites with pulsing but it's not how batteries operate in the real-world
"So the question is, why do they have to pulse? People can show pulse data, no problem, but we really want to see the continuous data. When you're continuously moving across 30-microns of lithium, what happens? That's what Prof. Sakamoto's point is as well [in the Levine article]. They might be doing some trick, reversing something and then pulsing again and then doing something else. That is not how batteries are operated in the field. Pulsing helps to solve the dendrite problem because as temperature goes up during the resting period, lithium metal will even out because it melts at a very low temperature. When you pulse, the resistance increases and the temperature increases. As the cells rests, the lithium smooths out. I don't know what other tricks they played during the resting period. We're curious." – Solid state expert

Lack of a voltage spike in the pulse data is another worrisome red flag

"We conducted a similar pulse experiment in our lab. But the problem is the voltage profile, which has no spike. All the lines look very flat. Typically, when we go with very high current density like 100mA, there will be some kind of voltage spike. But we don't see it [in their slide]. I conducted a similar pulse experiment and we always see the voltage spike, even in a liquid cell. I don't understand why they have no voltage spike at all.

There is a certain shape in the voltage we should be seeing, but we don't see it. The x-axis says 30-micron lithium, so they moved across 30-micron lithium, but with pulses, not continuously but using a resting period." – Solid-state expert

3) Phony claim A: Solid-state material resists dendrites

Red flag 2 (cont'd): CEO claims have found a magic material that resists dendrites – so why was a well-known, conventional trick like pulsing necessary?

We earlier pointed to a recent article that noted massive skepticism among solid-state battery experts regarding QS' dendrite claim. The article quoted a leading materials science professor "whose battery work is similar to QuantumScape's." The researcher disputed that QS has found a magical material and stated that their test simply pulsed the current, confirming the conclusion of the expert who we asked to analyze the data.

If True, QuantumScape Has Made the Biggest Leap in Batteries Since the Debut of Lithium-Ion

But most battery researchers don't believe it

Leading materials science professor – Jeff Sakamoto, University of Michigan: "there is no trail of evidence" to explain the purported breakthrough

“...Sakamoto is not convinced that the breakthrough is technological....**Sakamoto specifically suspects that QuantumScape is “pulsing” its cells**...“If they start to form dendrites, they can pull it back by reversing the current,” he said...**there is nothing that stands out as an obvious breakthrough magic material or magic coating that enables fast charge,**” Sakamoto said. “**There is no trail of evidence** that would explain how they made a leap in performance...”

3) Phony claim A: Solid-state material resists dendrites

Red flag 2 (cont'd): Pulsing is widely cited in the lithium dendrites literature as a cute lab gimmick. QS makes a mockery of their purported discovery by having to use it.

A simple Google search indicates that pulsing is a standard way to reduce dendrites – in the lab, not in the real world where batteries must operate continuously. If QuantumScape had found a material that naturally resists dendrites, they would not have had to resort to the same gimmick as everyone else. We note example papers below.

Suppression of Dendrite Formation via Pulse Charging in Rechargeable Lithium Metal Batteries

Matthew Z. Mavers, Jakub W. Kaminski, and Thomas F. Miller, III*

Cite this: *J. Phys. Chem. C* 2012, 116, 50, 26214–

26221

Publication Date: November 19, 2012 ▾

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Citations

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2012 paper on pulsing cited by 119 others

Dynamics of Lithium Dendrite Growth and Inhibition: Pulse Charging Experiments and Monte Carlo Calculations

Asghar Aryanfar[†], Daniel Brooks[‡], Boris V. Merinov[‡], William A. Goddard, III[‡], Agustín J. Colussi^{*†}, and Michael R. Hoffmann^{*†}

Performance improvement of lithium-ion battery by pulse current

Zhu, Shaoqing ^{a, 1}, Hu, Chen ^{b, 1}, Xu, Ye ^a✉, Jin, Yi ^b✉, Shui, Jianglan ^c✉

3) Phony claim A: Solid-state material resists dendrites

Red flag 2 (cont'd): Two former R&D employees confirm use of a pulse test: “maybe this impresses people” but tiny pulses for short periods are not “a real dendrite test”

A former R&D employee stated “Correct, it is” when we asked if the QS chart was based on a pulse test. We confirmed with a second former employee, who strongly disputed that the company’s data shows a solution to the dendrites problem and stated that the pulses are too short to represent a real-world battery test. Given that dendrites develop over time after repeated application of current, he added that the company would need to show “hundreds and thousands” of cycles versus the irrelevant one-and-done data shown.

Pulse test is “not a good way to judge that you’ve killed the dendrite problem”

*This test is a pulse test. You can tell that because the bottom green axis—they've got two normalized axes on the bottom. Every length of that pulse is depositing a very finite amount of lithium, and then they do a little bit of lithium plating, and then they increase the current. **This is not a good way to judge that you've killed the dendrite problem [laughs]** for the simple reason that if you have this in a large vehicle-size battery, a true commercial-size battery, and you really did want to charge the entire battery, not just a little bit of charging, which are these tiny steps, you'd want to charge the whole battery at a current. That's how you would prove this isn't a dendrite.” – Former R&D employee*

The pulses QS shows are far too short to prove anything regarding dendrites

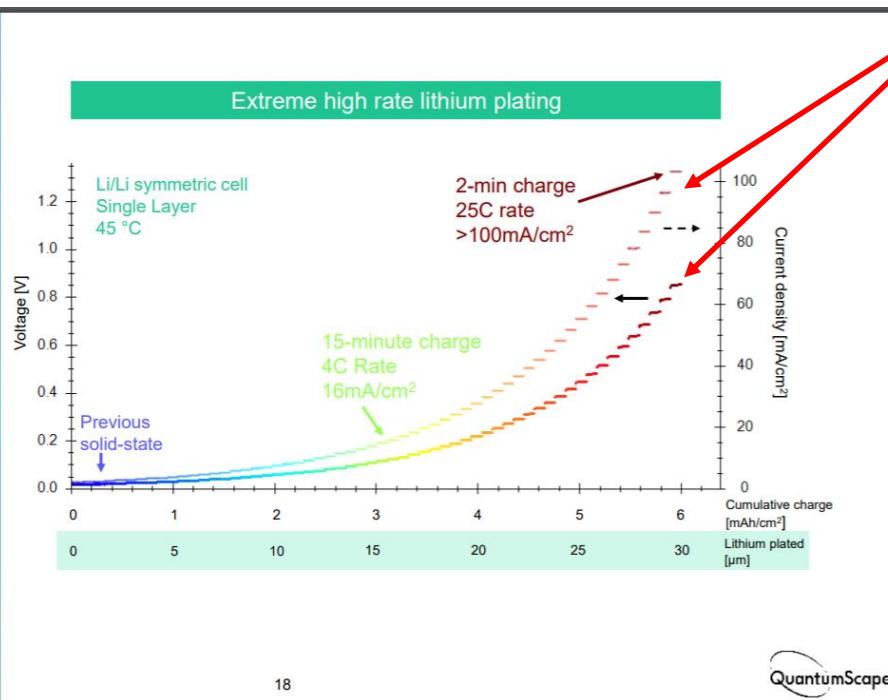
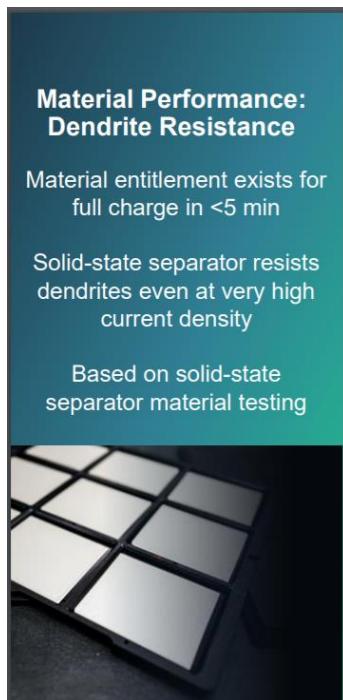
*That pulse step is so short that it's only taking a few minutes, and it's only depositing a fraction of a micron of lithium. You would have to hold that pulse for the full 15 minutes to prove that it didn't have a short, and you'd have to do that on the device again and again to find out when Volkswagen should void the warranty. **That's the real dendrite test.** The length of these pulses is still minutes; it's too short. The goal for charging a vehicle at the mall before you drive home would be the whole thing charged in 15 minutes. **To really judge, these pulses should be way, way longer, orders of magnitude longer. Maybe this impresses people by saying that you've killed the dendrite problem, but the real proof is doing the test hundreds and hundreds of thousands of times.** This is a tiny bit of current on cells for a little bit of time.” – Another former R&D employee*

3) Phony claim A: Solid-state material resists dendrites

Red flag 2 (cont'd): QS claims dendrite resistance “even at very high current density.” Ex-employee says longer gaps between pulses at higher current show otherwise.

QS states that the magical material for its “solid-state separator resists dendrites even at very high current density.” However, its chart shows otherwise, as indicated by a former employee. The right Y-axis shows current density – the higher the two staircase curves go, the higher the current density. However, as the curves go up and to the right, the gaps between each pulse become longer and more visible – that is, as the current rises, the separator has LESS ability to handle a continuous current and needs longer rests.

Dendrites data slide from QS December 8th “Battery Showcase”



Former employee explains that widening gaps toward top right of staircase curves show longer rest periods between pulses as current density rises

“The jagged steps are so close together in the blue region that you can't see the steps—it almost looks like a smooth curve, but then the steps become obvious at the end. Each step is getting longer, and each step is going up in current, which is on the far right y-axis.” – Former R&D employee

Note: Red arrows ours for emphasis

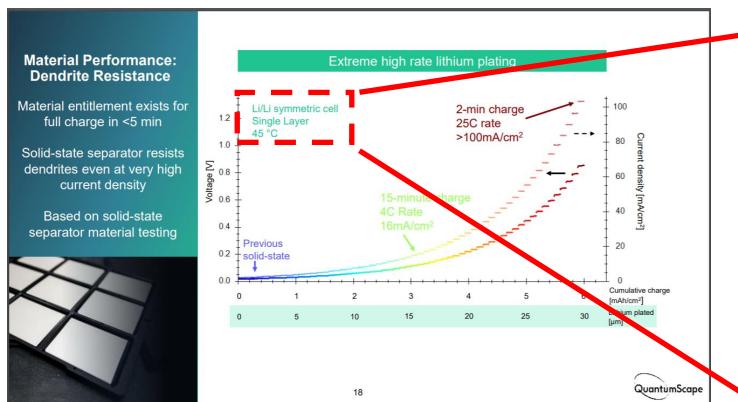
3) Phony claim A: Solid-state material resists dendrites

Red flag 3: QS cranked up the temperature during its dendrites test to a scorching 45 Celsius (113 Fahrenheit), unlike other tests that used 30C. Hint: it's also cheating.

The lab tests QuantumScape has shown for its single layer prototype have generally been at 30 Celsius, such as for its “Fast Charge” and “Battery Life” slides at its Dec 8th Battery Showcase. However, the dendrites test spiked the temperature 50% higher to 45C. Solid state battery experts and former employees called the cherry-picking of different test conditions as a red flag and a “trick” – asking “Why did the temperature go up? What happened at 30C?...Show me the 30-degree Celsius data.”

*“If this is a real dendrite-resistance achievement, it needs to be done at 30-degrees Celsius. **Why did the temperature go up? What happened at 30C?** That’s something we really want to know. That kind of trick for collaging data together from different cell setups is really a big no-no. That’s a red flag. Show me the 30-degree Celsius data.” – Leading solid-state battery expert and researcher*

Dendrites data slide from QS December 8th “Battery Showcase”



**Li/Li symmetric cell
Single Layer
45 °C**

Note: Red boxes and arrows ours for emphasis

3) Phony claim A: Solid-state material resists dendrites

Red flag 3 (cont'd): Lithium melts at a low temperature, and applying heat to melt dendrites is another ploy. Ex-employee jokes: does QS plan to put heaters under cars?

Quantumscape claims its solid-state separator is a magical material that nature created and which resists dendrites, but keeps resorting to heat as a gimmick, which anyone can do - first by using a pulse test which naturally heats the lithium (via the electrical resistance created) and thereby smooths out dendrites, and also by using an elevated temperature in the first place. An expert in ceramic separator materials as well as a former R&D employee both indicated that had QS kept the temperature at 30C like their other tests, they would not have been able to show this favorable result.

A former QS R&D employee states that hiking the temperature leads the battery to perform “more favorably” than at regular temperature, and wondered how QS expects actual batteries get to 45C “What they’re testing is a single-layer lithium anode battery at 45C, and that’s important because 45C is not room temperature. As you can guess, there are some benefits to going higher in the temperature. The battery performs more favorably. It also can discharge and recharge more favorably at 45C versus room temperature...what is going to get the battery to that temperature? Are they putting a heater or something in the car in order to provide that?” – Former R&D employee

A solid-state materials and chemistry expert with extensive experience in ceramic separators states that 45 Celsius is a significant percentage of the way to lithium’s melting point, which makes it hard for dendrites to form in the first place

“Lithium’s melting point is like 180°C, but if you’re a material scientist, you think of everything in terms of Kelvin and what fraction of the melting temperature you’re at in Kelvin. So, by that temperature, you’re a pretty high fraction of the melting point. If you’re at the melting point, you can’t make a dendrite. You also can use NMC as a cathode material, so you can’t really run at 180°C. If they chose 30°C, like the other slides, it would be harder to achieve this result.” – Solid-state expert

3) Phony claim A: Solid-state material resists dendrites

Red flag 3 (cont'd): Brazenly, despite resorting to an elevated temperature, the CEO recently claimed in an interview to have solved the dendrites problem - without having to raise the temperature.

Feb 2, 2020 article quotes Quantumscape CEO

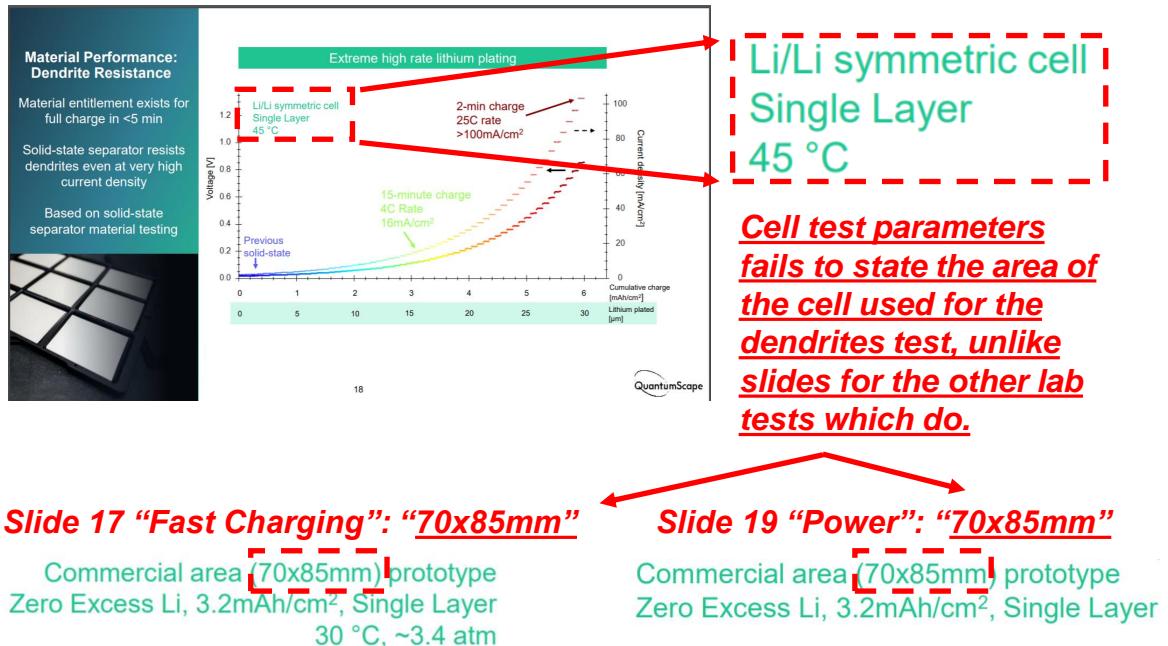
“What we’d be comfortable saying is we developed a theory of what causes dendrites, a theory that was different from the conventional wisdom, and we were able to empirically validate the theory well enough to allow us to build solid-state separators that work at record-high levels of current density without needing elevated temperatures while delivering >1,000 cycles,” he said. “These are of course, the parameters you need to hit to be useful in real cars, so that’s why this development is interesting and important.”

3) Phony claim A: Solid-state material resists dendrites

Red flag 4: QS hides the size of the lab sample used for the dendrites test. Solid-state/dendrites expert: “very strange format that’s not industry accepted” and “weird.”

Quantumscape discloses the dimensions of the lab-scale single-layer pouch cells used in the other tests shown in its data presentation. The slides for “Fast Charging,” “Power,” “Battery Life,” and “Cell Performance: Low Temp” indicate a 70x85mm cell, while “Material Performance: Low Temp” uses a 30x30mm cell. However, the dimensions for the separator sample used in the dendrites test are conspicuously omitted. A solid-state battery expert with extensive experience researching dendrites was incredulous at Quantumscape’s failure to show basic industry-standard information for its test.

Dendrites data slide from QS December 8th “Battery Showcase”



Solid-state expert with extensive experience in dendrites questions why the cell’s area/dimensions are not shown

“The other question I have is, they call it a single layer, but is it the same area single layer? Why aren’t they showing you what kind of a cell it was done in? Like what’s the area of this cell that they showed, and how does that compare to the area to their commercial area? The fact that they did it in this very strange format that’s not industry-accepted is weird.” – Solid-state battery expert with extensive experience researching dendrites

Note: Red boxes and arrows ours for emphasis

3) Phony claim A: Solid-state material resists dendrites

Red flag 4 (cont'd): Dendrite risk grows with surface area.

Experts suggest QS is playing games by using an irrelevant coin-size cell, unlike a real EV battery with 200,000 layers spanning multiple football fields of area.

Experts and former R&D employees indicate that anyone can prevent dendrites simply by using a small, commercially-irrelevant surface area for the solid-state separator. The entire challenge lies in preventing dendrites at scale, given the thousands of separator layers in an EV battery pack. QuantumScape's data is already questionable for using small single layer cells sized at 30x30mm and 70x85mm. Experts believe that the cell used for the dendrites test is EVEN smaller, or QS would have stated its size - making a mockery of the CEO's claim of having found a material that's resistant to dendrites.

Expert with extensive dendrites experience dismisses coin cells given "square miles" needed

"Another thing to keep in mind with this sort of data is you've got a very small area that you're doing this over. **This is the size of a coin cell probably** and so, you've got to ask if making a square centimeter that has high rate lithium plating capabilities is fantastic, if you need square miles." – Solid-state expert

Former R&D employee indicates QS is cherry-picking and that smaller lab samples make it easier to show "good" dendrites data

"30x30cm cells vs. 70x85mm have more rigidity and **the ability to not produce dendrites just because they're small**. The bigger one—my assumption is, there are clearly certain tests that they found more favorable on this smaller one and they decided to choose the better-looking data for the presentation. 30x30 has less surface area, less interaction, less chance of lithium plating—**there are a lot of different things in the science. It's better performing for certain ceramic reasons**. I would actually agree 100% [that they're cherry-picking different prototypes for different tests], and the reason why is scalability. There are some inherent benefits to having a smaller wafer." – Former R&D employee

Red flag 4 (cont'd): Former employee details QS struggles to get past the coin and pouch cell stage, as dendrite risk increases dramatically with cells bigger than a dime: “it just takes one dendrite to fail a cell”

A former R&D employee detailed the difficulties QS has experienced in taking research projects beyond the size of a coin cell, sharing an example where things looked great in a tiny cell – fast charging, battery life, and other parameters similar to those of the current technology – but failed in a slightly larger pouch cell format (which is still below a typical commercial dimension). The ex-employee indicated that dendrite risk in particular is highly sensitive to small increases in surface area – implying that it's meaningless to claim a dendrites breakthrough with a coin-cell sample.

Dendrites are the typical cause of failure in moving from coin cell to pouch cell size

“Some things died at the coin cell stage. I’m sure you’re familiar with this: as you increase the area, it increases the likelihood of failure. If you scale up to a pouch cell level, your barriers get exacerbated because there’s just more area that could be potential failures. And a lot of the failures for these types of batteries are dendrites. It just takes one dendrite to fail a cell. So, if you have more area, you have more probability of failure.” – Former R&D employee

Quantumscape research projects typically fail when cells are made larger than a coin or small pouch

“The patent is out there. It was a cathode project. It was compelling data because you got energy density, the ability to charge fast, and thousands of cycles before you got to 80% of capacity. It was the golden metric for the battery industry. But they didn’t move forward with that. We were able to make coin cells. The problem was when we switched from the sputtering small-scale sample to the scalable form, it was never able to mimic the performance. They made kilograms of the powder in scale, and they were able to build pouch cells. They went from half cells to a coin cell and to a pouch cell. The coin is like a dime and a pouch cell is bigger and square. The pouch cell is the stage at which most things died.” – Former R&D employee

3) Phony claim A: Solid-state material resists dendrites

Red flag 5: QS shows a one-time test on a cherry-picked sample. Dendrites develop after repeated charging, making any claim absurd without ageing/cycling data. Solid-state experts: a “gimmick,” “just a little R&D test”

Dendrites develop gradually as a cell is repeatedly subjected to current. Experts indicate that cycling a cell with current just one time for a brief period shows basically nothing. One expert indicated he would need to see the cell cycled at least 50 times to be convinced, versus just a one-time test.

Solid-state materials and chemistry expert dismisses a one-time test since “dendrites grow a little bit on every cycle”

“Anyone in this area knows this is just a little R&D test. Their conclusion that "material entitlement exists for full charge in less than 5 minutes." I don't know that I buy that. You've got a 25C rate there, and they're saying; we did this, and dendrites didn't form. **Yeah but, you only did that test that one time. And normally, what happens is dendrites grow a little bit on every cycle**, and you maybe even reverse them a little bit as you discharge, and then you grow a little more as you charge, but generally, it doesn't go all the way back. So, you do this a number of times, and then failure occurs.' – Solid-state materials expert #1

Another expert calls the QS one-time test a “gimmick” and says he'd want to see the cell charged at least 50 times to believe it had dendrite resistance

“One of the reasons why is because you have an aging effect. If they just said, we can do 100 mA/cm², and we're just going to 100mA /cm² 50 times and if they charged, even if they stripped lower, but let's say they charged at 100mA/cm², then they discharged at a low current **and then they did that again and again and again, that is one thing that would convince me, like, okay, this is real, and it's really impressive. The way they've shown it, it's kind of a gimmick.**“ - Solid-state materials expert #2

3) Phony claim A: Solid-state material resists dendrites

Red flag 5 (cont'd): Former employee slams QS dendrites test – “Is this a one-time thing?” – and states even 10 different samples would prove nothing, as a single car needs 200,000 layers and at most 1% can have a dendrite

A former R&D employee wondered how many cells QS had to test to find one with acceptable dendrites data. He indicated that showing one cell is irrelevant as a single car needs 200,000, and suggested that if the QS dendrites claim was true, they would have shown a large sample size of cells vs. a one-time test.

QS is cherry-picking a dendrites sample versus showing data that's actually convincing

“Is this a one-time thing, a ten-times thing, or an every time thing? That's unclear. So, you're not sure how many times they had to test until they could get that type of result to put out there. Who knows if the battery can really do that every single time. You would want to see a sample size - this comes back to the fact that you need 200,000 of these to power a car. If you have 1 or 2 or maybe 10 cells that are able to perform this great, that's great; then you should show that data. It shows that your science checks out. **If they wanted to make it convincing, they would show 100,000 of these cells that are put in one car**, as well as the success rate of all those batteries because in a car, you would really not want more than 1% of the single layers to have a dendrite. If you showed 10 single layer cells and 10 out of 10 are showing no dendrites, that's great...but 10 cells doesn't really power anything.” -
Former R&D employee

If the QS dendrites claim is true, they would have shown a sample size of hundreds of cells

The question is, do they have the full picture yet? I'm not 100% sure. **Because if they had the full picture and they knew exactly [what caused dendrites] then they would have hundreds of these [single layer cells] performing that way.** Every single one would perform that way. I guess the big thing is, we really have to keep perspective of how much they're showing. This is an important node to think about. Let's say you make 10,000 cells and 100 of them perform that way. - *Former R&D employee*

3) Phony claim A: Solid-state material resists dendrites

Red flag 6: QS dendrites test used a single-layer cell, which is meaningless as a typical cell may contain 100+ layers. Ex employees call single-layer merely “academic” and the lack of multi-layer data “super concerning.”

QuantumScape’s dendrites test is already cheating by using a small two-dimensional surface area – but the challenges grow exponentially when layers are stacked and it becomes a three-dimensional problem as well.

Ex-employee states that you can’t claim to have solved dendrites if the only data is single-layer
“If you want to say you have solved the dendrites problem, **you have to show you solved the problem in a real product, in a multiple-layer battery**. [The lab prototype] is just a single layer. A prototype that has two anode layers. That’s not enough. That’s academic. That still stays at a university. It’s not industry.” – Former R&D employee

Former R&D employee calls lack of multi-layer dendrites data “a real concern”

“Can they solve dendrites at scale? Can they solve it to be cost-effective? They still haven’t done anything in a multi-layer pouch, which I would say is **super-concerning** to me from a timeliness perspective. **Not having anything in a multi-layer cell is a real concern for me**... The separator has a job to do to stop dendrites but the separator also has to do other things: it has to conduct lithium, and it has to interface with the anode and with the cathode. It has to be manufacturable at scale. If you’ve tried to solve those problems all divorced from each other, that doesn’t mean that they all go back together—the solutions these come with all go back together. I would try to understand what do you have in a full cell? **What do you have in a multi-layer cell, and if not, why not? Why doesn’t it work?**” – Former R&D employee

3) Phony claim A: Solid-state material resists dendrites

Red flag 7: Ex-employees indicate 1% of the obstacle is testing a dendrite-resistant material, which others have done and isn't difficult, but 99% is manufacturing it at scale, where QS has shown nothing and where companies flop.

A former R&D employee stated that making a solid-state separator material that resists dendrites has “actually been before” and “is not that difficult.” He stated that the challenge for 50 years has been manufacturing the separator at scale, and that “multiple companies have gone bankrupt because of PPM-level [parts per million] failures.”

The real difficulty is not in coming up with a solid-state separator material but manufacturing a “thin uniform layer” of it at scale

“There are two parts to the problem. One is making the ceramic separator material itself. This is something that is not that difficult, actually. **And then you have to bond it and make it a thin uniform layer; that's the hard part.** That's where a process called sintering is used, which is high-temperature exposure of a preform of what you want and then the grains glue themselves to each other, kind of like soap bubbles coalescing. It's the same physics, surface tension...**Lithium metal has been looked at for 50 years, and dendrites have been the bane throughout. You can't solve the problem in the absence of an engineering protocol** that assures that all places in this actual cell and the quality is sufficient.” – Former R&D employee

Previous companies with a dendrites solution have gone bust when they started manufacturing

“There are two parts to the dendrites problem. One is the materials part. Some failure modes have to do with the mechanical properties of the material. The other set have to do with the quality of any of the components that have lithium metal in contact with the electrolyte, and **there are all sorts of issues in making sure you get every single one reliably at 100% in each cell all the time. Multiple companies have essentially gone bankrupt because of PPM-level failures** in the field of these cells and dendrites and consequential explosion.” – Former R&D employee

3) Phony claim A: Solid-state material resists dendrites

Red flag 7 (cont'd): Easy to demonstrate a tiny “non-commercially relevant” cell that resists dendrites. Former employees emphasize that the obstacle is “flawlessly” making “hundreds of square meters” per car; “Herculean”

Two former R&D employees stressed that the heart of the challenge is manufacturing vast quantities of an ultra-thin dendrite-resistant solid-state separator material per electric vehicle, and that the small single-layer pouch cell that Quantumscape has showcased is irrelevant from a manufacturability perspective.

The lab-scale prototype Quantumscape has shown is easy to make but commercially irrelevant
“They’ve done a single-layer pouch cell. It’s relatively straightforward to make sure the quality of that small piece in a particular configuration isn’t a problem in that **small, non-commercially relevant system.**” –
Former R&D employee

Solid-separator material has to “produced flawlessly” in vast quantities per electric vehicle
“Dendrites are a real problem...it has to be solved 100%. And therefore, **the ceramic separator needs to be produced flawlessly. They need to produce hundreds of square meters per vehicle of flawless 5-micron thick separator material. That’s a Herculean task.**” – *Former R&D employee*

3) Phony claim A: Solid-state material resists dendrites

Red flag 7 (cont'd): Yet another former employee highlights manufacturability as the monumental problem – even a single defect or “particle of dust” will lead to a dendrite and short the battery

Given the central importance of manufacturing as the key to preventing dendrites, we include detailed comments by a former R&D employee who discusses the challenges in working with a ceramic solid-state separator: making it ultra-thin, at extremely high temperatures, and then allowing it to harden and shrink, all without a single defect or debris over vast quantities of material required for a single car.

Manufacturing an ultra-thin solid-state separator tends to easily result in defects like an “irregular shape” or uneven shrinking, which then leads to dendrites

“Going from 30x30mm, Airpods size, to a bigger size; that's more surface area, more area for a dendrite or a pinhole. Pinholes are a big issue in ceramics. Any ceramics processing engineer talks about pinholes being one of the biggest issues that lead to dendrites. Imagine a piece of paper that's ridiculously thin, and you need to heat it up into a ceramic. Any ceramicist will tell you that you need to sinter and solidify that in an oven. You're taking it to a couple of thousand degrees so that ceramic can harden, stiffen, and typically shrink. **But when you're doing something that's so thin over that big of a form factor, it makes an irregular shape, or it shrinks too much in certain areas.**” – Former R&D employee

A single defect or particle of dust can create a dendrite and kill the battery

“If there's a defect or debris, you can create a pinhole. **Imagine if there's even a particle of dust that gets onto the surface.** Trying to get the chemistry right to put into a furnace at that high of a temperature, and have it perfectly come together in order to make something that's super uniform, super-flat - imagine if the sample isn't 100% flat and you put it into a battery. If it's not flat, it's not going to interact with the cathode and anode in different places, and the pressure points are where you can definitely see a crack or a pinhole forming. **Those pinholes will instantly short the battery.**” – Former R&D employee

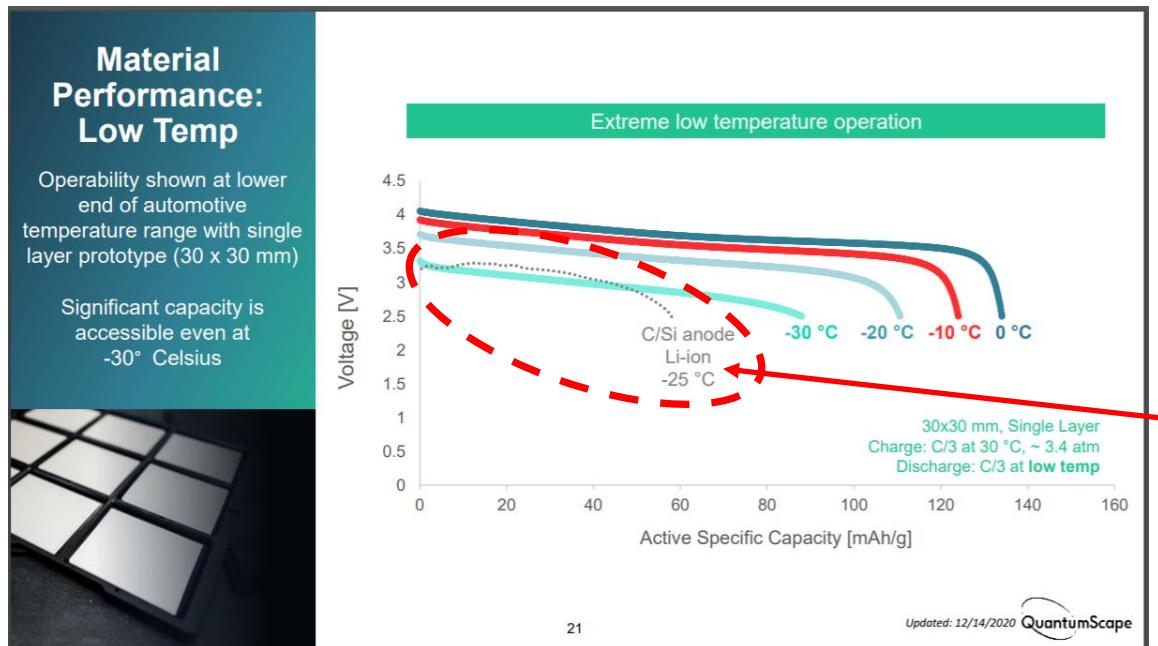
3. Phony claim B: Battery performance in low temperatures

3) Phony claim B: Battery performance in low temperatures

Operating at very low temperatures is mandatory for automaker acceptance, given cold climates where vast swaths of drivers live. QuantumScape claims its solid-state battery not only excels but exceeds typical Li-ion.

QuantumScape claims “extreme low temperature operation” and audaciously implies that its solid-state prototype performs better than conventional liquid Li-ion batteries in cold weather, stating that it retains significant capacity even at -30 °C, equivalent to -22 °F

Key data slides from QS December 8th “Battery Showcase” – slide #21



Key claims

“Extreme low temperature operation”

“Significant capacity is accessible even at -30 °C”

Chart suggests QS cell performs far better at low temperatures than conventional Li-ion

Note: Red circles and arrows ours for emphasis

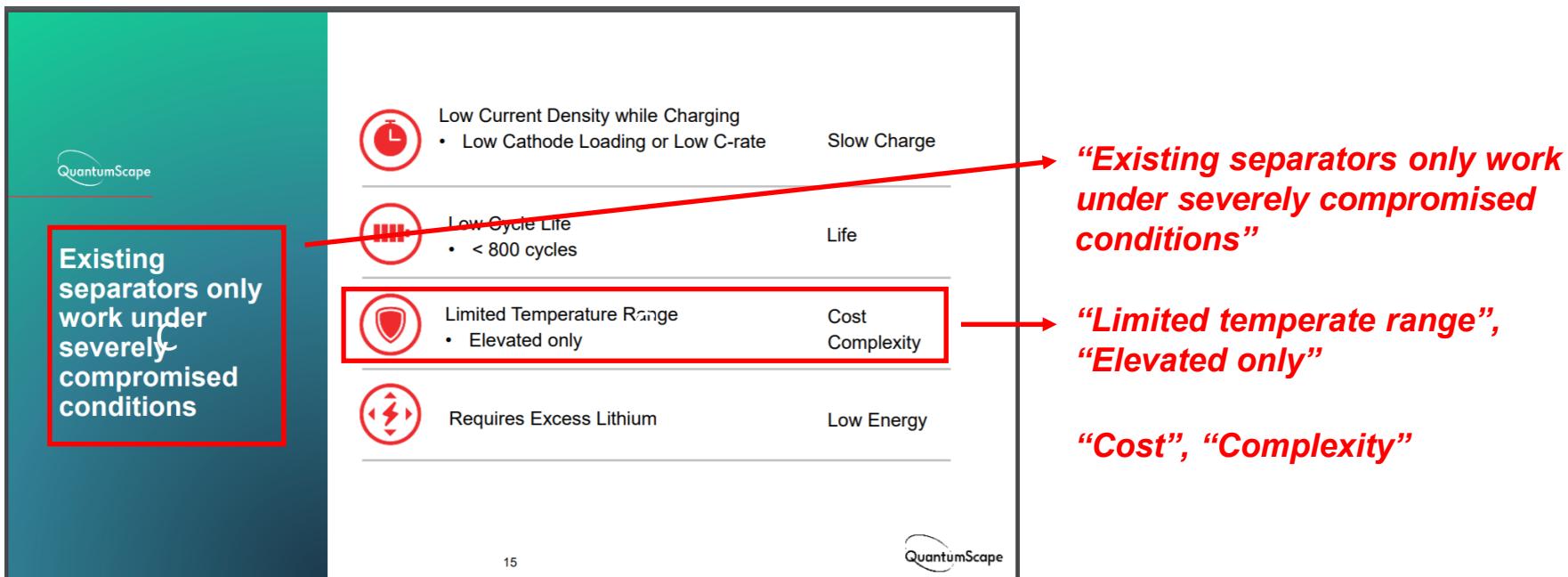
Source: https://s26.q4cdn.com/263384136/files/doc_presentation/2021/1/Data-Launch-Updated-Post-Presentation-20210107-2.pdf

3) Phony claim B: Battery performance in low temperatures

Cold climates are a long-standing obstacle to solid-state batteries, which have a solid lithium separator. Solids are dense unlike regular liquid Li-ion batteries, and hence need high heat before lithium ions flow back and forth.

QuantumScape's own slide points out the problem, indicating that current solid-state separators "only work under severely compromised conditions" – specifically stating they only work under elevated temperatures, which drives "cost" and "complexity."

Key data slides from QS December 8th "Battery Showcase" – slide #15



Note: Red boxes, circles, and arrows ours for emphasis

Source: https://s26.q4cdn.com/263384136/files/doc_presentation/2021/1/Data-Launch-Updated-Post-Presentation-20210107-2.pdf

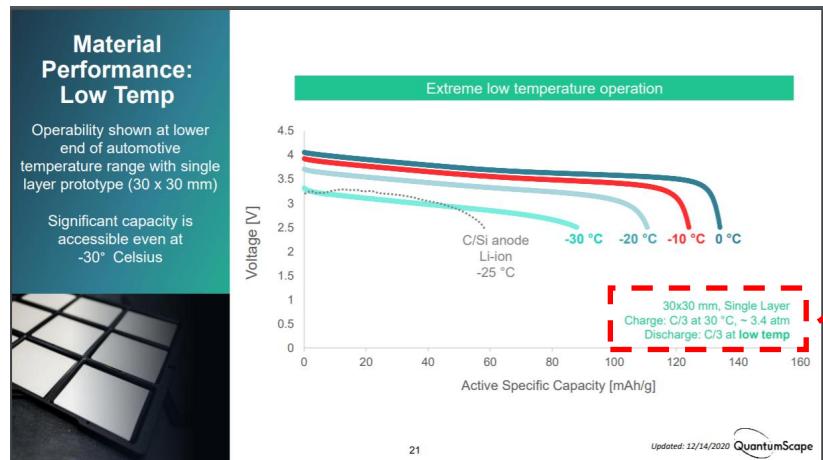
3) Phony claim B: Battery performance in low temperatures

Red flag 1: QS once again resorts to tricks and gimmicks, some buried in the fine print, which indicates that its 3x3cm prototype was actually charged at a sizzling 30 °C (86 °F) and only then discharged at a low temperature.

Obviously in the real world, cars in cold climates don't have the luxury of being charged in garages or parking lots where the temperature is kept at a sweltering 86 °F. It appears to us that QS concocted a rather unusual test in order to create a favorable slide headline. Lithium ions move in one direction (cathode to anode) while being charged and then in the opposite direction when discharged. QS seems to admit that it in cold temperatures, it can't move lithium through its solid state separator in both directions – the very definition of a working battery.

Key data slides from QS December 8th “Battery Showcase” – slide #21

Zooming into the fine print indicates the prototype was actually charged at 30 °C



Note: Red boxes and arrows ours for emphasis

Source: https://s26.q4cdn.com/263384136/files/doc_presentation/2021/1/Data-Launch-Updated-Post-Presentation-20210107-2.pdf

3) Phony claim B: Battery performance in low temperatures

Red flag 2: A former employee sharply contradicts QS data, stating that they couldn't even get the cells to work below 75 °C (167 °F): “A tall claim”; “I don’t believe that’s possible”; “definitely something that they could not have achieved”; QS slide data defies “common knowledge”

The former employee flatly rejected the company’s claim of low temperature performance.

“Actually, back when I was with the company, **they could not get the operating temperatures down to let's say, 75-degrees Celsius.**” – Former employee

“**The thing is, they could not have brought down the temperature** because a lithium metal anode and a ceramic separator, both of them work best when elevated [to high temperatures]...**That's definitely something that they could not have achieved**...This claim of the battery being happy at even negative temperatures, **that's a tall claim**, especially when they're starting to use solid-state electrolytes. **I don't believe that's possible**. I would definitely want some solid elucidation on that.” – Former employee

“I've been looking at the data. If you have their presentation that they gave out in front of you, I think it's slide number 21. They have this data out for carbon and silicon anode, that's for a conventional lithium-ion battery in the dotted line. And then they have different colors corresponding to 0°C, -10°C, and -20°C and -30°C as well. Purely from a materials perspective, because you have lithium metal, just a billet of lithium on the other side, which is going to be deposited - **the numbers that they show, it just defeats common knowledge.**” – Former employee

Source: Scorpion Capital consultation calls with experts

3) Phony claim B: Battery performance in low temperatures

Red flag 2 (cont'd): Former employee states QS “was never able to get” low temperature performance right and is stunned/skeptical “that this seems almost like a sudden discovery”; “until about a year back they couldn’t solve the problem and all of a sudden it’s just solved”; notes massive skepticism a recent battery conference

We found the ex-employee’s comments interesting and believe they speak for themselves.

Our question: “What are the main technical challenges/impediments that give you pause, that you’re skeptical that they’ve solved? What are the big things that you have to get right that you don’t think they’ve gotten right yet because it’s too hard of a problem?”

“Performance of the battery at low temperatures, especially sub-zero temperatures; that’s something that they were never able to get right back then. From all of the statements they’ve put out, from all of the publications that they’ve done...I mean, this seems almost like a sudden discovery. Until about a year back, they couldn’t solve the problem, and all of a sudden, it’s just solved and not just solved but stabilized and now scalable as well? That’s something that I would pause to look at and seriously evaluate from a materials perspective.” – Former employee

Former employee attended a recent battery conference where experts were skeptical of QS claim
“As far as the low-temperature performance is concerned, they [experts in attendance] didn’t agree on these numbers at all. There was a lot of skepticism about the low-temperature operation.” – Former employee

Red flag 2 (cont'd): Former employee says QS claim is as fanciful as making a “time machine”; contacts told him “low temperature operation is not something they were able to solve”; an explanation of the underlying science.

The former employee stated that low temperature performance is a “problem that plagues” solid electrolytes in particular, because they’re dense and inherently difficult to move lithium ions through, and therefore must first be “excited at high temperatures.”

Our Q&A with the expert

Q: “You’re saying as of a year ago, they hadn’t solved what problem?”

A: “***The problem that plagues lithium-ion batteries and more so solid-state batteries would be the battery’s performance at sub-zero temperatures. Let’s talk about temperatures below 32F. The people over there were never able to solve that because it was a materials problem.*** [Solving it] is sort of like saying I’ve made a time machine work. It just isn’t possible because when you introduce something called a solid-state electrolyte. It’s a solid. It’s going to have some sort of ionic conductivity – its responsibility is to let the ions pass through it. Because it’s a solid, it’s going to have extremely good electronic conductivity - it’s going to be a good conductor of heat and current, but just not materials like the lithium ions you’re expecting to flow through these solid-state electrolytes, which is only going to happen if all the molecules inside of it are excited at high temperatures. ***If you’re going to say it satisfactorily performs at low temperatures as well, that’s definitely reason for doubt because it’s just not possible from a materials perspective.***”

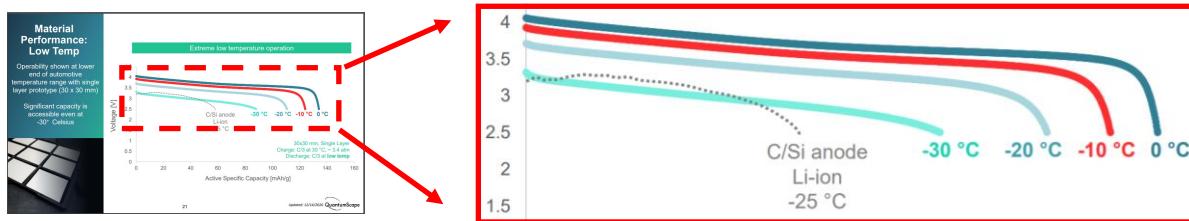
Q: “You said a year ago they hadn’t solved this problem based on people that you talked to?”

A: “I just contacted a couple of people...and ***they said the low-temperature operation is not something they were able to solve.***” – Former employee

3) Phony claim B: Battery performance in low temperatures

Red flag 3: QS further claims that its cell outperforms Li-ion at low temperatures. Former employee implies fraud: slide data “is just not true”; “just picked some data” for the deck; “not something I’m going to buy”

QuantumScape’s slide shows that its solid state battery does better in cold temperature than conventional liquid electrolyte-based Li-ion. A former employee analyzed the data in the chart and explained why it simply cannot be true.



Key data slide (#21) from QS December 8th “Battery Showcase” – referenced in comments below

Former employee explains why the data shown in the QS chart “is just not true”

A: “The number 140 that you see at 0°C - just a little bit of technicalities here - so 4,000 is a normal value. The active specific capacity should be ideally around like 3,500-4,000 because they are using lithium metal and at -30°C, you would have exactly 1%, if that, which is usable. This graph should be all the way where your carbon-silicon anode would be. The dotted lines and the -30 should sort of be coincidental, and the rest of them would be like marginal improvements over what you see. But again, you would expect the same trend for a conventional battery as well.”

Q: “You’re saying the data on this graph - the line should be different, like this is not the behavior you expect?”

A: “Look at all the color lines - shrink and move them such that the -30 coincides with the dotted line. That is exactly what the trend would be. **This shows that your conventional battery performance is inferior to your solid-state battery, which is just not true.**”

3) Phony claim B: Battery performance in low temperatures

Red flag 3 (cont'd): Ex-employee explains common-sense physics of solid vs. liquid electrolytes and why QS chart data is bogus in saying that their prototype performs better at low temperature than regular liquid-based Li-ion.

When a liquid is cooled, it still remains a liquid and its ability to move ions relatively easily doesn't degrade as much. However, a solid electrolyte can't move ions well unless it's heated. When that solid goes from hot to cold, its ability to move ions collapses.

Former employee explains why regular liquid-based Li-ion performs better "any day" for low temperature operation

A: "Slide 21 is definitely a little ambiguous, in my opinion - not even ambiguous; **I would say that they just picked some data that would represent something, and they put it in the deck. That's not something I'm going to buy.**"

Q: "You're saying this claim that conventional lithium-ion does worse in cold weather than solid-state, that just defies common sense?"

A: "Here's the deal. From a theoretical perspective, you have a liquid that actually performs pretty well at room temperature, and you have a solid which performs extremely well at high temperatures but only average room at temperatures. When you decrease the temperature on both of these formulations, the liquid is actually not going to lose much of its properties because, just from eighth-grade physics, your liquid is still going to be a lot more spread out in terms of your density of molecules and the solid is just not. As you keep loading your temperatures, it's just going to increase the density, and it's going to create a harder time for the molecules or the ions, in this case, to move through it. **So, I would say a conventional lithium-ion battery at -25°C and a solid-state battery at -25°C; I would pick the lithium-ion, the conventional battery, any day for a low-temperature performance.**" – Former employee

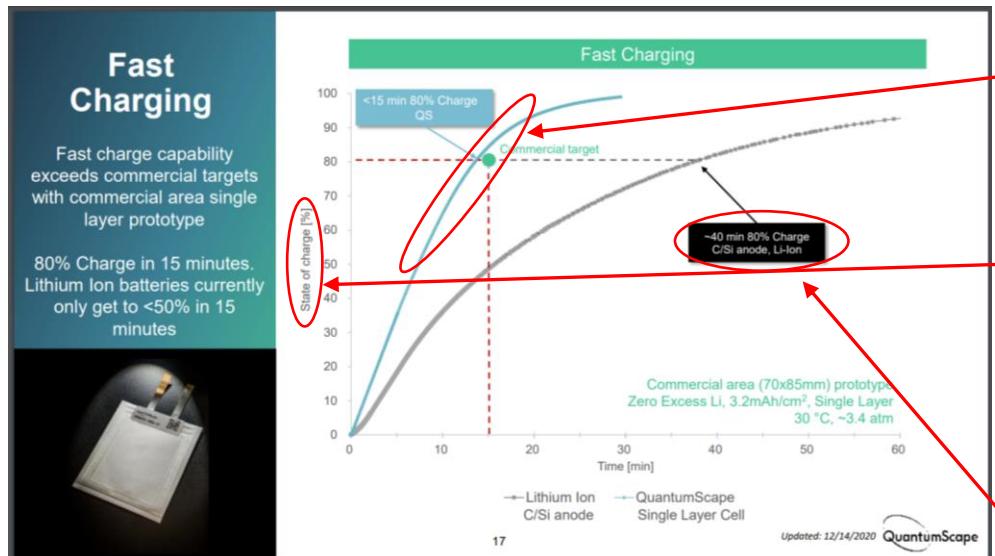
3. Phony claim C: Fast charging to 80% in under 15 minutes

3) Phony claim C: Fast charging to 80% in under 15 minutes

QS makes the dramatic claim that its prototype cell achieves 80% charge in under 15 minutes, versus current Li-ion batteries that take 40 minutes. Solid state battery experts and former employees call the data fake, misleading, or a “shell game,” and outline 4 red flags.

Leading solid state battery experts and former employees disputed QS' claims, listing 4 red flags which we detail in the next few pages.

Key data slide from QS December 8th “Battery Showcase” – slide #17



4 red flags we examine one by one in the next few pages

- 1) The curve showing QS fast charge appears to be made of fake data points - **“It’s not real”**
- 2) Graph is misleading, as the Y-axis is fails to state the total charge – **“a common trick”**
- 3) The slide fails to state that fast charging quickly destroys the cell, and hides how many times the QS cell can be charged at this rate – **a “shell game”**
- 4) QS misrepresents state of the art lithium ion charge times, to make their ‘data’ look better – **“sandbagging”**

Note: Red circles and arrows ours for emphasis

Source: Scorpion Capital consultation calls with experts; https://s26.q4cdn.com/263384136/files/doc_presentation/2021/1/Data-Launch-Updated-Post-Presentation-20210107-2.pdf

3) Phony claim C: Fast charging to 80% in under 15 minutes

Red flag 1: Curve showing QS fast charge appears to be made of fake data points. Leading expert: “It’s not real.”

We asked one of the world's leading solid-state battery researchers to scrutinize QuantumScape's fast charge data, and in the expert's opinion, the data points are fake.

"The gray line is something every lab can produce, and I would say it's the real data because you can clearly see the data points. The blue line, I think, is wishful. **It's not real. There's no variation in the data. I cannot see any data points. It's just a randomly drawn line. It's not actual data.** That's my interpretation for slide 17. If they were going to peer review like in science journals or publications, a reviewer like me would definitely ask for the original data set." – Leading solid-state expert

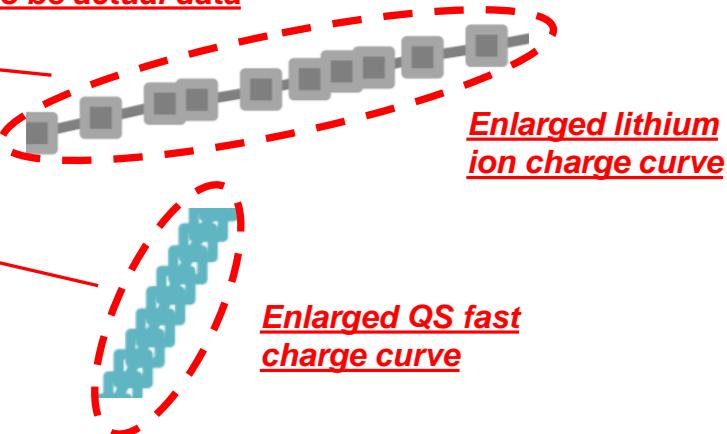
Slide #17 from Dec 8th "Battery Showcase"



Note: Red circles and arrows ours for emphasis

Source: Scorpion Capital consultation calls with experts;
https://s26.q4cdn.com/263384136/files/doc_presentation/2021/1/Data-Launch-Updated-PowerPoint-Presentation-20210107-2.pdf;

We enlarged the QS fast charge curve (blue) and the lithium ion one (gray) – blue QS data points are perfectly, evenly spaced which suggests they are fabricated, while gray data points appear to be actual data

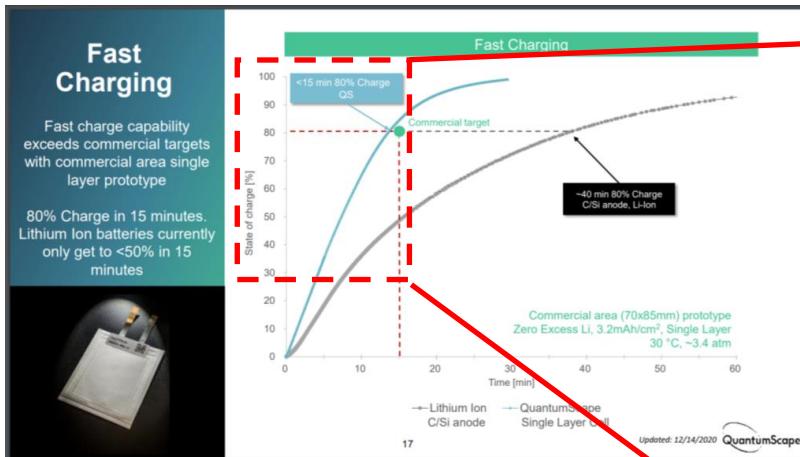


3) Phony claim C: Fast charging to 80% in under 15 minutes

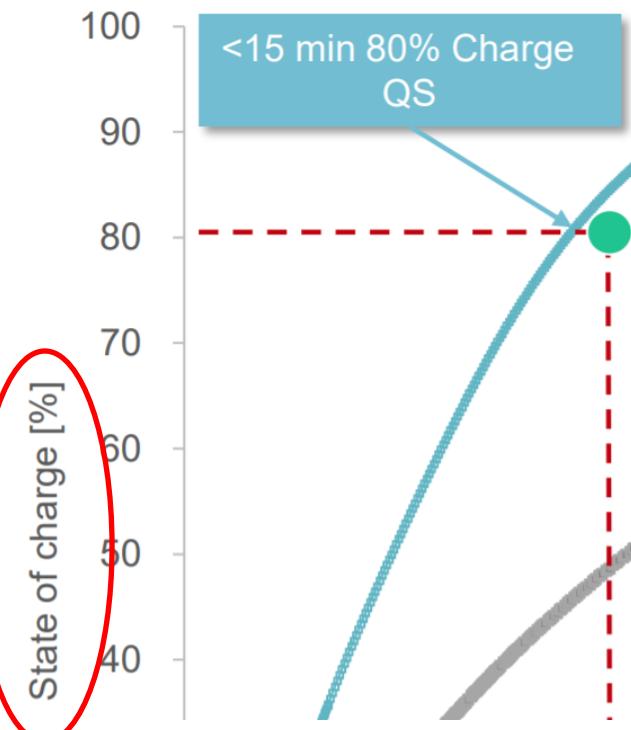
Red flag 2: Fast charge graph conceals the capacity the cell is charged to in 15 mins – because it's absurdly small, we believe less than 1/3 of a common hearing aid battery

Quantumscape boasts that its prototype can be charged to 80% in 15 minutes – but doesn't tell you to what capacity. Fast charge is meaningless if a battery lacks energy density. We find the lack of disclosure troubling, as reporting the actual capacity a battery is charged to is industry standard - even college students do this in lab.

Key data slide from QS December 8th "Battery Showcase" – slide #17



Zooming into the Y-axis shows "State of charge [%]" NOT actual capacity of the cell



Note: Red circles, arrows, and dotted rectangle are ours for emphasis

Source: Scorpion Capital consultation calls with experts; https://s26.q4cdn.com/263384136/files/doc_presentation/2021/1/Data-Launch-Updated-Post-Presentation-20210107-2.pdf

3) Phony claim C: Fast charging to 80% in under 15 minutes

Red flag 2 (cont'd): Battery experts call QS fast charge chart “a common trick” – fast charge is meaningless if the battery has virtually no energy

A leading solid state battery researcher estimates that the single-layer pouch cell QS shows is less than 200 milliwatt-hours (mwh) – which is at the level of a hearing aid and a only a small fraction of a standard AA-battery sized rechargeable lithium ion cell (“18650”).

Leading solid state battery researcher explains the “common trick” that the QS chart is using

“Notice the Y-axis is state of charge. It's a percentage, a ratio. Let me give you an example. A lithium-ion 18650 cell is 3.5 amp hour, with a nominal voltage of 3.6V. At 100% state of charge, these cells are rated at more than 10-watt hours. For the QuantumScape single-layer pouch cell, I bet that capacity is less than 200 milliwatt hour, which is at least 10 times less than the 18650 lithium-ion cell. **The QuantumScape data is particularly impractical** because their denominator is much, much smaller. They didn't really say what it is. The data they have is in terms of a state of charge percentage. **I would ask them to plot two different graphs - what's the actual capacity you've charged within 15 minutes? What's the absolute number in terms of watt-hours?**”

Our Q&A with the researcher explains that it's meaningless to compare 80% charge time on a tiny, lab-scale sample cell with a commercial lithium ion cell with high energy density

Q: “You're saying they're getting to 80% charge, but the total amount of charge is meaninglessly small?”

A: “That would be my guess. **It's a common trick, unfortunately.** When you compare lab-scale data to larger-scale like 18650 cells, it's not fair because 18650 cells deliver more than 10-watt hours now.”

Q: “You're saying the QuantumScape cell is probably less than 10% of the capacity of a Li-ion 18650 cell?”

A: “Yes, I am almost certain that's what happened”

3) Phony claim C: Fast charging to 80% in under 15 minutes

Red flag 2 (cont'd): Fast charge appears to be to less than 1/20th of an iPhone battery, yet QS cells will soon have the energy density to power...cars?

We are surprised that after a decade of R&D and hundreds of millions of dollars spent, that QuantumScape is showing fast charge data for a single-layer lab-scale prototype that appears to have a fraction of the capacity of a hearing aid.

200 mAh

*per battery expert estimate

QuantumScape single-layer pouch cell (7 x 8.5 cm)



650 mAh

Duracell hearing aid battery



3,400 mAh

AA-size lithium ion 18650 cell



3,687 mAh

iPhone 12 Max Pro battery



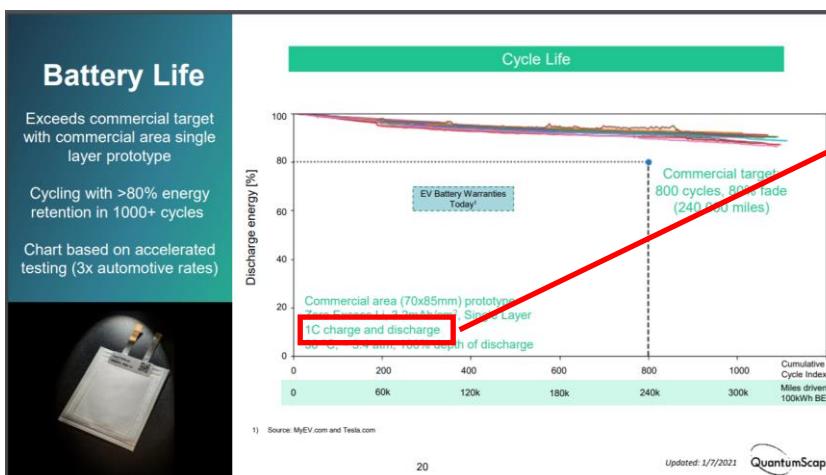
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3) Phony claim C: Fast charging to 80% in under 15 minutes

Red flag 3: Fast charging quickly destroys a battery cell – no wonder QS hides how many fast charge cycles its lab-scale prototype can handle. What's the battery life?

We find it telling that QS fails to state how many times its prototype pouch cell can be charged at a 15-minute rate. On a different slide unrelated to fast charging, QS claims its prototype has a battery life of 800 cycles. However, that slide DOES NOT use a fast charge rate. Instead, it uses a “1C charge and discharge” rate – which in battery-speak means a 1 hour charge/discharge. QuantumScape’s failure to state battery life using a 15 minute rate is a massive red flag.

Key data slide from QS December 8th “Battery Showcase” – slide #20



Source: https://s26.q4cdn.com/263384136/files/doc_presentation/2021/1/Data-Launch-Updated-Post-Presentation-20210107-2.pdf

Zooming into the fine print indicates “1C charge and discharge” – which is a technical term for a 1 hour rate, NOT 15 minutes, which is known as 4C

Battery University – What is C-rate?

C-rate	Time
5C	12 min
2C	30 min
1C	1h

Source: https://batteryuniversity.com/learn/article/what_is_the_c_rate

3) Phony claim C: Fast charging to 80% in under 15 minutes

Red flag 3 (cont'd): A former employee indicates the CEO is playing games by failing to disclose that fast charging quickly damages the QS battery – it's life “not so good.”

Former employees we interviewed called out the company’s “fast charging” claim as disingenuous, as it quickly damages the battery cell.

Former employee indicates that failing to disclose damage from fast charging is an example of the CEO playing games and misleading investors

Q: “When you say the CEO plays it close to the line, is there anything that you’re able to elaborate on there? Such as public statements that are artfully worded but are not actually representative of reality.”

A: “Yeah, I can give you one. In the last public presentation, they talked about fast-charge capabilities, but what they didn’t show is the sequential effect of all the fast-charges. Although the single-layer pouch cell is capable of fast charge, **there is too much damage caused during that fast charge to do it every single time, and they didn’t mention that.**” – Former employee

The former employee explained why the QS cell’s cycle life is “not so good”

“The cycle life is not specified and my understanding is it’s not so good. When you do fast charging, you damage the cell, and so its life is less. The damage mechanism is loss of lithium in the battery. It essentially plates out as an inert byproduct if the charge rate is too fast. And there are two effects: it decreases the amount of lithium available to move electrons, so your energy density goes down, and it creates a barrier film on the anode, and that is an impedance issue, so the cell has less power.” – Former employee

Red flag 3 (cont'd): A second former employee indicates it's "general knowledge" that fast charging degrades the QS battery. Solid state expert also calls QS claim bunk.

Another former employee explained the game that QS is playing – declining to show battery life at a fast charge rate, and misleading investors by showing them battery life at a SLOW charge rate instead. A solid state battery expert with extensive experience in the ceramic separator that QS appears to be using questioned whether its lab-scale prototype can be fast-charged more than a couple of times before failing.

Another former employee indicates it's "general knowledge" that charging fast quickly degrades the battery, and points out the company's failure to disclose proper data

"If you're charging and discharging fast, the general knowledge is that **you're going to degrade faster**. The fact that **there's no charge rate versus the cycling data at that particular charge rate** - so they can say this is how fast it charges, and then they're showing cycling data from a cell that's at a slower charge rate. You have to connect those two. It's easy to stick those in separate slides." – Former employee

A solid state expert wondered whether the prototype could be fast charged more than a few times before failing

"On slide 17, you get that fast-charging graph there, and they're showing less than a 15-minute charge, and that's good, but what's not clear at all in this is you can do that one time. The thing is, you can probably just go in the lab and put together current, any old lithium-ion configuration and force it to charge that fast, and it would not fail immediately. It's like, yeah; you can do this once, can you do it every time you charge a vehicle during its 200,000 life? I don't know the answer based on this data. If they had it, it would be here.... How many times can you do that before something bad happens? If it's thousands of times, fantastic. But **is it really just like a couple of times?**" – Solid-state expert

Red flag 4: QS misrepresents standard lithium-ion charge times to make theirs look faster. Two former employees call it a “shell game” and “inaccurate,” as newer Li-ion batteries can be charged in 5 to 15 minutes.

QS claims that conventional lithium ion batteries “currently only get to <50% charge in 15 minutes” and take “~40 minutes [for] 80% charge.” Two former employees explained that QS is using a misleading comparison.

Former employee calls QS claim a “shell game” because next generation lithium ion batteries have already shown 5 to 15 minute charge times

“Here’s the shell game on this one. **The shell game is that they’re comparing their battery to what is available in the marketplace today. But that’s an irrelevant comparison.** It turns out that a silicon anode has an inherently high charge rate, and so, the silicon anode can do to 5 to 10-minute charge, and a number of companies have demonstrated that. So, they made it look good by comparing it to the current but not the next-gen. The next gen are companies like Sila Nanotechnologies. They’re using a silicon anode but there are many others, but they’re the biggest. Their charge times will be five to 15 minutes. I don’t think Sila has achieved five minutes, maybe 15 minutes for them, but there are **other players that have achieved five minutes.**” – Former employee

Another former employee says QS claim is inaccurate and “sandbagging” and that conventional Li-ion battery charge times keep getting faster, making the competitive bar even more difficult for QS

“50% in 15 minutes isn’t really accurate. The last battery system I worked on was 80% in 25 minutes while their graphic is showing 40 minutes to get to 80%. So they’re sandbagging a little bit on the state of the art. **Certainly, they’re not better than the conventional technologies in the timeframe that QuantumScape wants to have something.** QuantumScape doesn’t have to beat 2021 with lithium-ion batteries. They have to beat 2030 with lithium-ion batteries because that’s when they’re going to come out. We’ve got a number of years of progress ahead of us that they’re going to have to keep up with.” – A second former employee

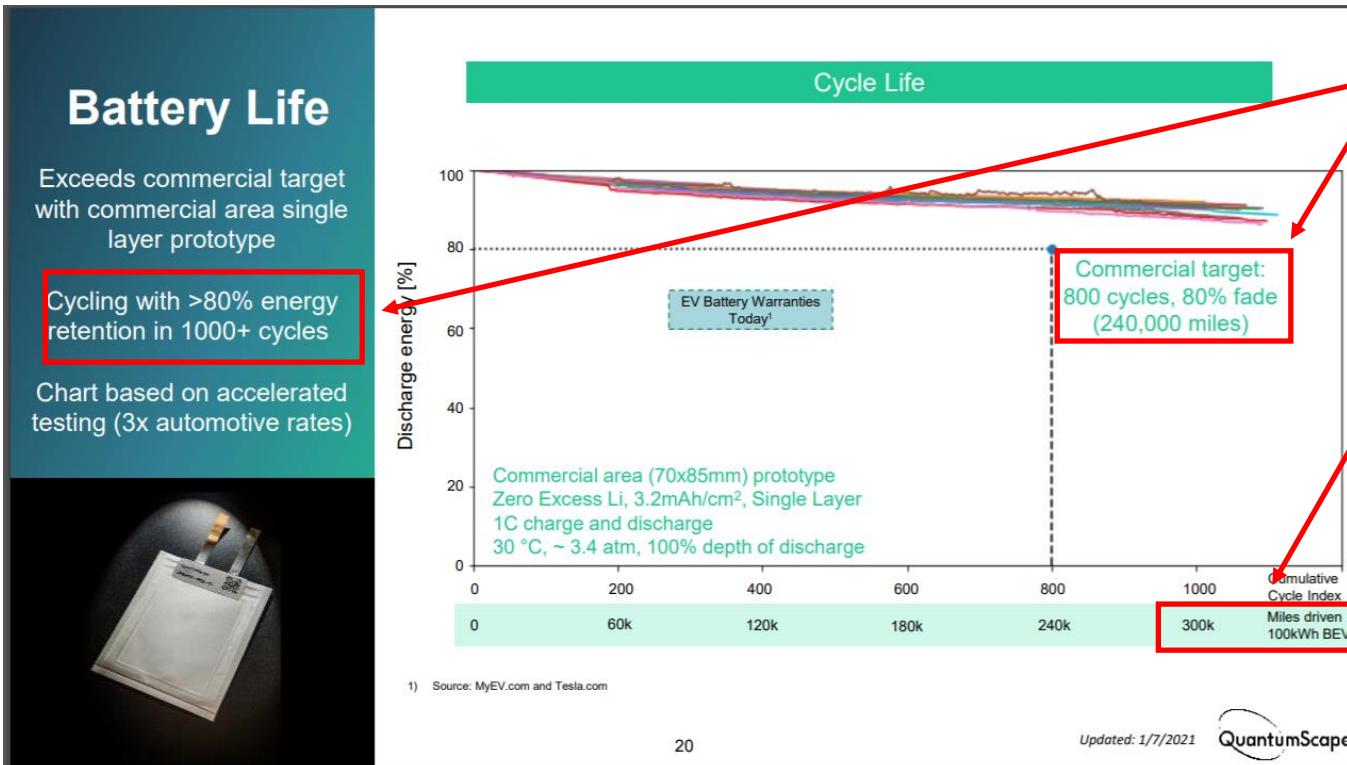
3. Phony claim D: Long battery life to 1,000+ charge cycles

3) Phony claim D: Long battery life to 1,000+ charge cycles

QuantumScape claims their battery can be charged 1,000 times, equal to 300k miles, with >80% energy retention – once again based on a small, single-layer lab prototype

One of the five key criteria QuantumScape lays out for an EV battery to be commercially relevant is battery life. They note that the commercial requirement is 800 charge cycles while maintaining at least 80% of the battery's energy retention ability.

Key data slide from QS December 8th “Battery Showcase” – slide #20



Key QS claims

Battery can be cycled 1000+ times, and still exhibit 80% energy retention

Equivalent to 300,000 miles driven

Note: Red boxes, circles, and arrows ours for emphasis

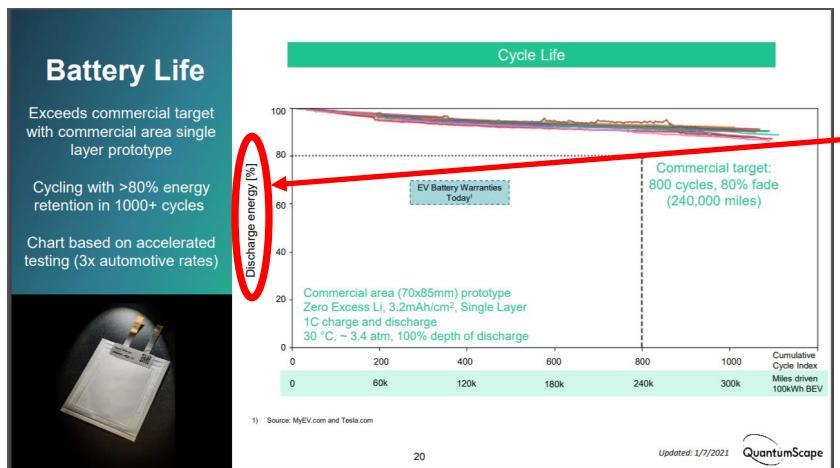
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3) Phony claim D: Long battery life to 1,000+ charge cycles

Red flag: QS once again hides the actual capacity the battery is charged to in its simulation. Experts indicate it's a common form of cheating when making battery claims, as at low energy loadings a cell can last forever.

Cycle life is one of the most important items reported for any battery. The more often a battery is charged and discharged, the shorter its lifespan, as each battery has a certain number of charge/discharge cycles in its useful life. “Depth of discharge” (DoD) is the percentage of a battery’s energy that has been used up before recharging, e.g., 80% DoD on a 10kWh battery is 8kWh. Here’s the rub: a battery may last 1,000 cycles at a low 10% DoD, but only 200 cycles at 80% DoD. Hence, battery performance data is meaningless unless BOTH 1) the total, actual level of charge is reported vs. just a percentage, as well as 2) the Depth of Discharge used for the cycle life test. We see neither in the QS data.

Key data slide from QS December 8th “Battery Showcase” – slide #20



- 1) **Graph DOES NOT show the actual capacity the cell is charged/discharged to over 1,000 cycles, which is industry standard for how cycle life is reported**
- 2) **Instead, the Y-axis says “Discharge energy [%]” – using a percentage instead of the ACTUAL numerical battery capacity and how it degrades over cycle life.**
- 3) **“Discharge energy [%]” is meaningless without knowing the numerator and denominator. Is this the same as the industry-standard term “Depth of Discharge,” and if so, how does QS define it?**

Note: Red boxes, circles, and arrows ours for emphasis

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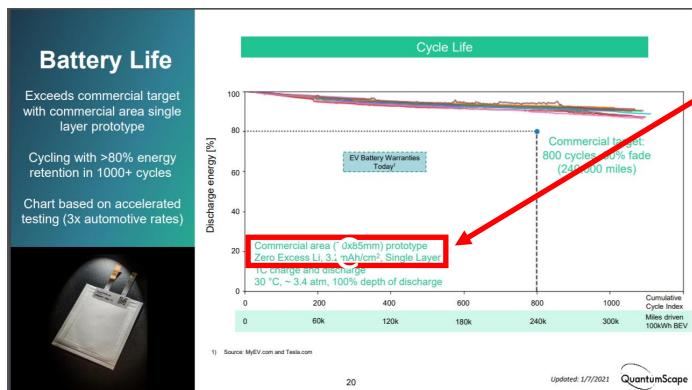
3) Phony claim D: Long battery life to 1,000+ charge cycles

Solid-state battery experts indicate the QS cell is <200mAh – or 1/3 the capacity of a common hearing aid. Showing 1,000 cycles at a tiny energy level is easy but a gimmick given massive energy requirements of real EV batteries

A solid-state expert used the fine print in QuantumScape's slides to calculate that the actual capacity of its prototype is about 200mAh – or about 1/3 the capacity of a typical hearing aid battery. In other words, QuantumScape claims to exceed the “commercial target” for cycle life for an electric vehicle battery – but by cycling a battery with a microscopic capacity.

“The y-axis is discharged energy percentage because you know they have only one layer, so it's 70x85-millimeter, so it's about 56 or 60 centimeters square. So, for the entire pouch cell, the total energy is about 200 milliamp-hour.” - Leading solid-state battery researcher

Key data slide from QS December 8th “Battery Showcase” – slide #20



Solid-state expert uses the fine print on QS slide to calculate the actual capacity of the prototype cell used for the battery life test

- 1) Area of prototype cell is 70x85mm, or 7x8.5cm, which is 59.5 square cm
- 2) Capacity of the cell is stated as 3.2mAh/cm squared
- 3) Therefore, actual capacity = surface area of 59.5 cm² x capacity of 3.2mAh/cm² = 190.4 mAh

Note: Red boxes and arrows ours for emphasis

Source: https://s26.q4cdn.com/263384136/files/doc_presentation/2021/1/Data-Launch-Updated-Post-Presentation-20210107-2.pdf

3) Phony claim D: Long battery life to 1,000+ charge cycles

Comments by solid state experts slam the QS cycle life claim: “definite red flag”; not an industry-standard battery test; Dept of Energy doesn’t even allow use of such ambiguous data by battery researchers

“Definite red flag” and not industry-standard to only state discharge energy percentage and not disclose the actual capacity

“They only stated discharge energy percentage. They didn’t tell you the absolute number. That’s a definite red flag. Each of their single pouch cells is 200 milliamp-hours, and at 80% depth of discharge, you’re utilizing 160 milliamp-hours. So after 1000 cycles,, how much capacity is left? This is the standard for lithium-ion battery tests. If we were reporting the data, we would put 200-milliamp-hour, which is a nominal capacity, on the Y axis. I’d show the cycle life as an absolute capacity number, like how much is it at the end of 800 cycles - we started with 200 milliamp-hour nominal capacity, so how much is it at the end?” – Solid state expert

Expert indicates that the Department of Energy doesn’t even allow cycle life data this nebulous

“If we made a 200 milliamp-hour cell, we must show the Department of Energy how much energy is left in absolute numbers after 1,000 cycles, when cycling 80% of the total energy. We’re not allowed to use percentages.” – Solid state expert

QS fails to define depth of discharge – a key parameter for cycle life tests

“You really need to understand what it means to have 100% depth of discharge. Does that mean you’re utilizing all 200 milliamp-hours of the cell, so the cell in total is capable of delivering 200 milliamp-hours? We have to make sure we understand how they define 100% depth of discharge. Normally when that is properly defined, the y-axis shows the absolute numbers - the capacity we are cycling to. I think it’s fair to say that QuantumScape should have followed this practice because when you show a percentage, the denominator must be clearly, unambiguously defined.” – Solid state expert

3) Phony claim D: Long battery life to 1,000+ charge cycles

Solid state experts (cont'd): “One of the ways to cheat” is “very low loadings”; Apple bought a solid-state startup with similar cycle life claim based on a tiny cell – flopped at more realistic load; lightly cycled cells can run forever

Infinite Power Solutions Demonstrates
75,000 Full Battery Cycles

May 13, 2012 by Jeff Shepard

Source: <https://eepower.com/news/infinite-power-solutions-demonstrates-75000-full-battery-cycles/#>

Fake cycle life claims are a dime a dozen among solid-state startups. Infinite Power – a failed Apple acquisition - claimed a preposterous 75,000 cycle life, also based on a tiny, low energy density prototype like QS

Cheating to use low loading for cycle life tests; doesn't translate to actual EV batteries

“One of the ways to cheat in batteries is to have very low loadings. So, you could have really good data, but it's not showing the same energy density or really like the same amount of charge passed that you would want to see in an electric vehicle cell.” – Solid state expert

“No problem” to show long cycle life at tiny capacities; data QS shows is meaningless

“Apple bought a solid-state battery company, Infinite Power, that showed excellent cycle life for solid-state batteries with a lithium metal anode. I think the areal capacity was something like 100 microamp/hour. They could cycle it for a long, long time. **If you're only moving a very small amount of lithium, you can cycle. That's no problem. That's one of the reasons why I emphasize the absolute numbers matter. I don't want to see percentages.** Just show the absolute numbers in terms of capacity.” – Solid state expert

If you're only cycling a battery to 10% of its capacity, it “can last forever”

“The nominal capacity [of the QS prototype] is 200 milliamp-hour, and **if you're only 20 cycling milliamp-hour, you're only cycling 10% and this battery can last forever.”** - Solid state expert

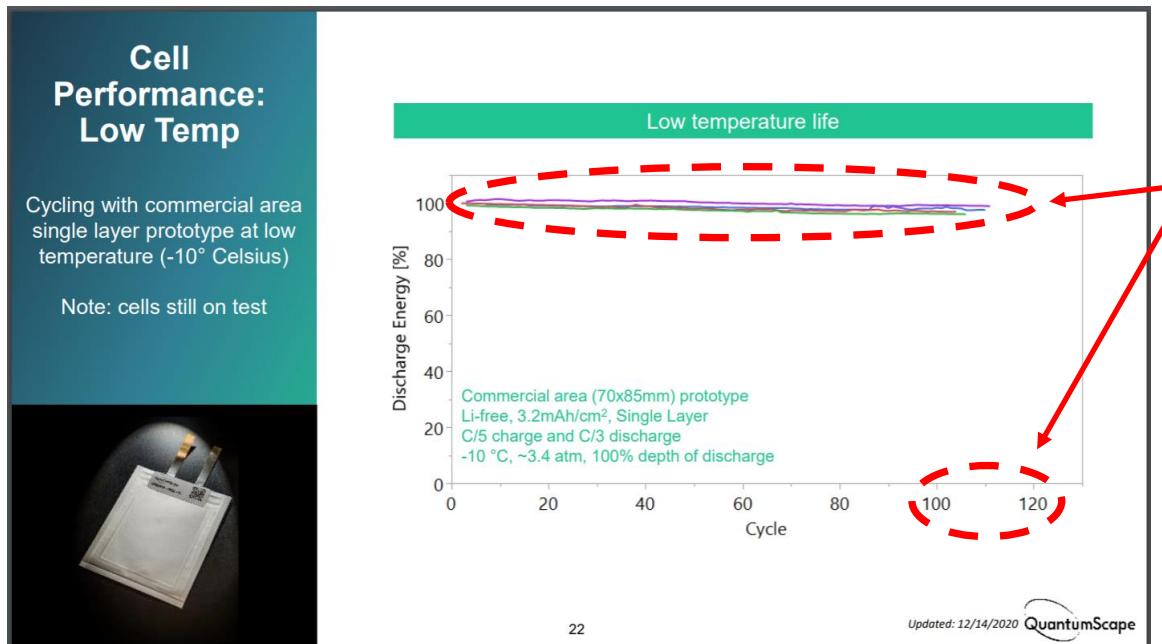
3. Phony claim E: Battery life in low temperatures

3) Phony claim E: Battery life in low temperatures

In addition to claiming that its battery performs better than Li-ion at low temperatures, QS implies it has long cycle life in cold conditions. Meeting both automaker criteria are essential for commercial viability.

Audaciously, Quantumscape not only claims “extreme low temperature operation” but its chart implies that its solid-state prototype performs better than conventional liquid Li-ion batteries in cold weather.

Key data slides from QS December 8th “Battery Showcase” – slide #22



Key claims

Chart appears to show cycle life to 110 charges and discharges at -10 C

Note: Red boxes, circles, and arrows ours for emphasis

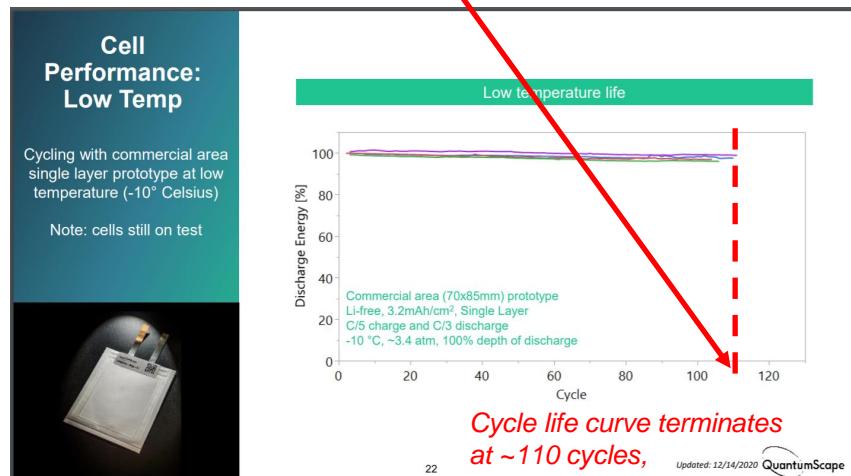
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3) Phony claim E: Battery life in low temperatures

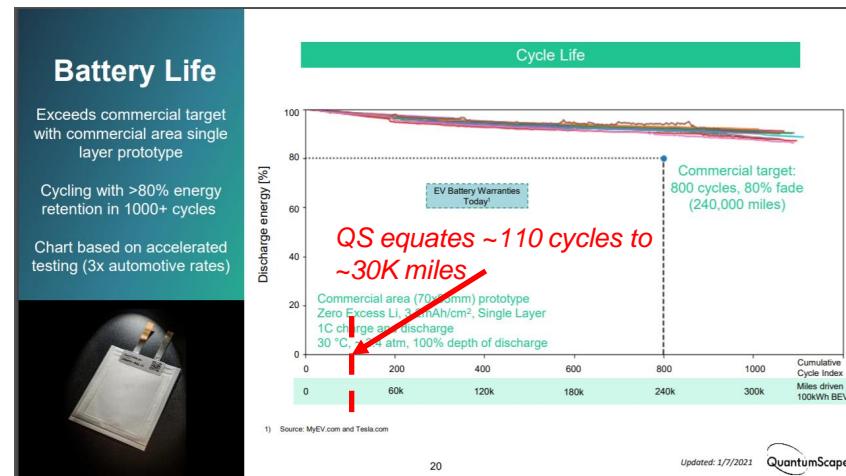
Red flag 1: The slide's fine print shows a battery life of only ~110 cycles, or a measly ~30K cumulative miles, contradicting its earlier claim of 1,000+ cycles and 300K miles. QS admits its cell flops on a key OEM requirement.

Tellingly, unlike other slides, the chart fails to include descriptive text for low temperature cycle life - such as “long”, “good”, or “acceptable.” Nowhere does the chart even clearly state how many cycles the battery lasts – which we find remarkable given that just a few slides earlier, the battery life chart for “normal temperatures” – conducted at a rather hot 30C (86F) – proclaims “1000+ cycles.” One has to look at the fine print in the X-axis to see that the data is actually abysmal. QS seems to hope that a large, misleading graph is enough to hoodwink investors. We struggle to see how their technology is viable if it barely has any life at temperatures common in New York, Chicago, and most of Europe.

Prose on slide fails to state actual number of cycles – but fine print in X-axis shows a short lifespan of ~110 charge/discharge cycles



A few slides earlier, QS claimed its battery can be cycled 1000+ times and still exhibit 80% energy retention



Note: Red arrows, lines, and text ours for emphasis

Source: https://s26.q4cdn.com/263384136/files/doc_presentation/2021/1/Data-Launch-Updated-Post-Presentation-20210107-2.pdf

3) Phony claim E: Battery life in low temperatures

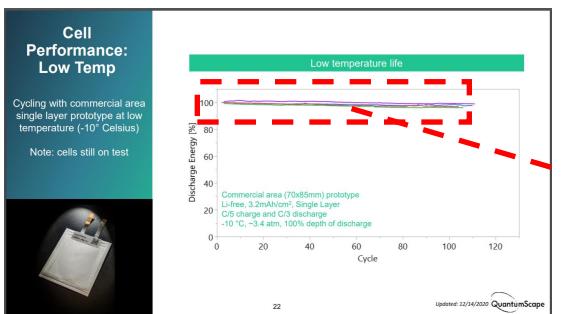
Red flag 2: The battery life chart appears to be fabricated, as it shows a cell being discharged at over 100% of its energy, which common sense indicates is impossible. The number of similar tricks and red flags makes us doubt it's an error.

We double-checked with a solid-state researcher, who confirmed that either what the graph shows is impossible – or it's using another trick with a misleading Y-axis, which is labeled with a made-up, undefined, and non-industry standard term in battery research.

Q: “Is there ever a situation where a cell can exhibit more than 100% of its discharge energy, or is that impossible by definition, in a typical cycle life test (such 80% DoD)?”

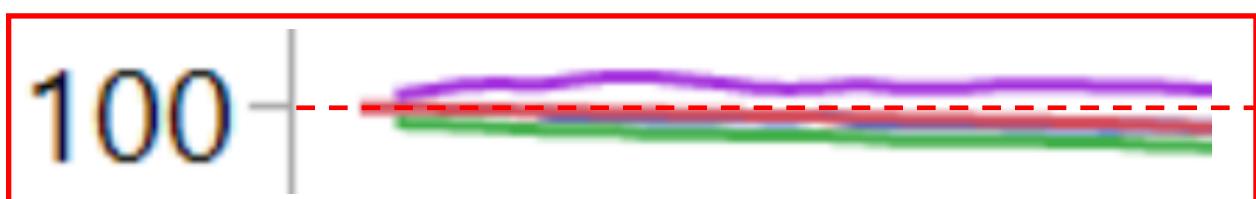
A: **“Yes. Of course.** This all depends on what one defines as the 100% depth of discharge (DoD). Imagine that the cell is capable of doing 122mAh, but one only define 61mAh as 100% depth of discharge (utilization rate 50%) - **such tricks are entirely possible.”** – Solid-state expert

Slide #22 from Dec 8th “Battery Showcase”



Note: Red boxes, arrows, dashed lines ours for emphasis

Y-axis is “Discharge Energy [%]” from 0 to 100% - purple line below shows a cell cycled at more than 100% of its energy. We overlaid a dashed line at the tick mark for 100% to make it clear.



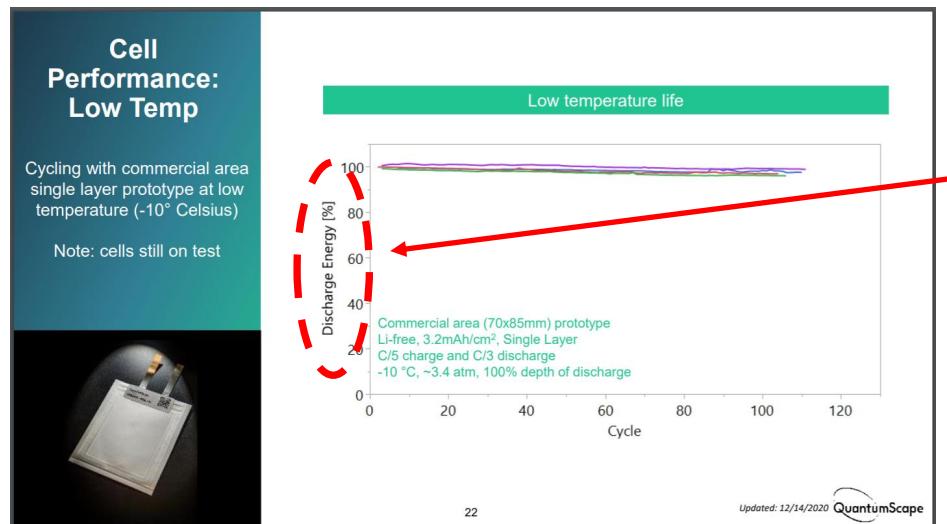
Source: Scorpion Capital consultation calls with experts; https://s26.q4cdn.com/263384136/files/doc_presentation/2021/1/Data-Launch-Updated-Post-Presentation-20210107-2.pdf;

3) Phony claim E: Battery life in low temperatures

Red flag 3: QS once again hides the actual capacity the cell is charged to. Experts quoted earlier indicate it's a common form of cheating when making battery claims, as at low energy loadings a cell can last forever. That is, at real EV capacity, QS cell may die well before 30K miles.

We earlier discussed the company's claim of 1,000+ charge and discharge cycles. Solid-state experts pointed to a significant red flag – that QS appears to be cheating by cycling its prototype to a low energy level (1/3 of a typical hearing aid battery), a common gimmick to show long battery life. The same red flag appears in its low temperature cycle life claim. Given that cycle life in cold climates already appears disastrous, we wonder how much worse it would be if QS cycled a cell at a load more realistic for an EV battery.

Key data slides from QS December 8th "Battery Showcase" – slide #22



Y-axis conceals the actual capacity the prototype cell is cycled at, instead using a non-standard and undefined term – "Discharge Energy [%]"

Note: Red arrows, lines, and text ours for emphasis

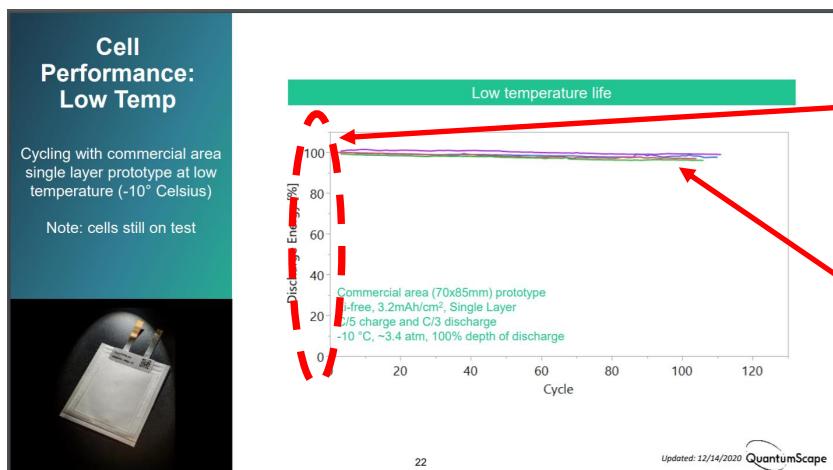
Source: https://s26.q4cdn.com/263384136/files/doc_presentation/2021/1/Data-Launch-Updated-Post-Presentation-20210107-2.pdf

3) Phony claim E: Battery life in low temperatures

Red flag 4: Solid-state expert indicates yet another reason cycle life is likely far short of 30K miles – problems across QS test samples, which they attempt to cover up with deceptive data presentation: “they don’t want us to see the statistical variations”

A famous book titled “How To Lie With Statistics” has an entire chapter devoted to the use of misleading chart scales – the QS low temperature cycle life slide is a classic example. The chart shows what appears to be 4 test cells, each represented by a different colored line. The lines cluster between 95-100%. Standard practice in battery research would be to scale the Y-axis from 90% at the bottom to 100% at the top. However, QuantumScape scales the axis from 0-100%, which creates the false impression that the lines are close to flat – that is, battery life is stable and barely degrades over time, under low temperature conditions.

Key data slides from QS December 8th “Battery Showcase” – slide #22



Y-axis is scaled from 0-100%, even though the 4 test cells shown are all between 95-100%

This creates the misleading impression that the cycle life trend is flat – that is, battery life is stable and barely degrades over time, under low temperature conditions

Note: Red arrows, lines, and text ours for emphasis

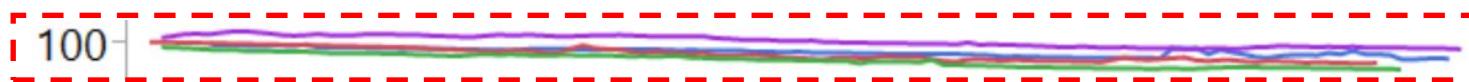
Source: https://s26.q4cdn.com/263384136/files/doc_presentation/2021/1/Data-Launch-Updated-Post-Presentation-20210107-2.pdf

3) Phony claim E: Battery life in low temperatures

Red flag 4 (cont'd): Solid-state expert believes QS is cherry-picking and hiding “reproducibility and variation” problems across cells, by using a misleading chart scale – “We cannot see from this data whether the cells shown are all excellent. Actually, I’m pretty sure they’re not.”

The expert – a highly published leader in solid-state research – indicated that researchers often cheat by making a batch of 10 cells and cherry-picking the one with the best data. Understanding cell to cell variations is critical in understanding what representative cell performance looks like. The expert believes that the QS samples show massive variation from cell to cell and problems with their battery life under low temperature conditions.

Zooming into low temperature cycle life trend on previous chart shows huge variation across 4 samples



*“When you show something in the 99% efficiency range, you should never plot a graph from 0 to 100 because people cannot see the variations. We need to see the statistical distribution of the different cells, where they plot between 95% to 100%, so we can actually see the statistical variations of the data. **If you plot the data like this, that means they don’t want us to see the statistical variations.**” – Solid state expert*

“That data would show you reproducibility and variation from cell to cell. This is a publicly-listed company. They’re going for production. I tell students that if you make 10 cells, I want to see the cell to cell variations because I don’t want them to report the best data. Pick something that’s representative. For a commercial company, we want to see the cell to cell variations. **We cannot see from this data whether the cells shown are all excellent. Actually, I’m pretty sure they’re not.** Replot this data from 95 to 100 and I’m pretty sure it’s not all the same.” – Solid state expert

3) Phony claim E: Battery life in low temperatures

Red flag 4 (cont'd): A standardized battery reporting checklist, discussed earlier, attempts to prevent research fraud by requiring authors to certify basic data. We noted the QS data fails to meet almost every criteria, which even warns against the Y-axis trick QS uses here.

The checklist requires researchers submitting battery papers for publication to not use a Y-axis scale of 0-100% and instead to use 90-100%.

Standardized data reporting for batteries

Revision 1.0, Last updated: Nov 10, 2020



If a key point of your paper is the performance of a battery, complete the below form

- » Authors are encouraged to include this completed document as supplemental information at the time of submission. Not doing so may cause delays if your paper is selected for peer review.
- » Please confirm that each item in the list is present in the manuscript or supplemental information by checking the corresponding box. For any items that are not present, please provide details in the text box for the editorial team and reviewers to consider.

Coulombic efficiency for at least 3 cells with the Coulombic efficiency of each cell reported individually and the average capacity and standard deviation reported

confirm

Coulombic efficiency and capacity vs cycle graphs should use reasonable y-axis scales. For instance, Coulombic efficiency should not be reported on a y-axis scale of 0-100% but rather 90-100% etc.

confirm

I verify that this form is completed accurately in agreement with all co-authors, to the best of my knowledge

Submitting author name:

For general queries or feedback regarding this form please email joule@cell.com

“Coulombic efficiency and capacity vs cycle graphs should use reasonable y-axis scales. For instance, Coulombic efficiency should not be reported on a y-axis scale of 0-100% but rather 90-100% etc.”

Red flag 5: “Coulombic efficiency” is a basic, essential measure of cycle life. Leading expert: “throughout QuantumScape’s entire presentation, we don’t see any Coulombic efficiency numbers. That’s a huge red flag”; explains why small variations between 95-100% matter.

A solid-state expert explained that Coulombic efficiency (CE) is similar to a compound interest rate: if “you lose 1% each time” you cycle your battery, it can’t last more than 100 cycles. Therefore, very small percentage variations in CE – less than 1/10 of 1% - exert a massive effect on cycle life.

“For lithium-ion cells, one of the key things is the Coulombic efficiency number. Think of it like a compound interest rate, where if each time you cycle your battery and you lose 1% each time, your battery cannot last more than 100 cycles or 200 cycles. It’s very easy to calculate. **Today’s lithium-ion batteries operate at close to 99.9% Coulombic efficiency and that enables us to go for a few hundred cycles.** For cells working in the region of 3,000 cycles like [redacted] has shown, you need 99.95%, 99.96% [Coulombic efficiency]. So we’re very particular about Coulombic efficiency measurement. And **throughout QuantumScape’s entire presentation, we don’t see any coulombic efficiency numbers. That’s a huge red flag.**” – Solid-state expert

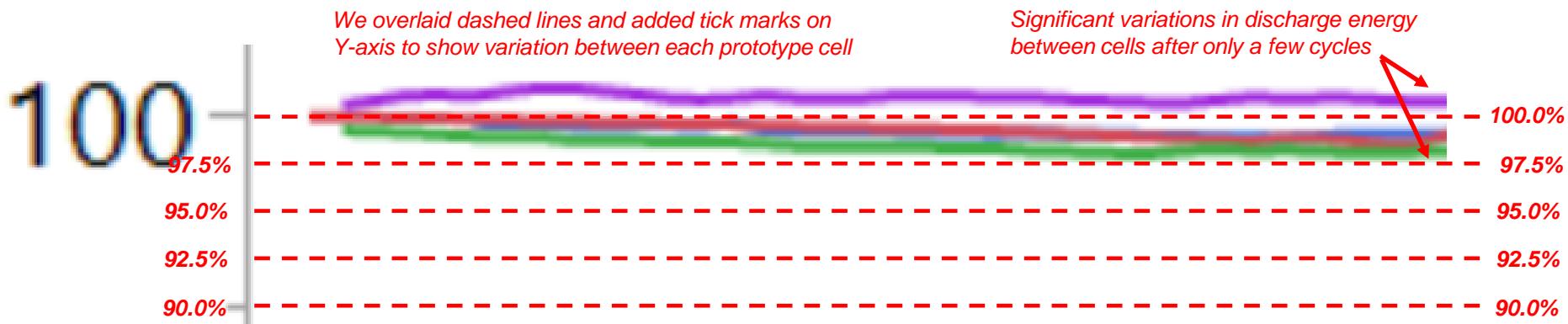
“The Department of Energy’s Battery 500 Consortium took four years among 11 different scientists to raise the lithium coulombic efficiency from 90% to 99.6% and right now they’re struggling to go above 99.6%. 99.6% means that we can cycle something like 500 cycles. For 99.6% to 99.9%, we’re still ongoing. **If your Coulombic efficiency is not 99.9% or close to that value, cycle numbers to 1000 are very unlikely in lithium metal cells.**” – Solid-state expert

3) Phony claim E: Battery life in low temperatures

Red flag 5 (cont'd): Massive variations in QS cycle life data suggest that its cells have disastrous and instable Coulombic efficiencies and cycle lives, which explains why they fail to disclose this basic metric of battery life.

We enlarged the trend lines in the low temperature cycle life chart. Each of the 4 colored lines appears to be a different prototype cell. The enlarged section below captures the trend to ~30 charge and discharge cycles. Two issues jump out. First, the data reinforces the expert's conclusion that the Coulombic efficiency is low – after only ~30 cycles, the samples are only retaining about 98-99% of their discharge energy. We note the expert's comments on the previous page that standard Li-ion Coulombic efficiencies are 99.9%. The difference between 98% and 99.9% in Coulombic efficiency terms is night and day in terms of battery life. Second, after a mere ~30 cycles – which we estimate is equal to about 9,000 cumulative miles* - the individual samples already begin to show significant variations in discharge energy. These differences appear to get even larger at more cycles, suggesting that the QS prototype cells have instable and unpredictable lifespans.

Slide #22 from QS December 8th "Battery Showcase" – enlargement of cycle life trendlines



3. Phony claim F: “Aggressive automotive power profiles”

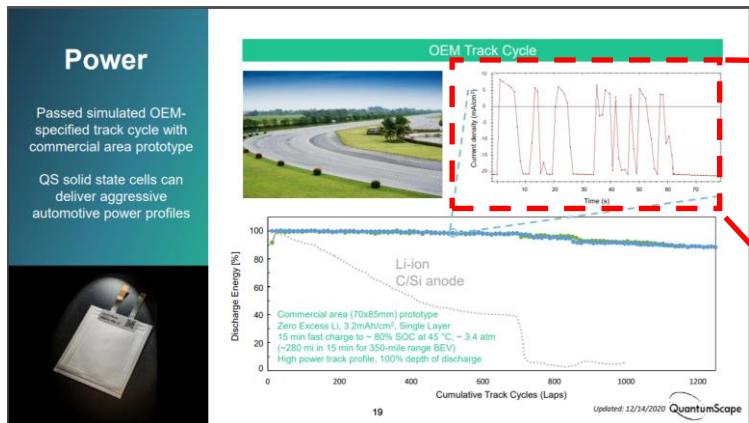
3) Phony claim F: “Aggressive automotive power profiles”

QS claims its cell has an “aggressive automotive power profile,” showing a simulation of a cell powering a car on a track. Red flag #1: Solid-state experts blast the data as “ridiculous” and unusual: “nobody in our field” uses this protocol, “never seen people reporting data in this way”

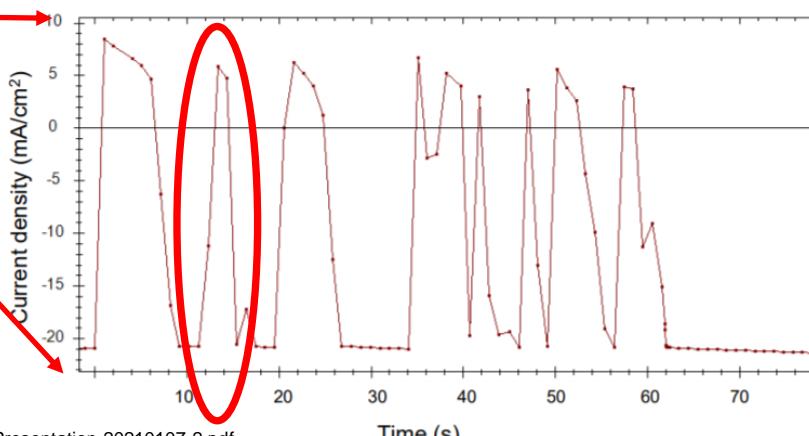
If one zooms in to the “track cycle” data, it appears to use short pulses of merely 5-10 seconds each, each one presumably a lap around a simulated racetrack. A solid-state researcher slammed the data as non-standard and “a huge problem” as batteries need to deliver constant current for long periods vs. 5-10 second bursts.

“The x-axis is in seconds. So they’re pulsing. The current density they’re applying – the charging or discharging - each cycle only lasted for 10 seconds. This is ridiculous. I’ve never seen people reporting data in this way. This is a huge problem. The x-axis is in seconds, not even minutes. I mean, what kind of battery application uses pulsing for a few seconds? When you operate devices, you are drawing on constant current for a long time.” – Solid-state battery researcher

Key data slide from QS December 8th “Battery Showcase” – slide #19



Zooming into the fine print on the X-axis shows 5-10 second pulses, each apparently a simulated lap around a track



Note: Red boxes, circles, and arrows ours for emphasis

Source: https://s26.q4cdn.com/263384136/files/doc_presentation/2021/1/Data-Launch-Updated-Post-Presentation-20210107-2.pdf

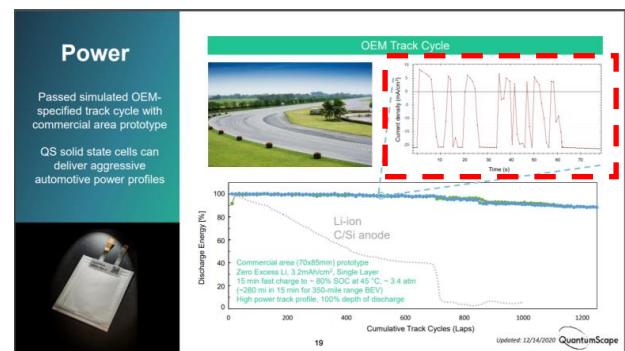
3) Phony claim F: “Aggressive automotive power profiles”

Red flag 1 (cont'd): Experts detail other reasons the track simulation data is impossible to decipher, not industry-standard, and suggestive of deception: “they don’t follow any protocols that are commonly adopted in the field”

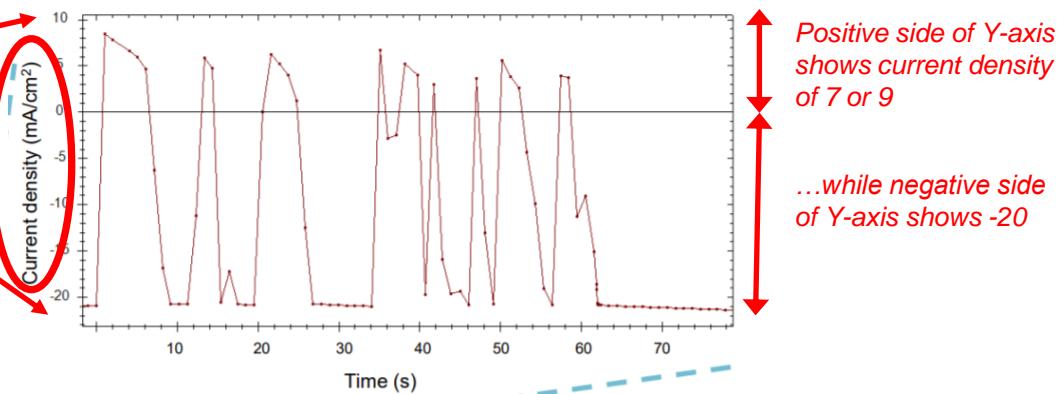
The solid-state battery researcher who we asked to analyze this data – a leader who is highly published in the field - pointed out yet another red flag: the current density profile makes no sense and, contrary to QuantumScape’s claim, does not represent actual laps around a car track.

*“The other thing we can see is current density of -20 while on the positive side it’s only a 7 or 8. It’s very asymmetric. So, it means plating and depositing. I don’t understand the reason why this profile is demonstrated. I don’t even know what positive and negative means. But basically, you’re depositing and stripping mass. **I don't know why this cycling performance is considered cumulative track cycles in terms of laps because, again, nobody in our field is using this type of protocol to show data** because when we show cycle data, it’s usually 80% depth of charge under constant current conditions and how long it can cycle and we say 20% depth of charge” – Solid-state battery researcher*

Key data slide from QS December 8th “Battery Showcase” – slide #19



Y-axis fine print shows a highly unusual and lopsided current density profile



Note: Red boxes, circles, and arrows ours for emphasis

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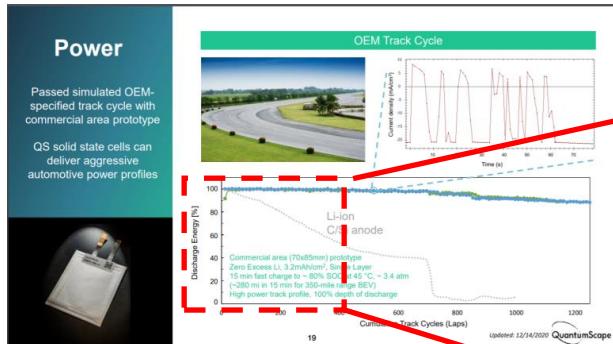
3) Phony claim F: “Aggressive automotive power profiles”

Red flag 1 (cont'd): The data shown is so obfuscated that leading solid-state experts and former employees were stumped and couldn't even describe what it means – a telling sign in previous frauds we've analyzed.

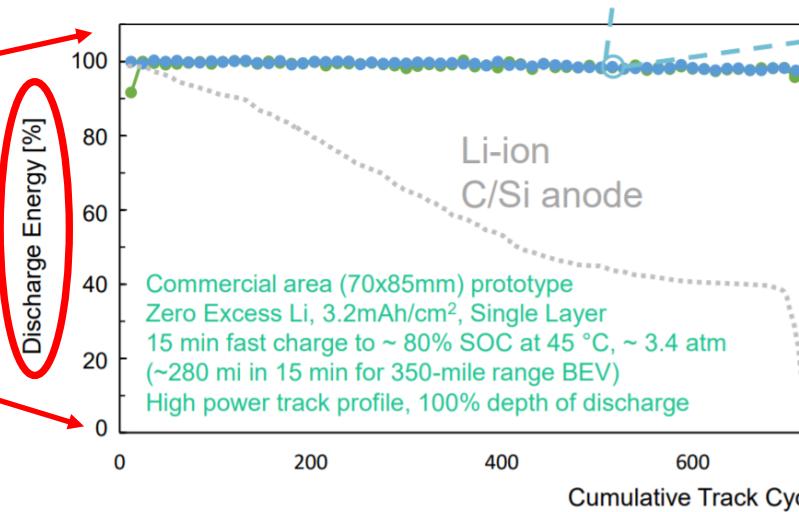
In analyzing frauds and promotes over the years, we have learned that it's rarely accidental when a company makes it difficult or impossible to understand the data or science behind its supposed breakthrough.

“For the lithium-ion cells, the y-axis labeling here doesn't say depth of discharge. It says "discharge energy percentage." So, all of these axis definitions need to be clearly defined. They don't follow any protocols that are commonly adopted in the field. What does discharge energy percentage mean? What's the denominator? What's on top? And how is this comparison made?” – Solid-state battery researcher

Key data slide from QS December 8th “Battery Showcase” – slide #19



Y-axis makes it impossible to understand the “data” shown, using what experts imply is a non-standard and made-up label – “Discharge Energy [%]”



Note: Red boxes, circles, and arrows ours for emphasis

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3) Phony claim F: “Aggressive automotive power profiles”

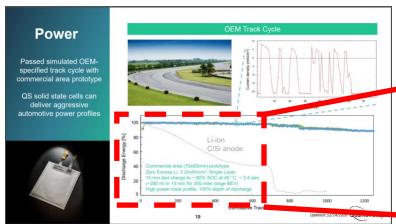
Red flag 2: Similar to its “Fast Charging” claim, QS misrepresents the power profile of standard Li-ion cells, in order to make theirs look better. Solid-state expert: “They always pick a bad cell to compare their cell to”

Two solid-state experts indicated that QS cherry-picked a bad Li-ion cell in order to make their prototype appear better, and were dismissive of the QS cell’s “better” power profile.

*“The silicon-carbon cell performance in slide 19, I think again you see the discharge energy is in percentage, which **really, really worries me because lithium-ion cells do not look like that at all**. If you look at some of the Sila Nanotechnology data, 1000 cycles is very flat. **They always pick a bad cell to compare their cell to**. The gray reference is not state of the art carbon anode.” – Leading solid-state battery researcher*

*“First, the graph on the bottom, there's stuff on there at the top showing tremendous stability and then the reference is lithium-ion with a carbon-silicon anode. There are plenty of carbon-silicon anodes that have pretty early failure. People have not, in those systems, really been able to deal with a never-ending SEI growth problem. Okay, fine. But **what would it look like compared to an actual EV battery from a state-of-the-art player like Panasonic or CATL or LG? My guess is that reference to those gray dots that look terrible probably looks a whole lot more stable.**” – Solid-state materials and chemistry expert*

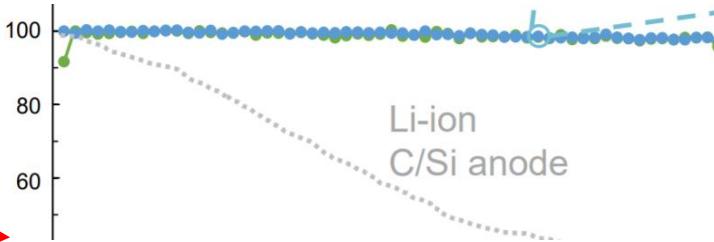
Key data slide from QS December 8th “Battery Showcase” – slide #19



Note: Red boxes, circles, and arrows ours for emphasis

Source: https://s26.q4cdn.com/263384136/files/doc_presentation/2021/1/Data-Launch-Updated-Post-Presentation-20210107-2.pdf

The stable blue curve at top is the QS lab sample. Gray curve below cherry-picks a Li-ion cell that fails early.



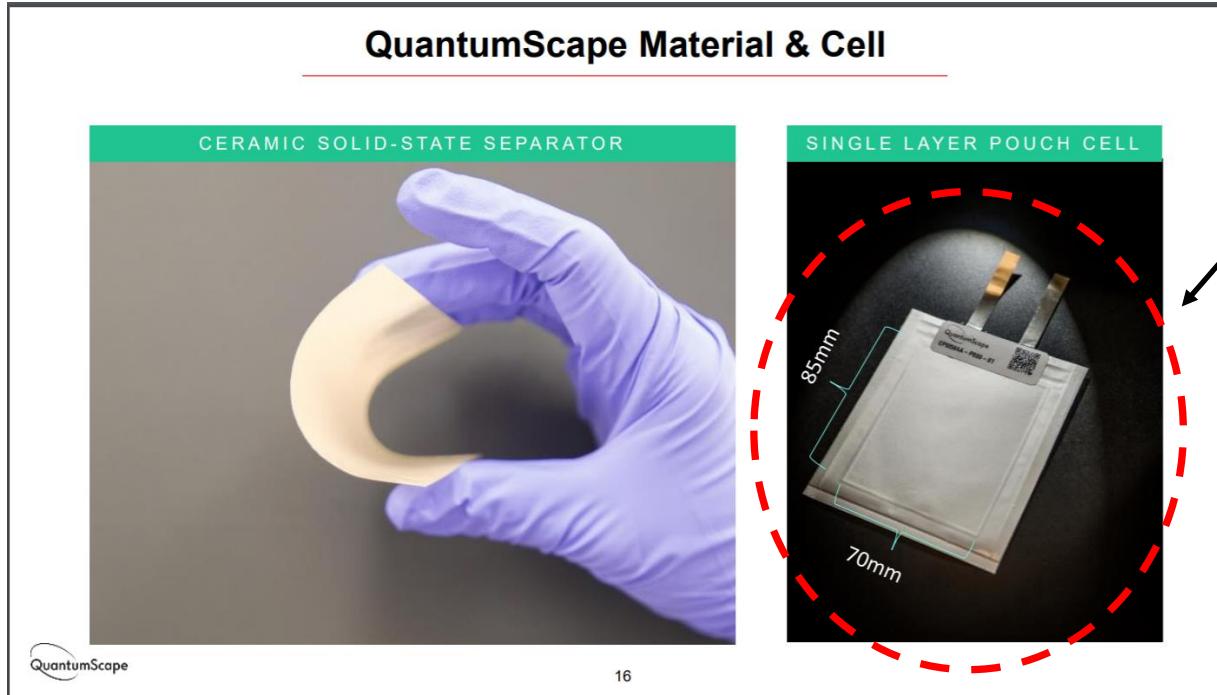
4. Multi-layer cells: a fraudulent narrative to cover-up a failure

4) Multi-layer cells: a fraudulent narrative to cover-up a failure

Almost all of the data QS has shown is for a single-layer cell, which experts dismiss as irrelevant, as EV batteries have 3,000 packs, each with 100+ layer cells. Plans for one-story shacks mean little for 100 story skyscrapers.

QuantumScape's filings state that it must stack "over one hundred" layers at a time for each pack inside an EV battery.

"To achieve target energy density, QuantumScape needs to stack its single-layer cells in a multi-layer format, which is enclosed within a single battery package. QuantumScape's battery cell will require over one hundred single-layer battery cells within each battery package." - QS SEC filing, 11/10/20



A small single-layer pouch cell, either 70x85mm or 30x30mm in size, is the basis for QuantumScape's far-reaching claims of a breakthrough solid-state battery

4) Multi-layer cells: a fraudulent narrative to cover-up a failure

A former employee emphasizes how little it means to show single layer data, and frames the monumental task of scaling to multilayer cells comprising 200,000 layers in total: “the biggest issue that they’re facing”

The former employee used the example of a Tesla model 3, which he indicated has thousands of cells each with 50-100 layers, to indicate the massive technical challenge that awaits QuantumScape given that “What they have shown is data for one. One layer.”

*“Tesla is a great example. The model three has 3700 cells in it. Each of those cells are comprised of 50 to 100 layers. That’s the scale at which the battery needs to be. You need to have 50 to 100 of these layers, and the solid-state battery has a higher capacity than the lithium-ion battery, so you probably don’t need 3700 of these to fuel a car; you probably need maybe only 2000, but then you need 2000 cells. If you do the math there, 50 to 100 layers, let’s just say 100 on the high side for easy math—2000 cells, **you’re looking at 200,000 layers of the separator to give the energy that you need to fuel a car. That’s a lot.**” – Former employee*

“What they have shown is data for one. One layer. So, you can understand that the ability for them to scale that up is going to take some serious time and effort because to get from just having one cell cycling to having technically 200,000 layers cycling, that’s a huge scaling issue. Before we can do that, we’ve got to start getting the cells together or start getting these layers together, and **that’s really the biggest issue that they’re facing.”** – Former employee

Source: Scorpion Capital consultation calls with experts

Solid-state experts indicate that the reliance on single layer data is a “glaring” red flag and too little even for a VC investment: “after all the capital that has been invested, why are they only showing single layer data?”; just a double-sided cathode, not even a true battery.

Experts indicate that “without a doubt, if there’s one takeaway” it’s that QuantumScape is making bold claims of a breakthrough based on a single layer prototype – which in the industry is not even considered a real battery.

“Some of the other things that are notable about QuantumScape, and **frankly, the most glaring one is the size of the cell. It’s a single-layer cell, and when people refer to single-layer cells in the industry, they usually talk about it as a double-sided cathode** because how you would make a cathode at scale is you coat both sides of a current collector. A current collector, in this case, would be aluminum. You would coat on the topside and on the bottom side; in the industry, it’s called the A and B side. And they are showing data off of a true single layer, and that is, **without a doubt, if there’s one takeaway, it’s why after all the capital that has been invested, why are they only showing single-layer data?**” – Solid state expert

“You’ve got a single-layer cell, and if I was going to invest in this as a venture investor, I would want to see an awful lot more data than this. If I was thinking about making an investment as a venture investor, I would want to see if they have to cherry-pick a good one. All I have to do is make something and get it to happen one time. What if I keep doing that -30°C? Do I end up with a dendrite on cycle 5? You wouldn’t know from this.” – Solid state expert

Claiming a breakthrough off a single layer sample is like using one transistor in 1940 to say you built an Intel CPU – “It means they don’t have good multilayer data”; cracked cells, short circuits from dendrites when stacked

Solid-state experts explained the step-function difficulties that arise when going from a single-layer 2-dimensional cell to a 3-dimensional format with hundreds of layers.

“I think it means they don’t have good multi-layer data. Let’s just start with that. They don’t have good multi-layer data; that’s what I would assume if I was looking at putting money in this.” – *Solid-state expert*

“I think the single transistor to integrated circuit comparison is somewhat relevant here. They’ve got a single-layer. There’s no lithium on the negative electrode side until you charge the battery. The dimensions of the cathode change only just a little bit, but the negative electrode side goes from nothing to all the lithium on every cycle. So, you have these dimensional changes. In their deck, you see 3.4atm, which I assume is 3.4 atmospheres of pressure, which is a little odd to refer to it that way. But **you get this stack under pressure, and you’ve got everything changing dimension, and if you don’t have pressure, you’d probably get dendrites, you’d probably get nonuniform plating.** Having a solid-state separator does solve some problems, but it also creates some problems.” – *Solid-state expert*

*If the pressure is not uniform, for example, you don’t perfectly have the same thickness of electrolyte everywhere, some of these cells, you’re going to change dimension faster than others in some layers. Then you have nonuniformities in pressure. Does that drive either **cracking of this material? Does it drive dendrite formation** in some area preferentially?” – *Solid-state expert**

4) Multi-layer cells: a fraudulent narrative to cover-up a failure

The CEO appears keenly aware that single layer is a low bar, and has recently begun pushing a disingenuous narrative: we've proven single-layer works and NOW - "for the first time" - we'll finally focus on multilayer cells

In a February 25, 2021 Yahoo Finance interview, the CEO of QuantumScape laid out one of the big questions in investors' minds.

"And I think the big question back then was, this is great. This is a breakthrough. But can these guys take that single layer cell and make a multilayer cell out of that?" – QuantumScape CEO, 2/25/2021.



Source: <https://finance.yahoo.com/video/quantumscape-ceo-shares-two-exciting-151621348.html>

4) Multi-layer cells: a fraudulent narrative to cover-up a failure

On Feb 16, 2021 QS announced with fanfare that it has finally made a multilayer cell. The stock jumped 31%. However, note the telling placement of a key phrase: “We are please to report for **the first time that we have made 4-layer multi-layer cells in the 30x30mm form factor...”**

The contrived phrasing suggests that Quantumscape is trying to mislead investors into thinking that this is the first time they've made multi-layer cells, when all they're saying is that this is the first time they're talking about it.

Quantumscape Q4 FY2020 “Letter to Shareholders”, Feb 16, 2021

We are pleased to report for the first time that we have made 4-layer multilayer cells in the 30x30mm form factor, and we have now seen close to 800 cycles at 30°C with over 90% capacity retention at both C/3 and 1C rates – substantially similar to the single-layer cells we reported in December. We used 30x30mm cells, made from separators cut from our standard target commercial area separators, because it allowed us to effectively quadruple the number of test cells as we work to scale up our engineering line capacity.

We believe these results demonstrate that it is possible to stack our single-layer unit cells, and to do so without adversely impacting the cycle life and capacity retention performance of the cells, i.e., while maintaining performance similar to single-layer cells. The data from these tests is shown below and is generated at near-room temperature (30°C) at rates ranging from C/3 to 1C (three-hour charge/discharge to one-hour charge/discharge.)

4) Multi-layer cells: a fraudulent narrative to cover-up a failure

The best way to cover up data that would blow up your SPAC is to pretend that you don't have it yet. We think the CEO's recent statements about the status/timing of multi-layer cells are not only disingenuous but constitute fraud – a ruse to pump the stock with a fake “new” milestone.

In the Feb 25, 2021 Yahoo Finance interview we referenced a few pages earlier, the CEO states that the 4-layer cells he had just announced were a “big breakthrough” and that he won’t have 8-10 layer cells until end of this year.

JAGDEEP SINGH: [...] “And I think what we were really pleased to see, as we reported last week in our earnings call, that we, in fact, had taken four layers and stacked them up together to make a four-layer cell [...] And that was the big breakthrough because what that means is that we can now continue to scale this technology. Later on this year, we hope to have an eight to 10-layer cell. And if we hit that milestone, then we'll be on track to deliver actual sample cells to our automotive OEMs. So that was a pretty big deal.”

BRIAN SOZZI: “Jagdeep, that sounds very important, what you just mentioned, eight to 10 cells by the second half of this year. I think a lot of folks are still getting to understand your company. And you've had, really, some big developments in many respects that come out of left field or come out of the blue. You wake up one morning. And you see, wow, the stock's up so much. When do you expect to reach that eight-layer cell? What's the date? Is there some timeline you can provide?”

JAGDEEP SINGH: “Yeah, the eight to 10-layer cell, we think, is going to happen by year end. So we don't want to set expectations too high. I mean, we've been fortunate so far that the goals we've set, we've been able to meet, the single-layer cell announcement, this multilayer statement was, I think, ahead of what anybody was expecting. But I think the eight to 10-layer cell, we're targeting by year end.”

4) Multi-layer cells: a fraudulent narrative to cover-up a failure

Red flag 1: Multiple former employees indicate that QS has tried to make multilayer cells for years but flopped: “I actually helped set up the multi-layer pouch line, but it just didn’t work”; “hurdle” that “they haven’t overcome”

Multiple former employees we interviewed indicated QS can’t successfully make multi-layer cells.

Our Q&A with Former Employee #1 indicates problems in making multi-layer cells

Q: “Were they making multi-layer cells years ago, and they just couldn’t get them to work?”

A: **“I actually helped set up the multi-layer pouch line, but it just didn’t work.”**

Q: **“They couldn’t get multi-layer cells to work?”**

A: **“Correct.”** - Former employee

Former employee #2 was less blunt but confirmed multi-layer as a “hurdle”; overall tone of the interview suggested the ex-employee had more damaging info but preferred to speak indirectly
“The biggest manufacturing hurdle that they need to overcome - that is something they haven’t overcome yet, is stacking the cell...Let me just put it in a general sense - you want to get to your final product before you start stacking and layering, and I can say that there are certain things that they were doing to try to push to get to that final product and finalize what specs they were looking for before they began that process of stacking. I think there are some issues with - how do I put this? The single-layer they’re trying to aim for is like the final product, and I think that final product, they’ve been changing what they’re targeting or the specs they were trying to hit before they went to the multi-layer.” – Former employee

4) Multi-layer cells: a fraudulent narrative to cover-up a failure

Red flag 2: The CEO indicated in his Feb 25th Yahoo Finance interview that they've shown a 4-layer prototype now, and the next step is an 8-10 layer cell that “we’re targeting by year end.” Our calls with members of VW’s EV battery group lead us to suspect that the “upcoming” 8-10 layer prototypes are old news and that QS has had them for some time.

If what we suspect is true, the question then becomes – where’s the data? As well, are the statements below truthful?

CEO comments during recent interview

“Yeah, **the eight to 10-layer cell, we think, is going to happen by year end.** So we don’t want to set expectations too high. I mean, we’ve been fortunate so far that the goals we’ve set, we’ve been able to meet, the single-layer cell announcement, this multilayer statement was, I think, ahead of what anybody was expecting. But I think **the eight to 10-layer cell, we’re targeting by year end.”**

Source: Transcript of Yahoo Finance interview 2/25/2021 <https://finance.yahoo.com/video/quantumscape-ceo-shares-two-exciting-151621348.html>;

Red flag 3: Solid-state cells expand while charging due to properties of lithium metal, dooming efforts to stack them in layers. Experts and ex-employees indicate it's basically unsolvable: "mechanical breathing," swollen cells.

A solid-state expert explained that “lithium metal is a piston” that expands in volume as it charges, creating “extremely important” issues in stacking cells.

“The mechanics are extremely important, and this is why the single-layer thing is such a big deal. Lithium metal is a piston. That means that when it charges, it’s actually expanding in volume. So, when you have 20 or 50 or 100 layers together and they’re constantly going back and forth, you have mechanical breathing that’s way more than the mechanical breathing that you see in lithium-ion. So, the mechanics of this cell may be much more favorable than if you had a multi-layer cell. This is one example where I can for sure say I would love to see this in a multi-layer cell.” – Solid state expert

Evaluation of The Electrochemo-Mechanically Induced Stress in All-Solid-State Li-Ion Batteries

“Most Li-ion battery electrode materials experience volume changes during lithiation and de-lithiation. The Li compositional inhomogeneity causes stress, which is referred to as the “diffusion-induced stress” and leads to mechanical failure of electrodes during battery cycling...With the increasing interest in all-solid-state Li-ion batteries (ASSLBs)^{14–18} owing to their improved endurance and safety, their mechanical degradation becomes a critical and unsolved issue that impacts the performance and life of ASSLBs.¹⁹ The mechanical degradation of ASSLBs is expected to be more severe than that of traditional Li-ion batteries, since the solid electrolyte (SE), unlike the mechanically compliant liquid electrolyte, imposes additional mechanical constraints on the deformation of electrodes.”

Paper on solid-state battery failure due to mechanical stress from lithium expansion – “a critical and unsolved issue”

4) Multi-layer cells: a fraudulent narrative to cover-up a failure

Red flag 3 (cont'd): Ex-employee explains why even a single-layer cell expands 40% - says imagine trying to sell Apple a phone battery with moving parts that gets 40% thicker during charging; “how do you package it?”

Our Q&A with a former employee shed light on one of the most difficult and unsolved problems in making multi-layer solid state cells.

Q: “What are the challenges in going from single-layer to multi-layer? What compounds the difficulty?”

A: “In a conventional lithium-ion battery, the anode is like a sponge, and the lithium is absorbed into the sponge where the battery charges, but the sponge stays the same size. In a solid-state lithium metal anode, the anode is not a sponge. **The anode is just lithium, and, therefore the cell expands when it charges. So, you have moving parts inside the battery.**”

Q: “How much does it expand the lithium anode?”

A: “40%. The anode expands infinitely because the anode doesn't exist when the battery is discharged. The lithium is all in the cathode. And it plates out on the anode when you charge the battery. **The whole-cell expands 40%.** The expansion of the anode is; basically, you're dividing it by zero, the expansion is infinite.”

Q: “How do you stack that? How do you solve that problem by stacking it?”

A: “Exactly, right? And then how do you package it? **Imagine you're trying to sell this battery to Apple.** We want you to put it in your phone, but when you charge the phone, **the battery is going to get 40% thicker.**” – Former employee

4) Multi-layer cells: a fraudulent narrative to cover-up a failure

Red flag 3 (cont'd): The former employee continued that it's a “super-hard problem” that doesn't even have a conceptual solution today - 40% cell expansion gets even worse with 50+ stacked layers; solid-state battery in an actual electric car would expand by one foot.

An EV battery that expands by a foot between charge and discharge strikes us dead on arrival.

“It's a super-hard problem. Now, let's think about that in a multi-layer concept. I stack up 50 layers of anodes and cathodes and separators, and now every other layer expands. The anodes expand, the cathodes don't, and everything moves, **and I've got to connect tabs to all of those layers to get current in and out, and I've got to keep it all compressed and consolidated.** Imagine that every layer moves 30 microns.” – Former employee

“Let's say the total stack is 100 microns when it's discharged, and it charges to 130 microns, but now you stack that up to a meter in an electric vehicle battery. Now it's 30-cm. That's a foot of expansion. The percentage is still 30%. How do you deal with the fact that the terminal moved? The terminal physically moves by a foot. **So, how do you absorb that? How do you come up with a concept that works there?**” – Former employee

Source: Scorpion Capital consultation calls with experts

4) Multi-layer cells: a fraudulent narrative to cover-up a failure

Red flag 4: Dendrites are a fatal problem in the transition to multiple layers. Ex-employees: QS needs to stack ultra-thin solid-state separator layers for weight/energy density, but thin layers get dendrites; “it just shatters”

A former employee explained that thin layers are needed, but thin layers “very easily get a dendrite.” He described the challenges “as these things expand and contract during cycling” to the point “where it shatters.” He indicated that the difficult trade-offs between separator thickness, dendrite resistance, and energy density are unsolved.

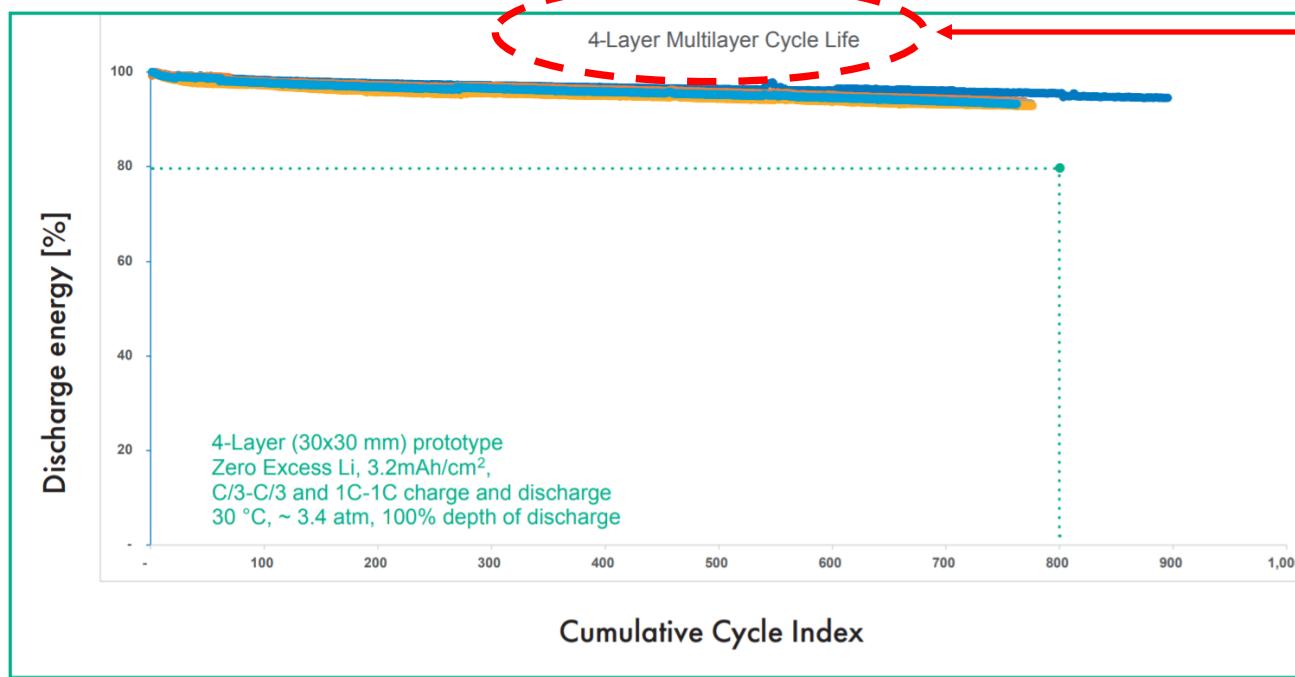
Former employee responds affirmatively to our question: “They’re struggling with a dendrite issue in the transition from single-layer to multi-layer cells?”

“Right. Let me explain some things about just the inner workings of these batteries. The separators are pretty thin. They could range anywhere from 5 microns to 100-200 microns in thickness. This is where it’s really tough scale when it comes to ceramics processing....**In a perfect world, you want to get the separator as thin as possible**, to just a few microns. A few microns is smaller than your hair. But also you want it to survive all these different battery tests...Think of it on a basic conceptual level - here’s something so thin, and then you have to quickly charge and discharge electricity and **you can very easily get a dendrite forming, which is a spike growing on the anode side and that spike is going to end up putting a hole into that thin separator because it’s just too thin.**”

“If it’s too thin, the dendrite is going to break a hole into it. But if you make it thicker, you’re losing a lot of energy density because you’re consuming more space. Not only that, but as these things expand and contract during all the cycling, it’ll expand to a certain point where it shatters because, at the end of the day, it’s ceramic. Think of it like a ceramic pot, where you put so much force on it, it just shatters. These are two issues that you’re going to have, whatever type of ceramic.” – *Former employee*

Red flag 5: CEO claims multi-layer breakthrough a few weeks ago, but won't show data for most key OEM criteria: fast charge, power, low temperature, dendrites. Only 4-layer cells while QS admits 100+ layers needed.

In conjunction with its earnings call on Feb 16 2021, QS claimed it has now made multi-layer cells – but only 4 layers thick, or about 4% of the way to the 100+ layers it needs per cell. The company made bold claims about the performance of its multi-layer prototypes, but only showed one data slide – cycle life. Curiously, QS declined to show data on other key automaker criteria it showed in December for its single-layer sample: fast charge in 15 minutes, automotive power profile, dendrite resistance, low temperature cycle life, and low temperature operability.



"4-layer Multilayer Cycle Life"

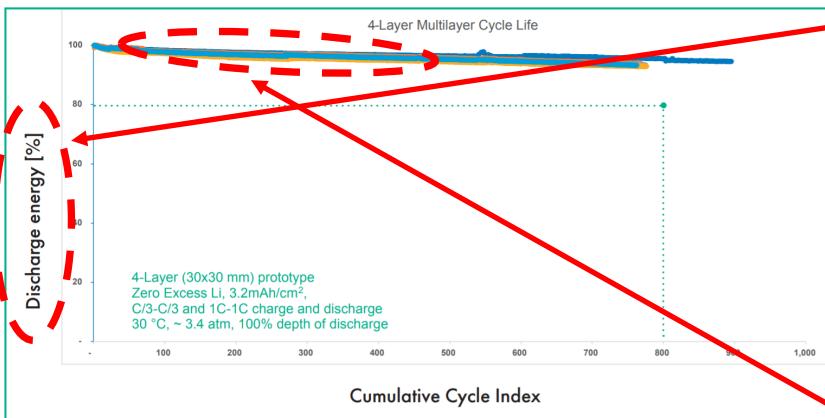
Company only showed one meager data slide for its 4-layer cell.

Where's the comparable data it showed for its single-layer cell at its Dec 2020 Battery Showcase?

4) Multi-layer cells: a fraudulent narrative to cover-up a failure

Red flag 6: The one scrap of data shown for its multilayer cell – cycle life – exhibits the same sleight of hand as its cycle life claims for single-layer cells. Standard “Coulombic efficiency” metric is once again missing, without which cycle life claims are meaningless

At its Dec 8th Battery Showcase, QS showed two slides for cycle life for its single-layer cell. We noted extensive red flags for each claim – cycle life at normal operation, and under low temperature conditions. Each of those red flags applies in spades to the same claim it makes for its 4-layer prototype cell. We summarize them here.



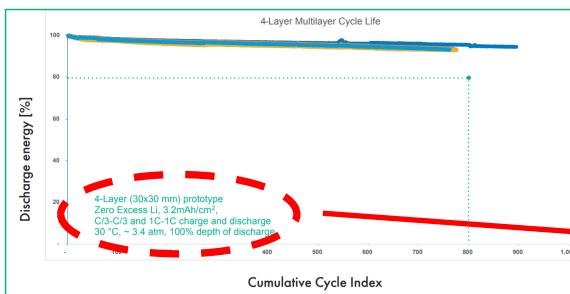
- 1) QS **hides the actual capacity the battery is charged to**, using “Discharge Energy [%]” as the Y-axis instead. Experts indicate it’s a common form of cheating when making battery claims, as at low energy loadings a cell can last forever.
- 2) QS cell appears to be a **fraction of the capacity of a hearing aid**. Showing 1,000 cycles at a tiny energy level is easy but a gimmick given massive energy requirements of real EV batteries
- 3) Cycle life test used is **not industry-standard battery test**. We noted that an expert’s comment the Dept of Energy doesn’t even allow use of such ambiguous data by battery researchers
- 4) Common trick in fake cycle life claims is **scaling the Y-axis from 0-100% to hide cherry-picking and variation problems** across cells. Battery journals specifically warn against the gimmick QS uses.
- 5) **“Coulombic efficiency”** is a basic, essential measure of cycle life. Experts indicate it’s a huge red flag that QS never discloses it. Massive variations in QS cycle life data suggest that its cells have disastrous and instable Coulombic efficiencies and cycle lives.

Red flag 7: Alarmingly, QS adds a new trick for its 4-layer prototype, buried in the fine print – testing battery life under tortoise-like 3 hour charge rates, making a mockery of its “15 minute fast charge” claim.

We asked a solid-state researcher to analyze the “new” multi-layer data, who noted various concerns: a slower charge rate suggests struggles with dendrites; an ongoing failure to state the capacity of the cell; using a Y-axis with a non-standard, undefined measure of cell performance – all indicative of issues in scaling to multilayer prototypes.

“This means that **charging is done for 3 hours** and discharge for 1 hour. This type of slow charging is very typical for Li metal batteries. Plating of Li is where [a] dendrite growth issue can occur. Therefore charging (plating lithium metal) is often done at slower rates.” – Solid state expert

“During the charging of [a] multiple layer pouch, it is **extremely challenging to ensure ALL layers plate lithium uniformly. QS has to lower the rate**...I want to stress that they must clearly define what is 100% depth of discharge...if the entire lithium capacity is utilized , cycle life will suffer. Therefore, the critical question is **what is 100% depth discharge** – according the dimension they give, the cell is about 122mAh capacity. They should label their y-axis, the actual capacity cycled. They also **did not use the actual critical current density** – C rate is meaningless if the actual current density mA/cm² is not shown.” – Solid state expert

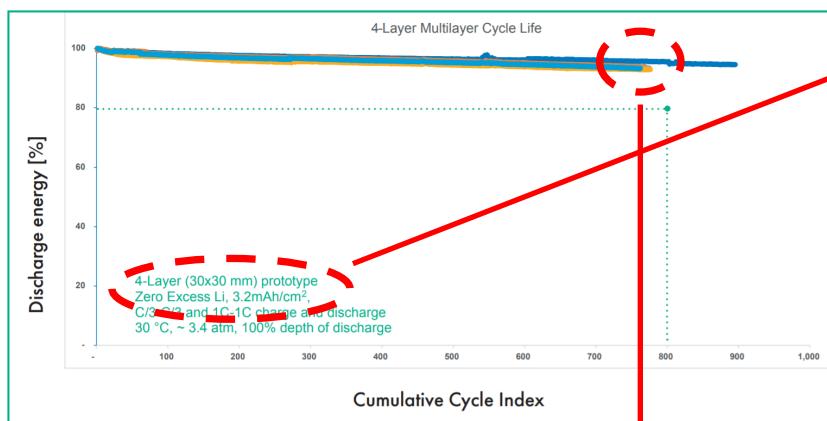


Fine print indicates C/3 charge rate – which in battery-speak means a 3 hour charge

4-Layer (30x30 mm) prototype
Zero Excess Li, 3.2mAh/cm²,
C/3-C/3 and 1C-1C charge and discharge
30 °C, ~ 3.4 atm, 100% depth of discharge

Red flag 8: The ever-shrinking prototype cell. The single-layer cycle life test used a 70x85mm cell, while the multi-layer test used 30x30mm samples – only 15% of the square surface area. QS excuse: “because” we’re still working to “scale up our engineering line capacity”

In solid-state battery development, a critical sign of progress is advancing to cells with larger surface area, given the step function difficulties that arise in each scaling step. QS appears to be going in reverse. A single electric vehicle needs flawlessly manufactured separator material measured in football-field size dimensions – yet QS is pointing to manufacturing constraints, even though its slide data suggests that they only used 4 or 5 coin-sized 30x30mm prototype specimens for the test.



Enlargement appears to show 4 or 5 lines, suggesting 4 or 5 individual cells used, yet QS points to scaling constraints



Fine print indicates 30x30mm prototypes, in contrast to single layer cycle life test that used 70x85mm samples, i.e., 15% of the surface area ($900 \text{ mm}^2 / 5950 \text{ mm}^2 = 15\%$)

Recent “Shareholder Letter” explains reason for smaller cells in multi-layer test

“We used 30x30mm cells, made from separators cut from our standard target commercial area separators, because it allowed us to effectively quadruple the number of test cells as we work to scale up our engineering line capacity”

5. Quantumscape can't even reliably make TEST cells that work, we believe

5) Quantumscape can't even reliably make TEST cells that work, we believe

Before we detail manufacturing/scaling obstacles in the next section, we level set where QS finds itself today. Three different former employees indicate that QS still struggles to produce a few lab prototypes that work: “We built 300 cells a day, a few of them were ok to test.”

Our research indicates that manufacturability is as much an unsolved and daunting problem as the science. To illustrate the mammoth difficulty in manufacturing solid-state cells, we note comments from ex-employees on the company's inability to produce even small numbers of working cells reliably and consistently.

A former employee noted the grim reality about the company's ability to even make a few samples that “were okay to test”

Q: “What about repeatability? Did they make 20 cells and found one where they could do this?”

A: **I would say that's almost certainly the case. It certainly was the case when I worked there. We built 300 cells a day, and a few of them were okay to test.” – Former employee**

...In stark contrast to....

Quantumscape's recent bullish announcement about its scalability plans

“QS-0 is intended to have a continuous flow, high automation line capable of **building over 100,000 engineering cell samples per year**. We expect to secure a long-term lease for a second building with approximately two hundred thousand square feet in the second half of this year and for QS-0 **to be producing cells by 2023.”** – Letter to Shareholders, 2/16/21

5) Quantumscape can't even reliably make TEST cells that work, we believe

Ex-employees indicate that even today, making prototype cells is a fickle, haphazard “arts and crafts” exercise that’s “very sensitive” to the person doing it; lab samples are so brittle they break at “astronomically high” rates with manual handling.

We quote two ex-employees below, who indicated that the current process for making cells at Quantumscape is the exact opposite of anything automated, robust, or within a million miles of what anyone would call “scalable.”

“Someone who still works on that project says that it's **still a very arts and crafts-like process, which means it's very sensitive to who's doing it**, so that's why it's probably not robust.” – Former employee

“When you want to put all these things together, the cathode, anode, and the electrolyte, you're putting the ceramic between two different battery terminals and you have to hammer it down and put it together in a pouch and then cycle it, there are a lot of chances to break the separator. You can imagine working with parts that are a few microns thick by hand and placing it onto another device by hand. **The chances of this getting broken are probably astronomically high. For sure it was high in what I saw. The separator itself would break for manual labor reasons.** You're dealing with something like 75x85mm, this plate that's super-thin, you're trying to put it together with a cathode and an anode and the gel catholyte probably gives it a little bit more flexibility so that you can build it a little bit easier and get to testing.” – Former employee

Source: Scorpion Capital consultation calls with experts

5) Quantumscape can't even reliably make TEST cells that work, we believe

We find ex-employee comments to be devastating: still don't have a robust process for making a few test cells; "it was really hard to get a full cell that was repeatedly performing for a long period"

Former employees lay out the actual state of affairs behind the Quantumscape hype.

Former employee #1

"I left partly because I didn't believe in the team and the technology... **My skepticism comes from how often they were able to do it and what yield. When I was there, it was really hard to get a full cell that was repeatedly performing for a long period of time**, especially the technology that they moved forward with is the technology that I worked on, so I understood the difficulties with it.... I mean, it took them how many years to solve it on a research scale? And that's the other key thing for me is that as a person who has an eye for manufacturability and scalability, **it's one thing to show it on the research level and another thing to show that it can be scalable**. The infrastructure there when I left, I don't think they expanded that building footprint, so it probably is the same." – *Former employee*

Former employee #2

Q: "What is your personal opinion of the claims that they made [in the Levine CEO/CTO interview]? Do you believe them?"

A: "I believe them for a sample or two or maybe three or maybe four or maybe 10, but **I don't believe that they can do that pretty consistently. It's not a robust process at the moment**. So, even with a non-robust process, you will probably get some good cells. I don't doubt that part. It's just, can you do it robustly? **And from the people that I still talk to, they can't.**" – *Another former employee*

5) QuantumScape can't even reliably make TEST cells that work, we believe

Yields low even for test cells, scaling is a non-starter: “I doubt their ability” to make even one-layer samples “repeatedly in a reliable manner”; yields are “something they never report”

A former employee indicated skepticism at QuantumScape's yields, suggesting they were atrocious and that the math would work against them if they tried to build cells with larger surface areas.

“I doubt their ability to make that [a 70x85mm single layer prototype pouch cell] repeatedly in a reliable manner. You can see everything once and get lucky. You can do things maybe 10 times and be onto something. Whenever I see the data points, I always just wonder how many data points are in there and what is their yield? That's something they never report.” – Former employee

*“Usually, when you do a build, you make a certain amount of material, and that gets you a certain number of pouch cells, and that's usually a batch. And so, out of that batch, if it's 1% of the cells that they made were the ones that worked, yeah, you can show that 1%. But what about the 99%? ***When you scale area, it exacerbates the problem.*** So, let's be optimistic and say if they have a 50% yield of a batch of 100 cells, you multiply that in area, it's to a power of 2. ***Basically, your yield would be equivalent to 25% in a doubled area, for example.***” – Former employee*

Source: Scorpion Capital consultation calls with experts

6. Red flags around scaling and manufacturability render QuantumScape's cells a pipe dream

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Even if the science was real, ex-employees and experts indicate skepticism and “roadblocks” about scaling from coin-size test samples to EV-level capacity and energy density, and reject that QS could flawlessly manufacture square miles of solid separator needed without dendrites

QS has shown prototypes with capacity smaller than typical hearing aid batteries, roughly 200 mAh. On top of scaling battery capacity, QS also has to scale energy density, and then scale manufacturing. Ex-employees indicate it “looks great on paper” but...

“Number one red flag and unanswered question is scalability. I will completely change my tone when I see a 20Ah battery from them. **Two is energy density.** Three might be whether you can scale sintering, that high-temperature process, but I think that's probably a little bit more nuanced. But one and two are the big ones. And one is the biggest one. There have been people who've shown really good data with single-layer pouch cells that could never scale. There was a thin film battery company that showed amazing cycling data, but they made it in a way that was never going to scale, so that company does not exist today. Can QuantumScape's single-layer cell scale and can it achieve a reasonable energy density?” – Solid state expert

“Although this looks great on paper, the real challenge comes with getting the product out in the market and that is where I feel that there are **significant roadblocks.**” – Former employee

“People need to understand what is needed for them to get to that manufacturing level. It goes back to the fact that you need to have that final spec battery ready and hit the mark for the size, the capacity, the pressure, the temperature, cycling speed, all of that. **But then you also need to do it on such a scale that you're able to make hundreds, millions of these things over and over,** like separators to make one part—but the separators, hundreds and millions of them.” – Another former employee

6) Red flags around scaling and manufacturability render QuantumScape's cells a pipe dream

We note comments from Elon Musk during a Nov 2020 interview, indicating that 99.9% of the challenge in battery cells is manufacturing.

*“In fact, there’s an old saying, ‘It’s like it’s 1% inspiration and 99% perspiration’ — it might be **99.9% in the case of battery cells**. You’ll see a lot of announcements — this cell breakthrough, that cell breakthrough, this technology breakthrough, and say, ‘Okay, well, why can’t they just make a lot of them?’ It’s because the **scaling up of the production process is much harder than moving something out on a lab bench.**”* - Elon Musk, Nov 24, 2020 interview

Video: <https://www.youtube.com/watch?v=-4JJ6ASXgBI>



European Conference on Batteries: Elon Tesla Battery Update 24th November 2020.

6) Red flags around scaling and manufacturability render QuantumScape's cells a pipe dream

A former QS employee states scalability and manufacturing are a “huge gap”; “not manufacturing folks”; “closer to R&D scale”; “very skeptical” of CEO’s statements and thinks “buying time” while they struggle; skepticism was universal across all 9 ex-employees we interviewed

We found the level of skepticism among QuantumScape’s former employees to be consistent and notable.

“My focus is scalability and manufacturability and that’s a huge gap. I think they said in five years they’d be generating revenue. Five years to get to a mass-production scale is way too optimistic, especially for the technology that they’re doing. My biggest concern is always on manufacturability, especially the people that I know that are there. They’re not manufacturing folks. They are not process engineers. They’re closer to R&D scale. You can do this once or twice or a dozen times, but if you’re trying to make a product out of it and a product that will go into an EV...” – Former employee

“The one thing that bothered me from Jagdeep’s statement about manufacturability...I feel like they’re buying some time to show something, and I think they’re buying time to show that they can do these [cells] repeatedly or reproducibly. So, I’m very skeptical of the scale part because, actually, I looked into the scale-up when I was there.” – Former employee

Source: Scorpion Capital consultation calls with experts

6) Red flags around scaling and manufacturability render QuantumScape's cells a pipe dream

Red flag 1: Solid-state separator must be ultra-thin to have required weight vs. energy density – so thin that it's a super-human, unsolved problem. QS appears to be struggling with a separator so thick that it's dead on arrival.

A solid-state expert explained that a ceramic-based separator, as QS has admitted it's using, is dense and must therefore be extremely thin – 10-microns – or it will weigh too much for the battery to achieve the energy density they claim. He referenced comments from QS that lead him to believe that the separator is the width of a human hair – a red flag as a human hair is ~75 microns, per Wikipedia – or more than 7 times thicker than needed.

*"We know that it [QS solid-state separator] is an oxide and whether it's LLZO or some other oxide, most oxides and ceramics are going to be very dense, and why is that relevant? Whether it's LLZO or some new oxide material that is amazing and they own outright, **the challenge is that you have to get to a very thin layer. So, they talk about 400Wh/kg.**"*

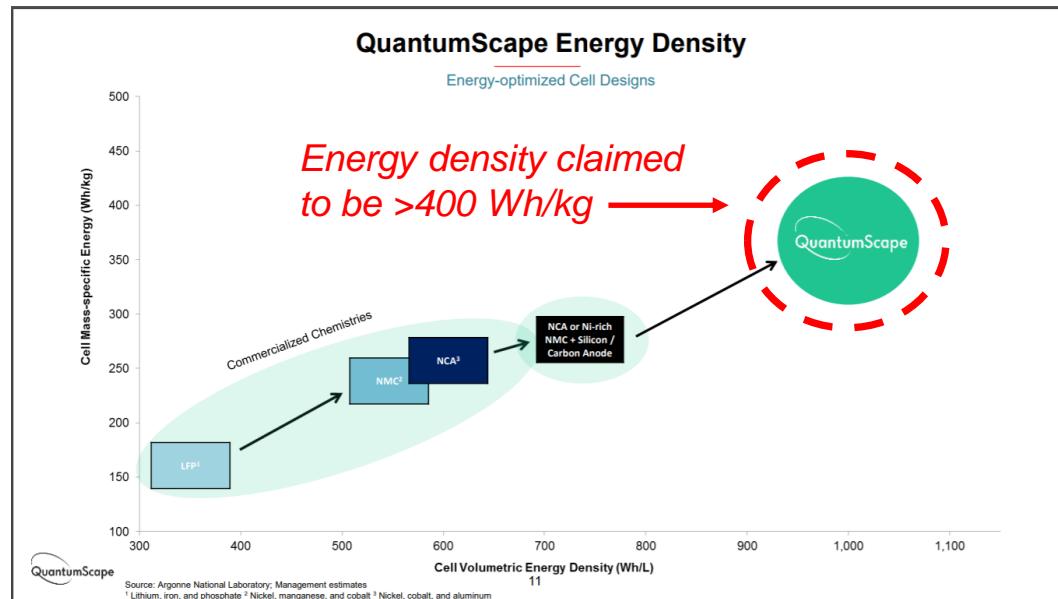
*"**In order to get to something like 200Wh/kg, they have to have a 20 or 30-micron separator. In order to get to 400, that separator has to be well under 10-microns, and they talked about the separator as being thinner than a human hair, and that is a bit of a red flag because a human hair could be 100-microns** if you have thick hair. On average, a human hair is probably 50-microns. If we're going to take that term literally, a 40 or 50-micron separator is not going to get you to that high specific energy. So, if your separator weighs a lot and if your separator is relatively big, it's going to weigh a lot, and that hurts your specific energy because it's inactive [...] There's a really good graph that Jeff Sakamoto from the University of Michigan put out. It's a saddle curve that shows three key points, which is excess lithium, thinness/thickness of the separator, and I think the y-axis might just be specific energy achieved." – Solid state expert*

6) Red flags around scaling and manufacturability render QuantumScape's cells a pipe dream

Red flag 1 (cont'd): QS claims an outlandish energy density >400 Wh/kg, but their separator appears to be 7X or more too thick to achieve it – which implies an energy density far lower than even conventional Li-ion batteries. QS SEC filings vaguely allude to but bury the struggle.

QuantumScape claims an energy density >400 Wh/kg, but we see no mention of the thickness of its solid-state separator – without which the energy density claim is meaningless. Its 10K filing, however, suggests that the thickness is a problem – “our business could fail” if we can’t reduce its thickness and overcome other barriers.

Slide 11 from QS December 8th “Battery Showcase”



QS most recent 10K

“We are working to improve the reliability and performance of our solid-state separator, including decreasing the thickness.”

“We are likely to encounter engineering challenges as we increase the dimensions, reduce the thickness and increase the volume of our solid-state separators. If we are not able to overcome these barriers in developing and producing its solid-state separators at commercial volumes, our business could fail.”

Note: Red text and dotted circle inside slide is ours for emphasis

Source: https://s26.q4cdn.com/263384136/files/doc_presentation/2021/1/Data-Launch-Updated-Post-Presentation-20210107-2.pdf
https://www.sec.gov/ix?doc=/Archives/edgar/data/1811414/000156459021007621/qs-10k_20201231.htm

6) Red flags around scaling and manufacturability render QuantumScape's cells a pipe dream

Red flag 1 (cont'd): Two former employees indicate separator thickness issue is unsolved, without which all key QS claims go out the window. If it's too thick, it lacks energy density and “negates” the entire reason for a solid-state battery. If it's too thin, it fails due to dendrites.

In contrast to the CEO's lofty claims, former employees paint a picture of a company still struggling with the same basic, unsolved issues that have blown up previous attempts at a viable solid-state battery for 50+ years.

Former employee indicates concern that QS hasn't revealed the thickness of the separator

“Can they solve dendrites at scale? Can they solve it to be cost-effective? One of the solutions was to make the separator thicker, and that typically reduces the performance of the cell, and it quickly negates a lot of the advantages that solid-state gives because now you've got a separator that's super-thick, and all the cell is occupied by separator and all the advantages of energy density and everything go out the window. If they say they can make a separator that works, but they won't tell us how thick it is or how it performs or how long it performs—they still haven't done anything in a multi-layer pouch, which I would say is super-concerning to me from a timeliness perspective. Not having anything in a multi-layer cell is a real concern for me.” - Former employee

Another former employee suggests that basic separator issues are unsolved

“The key thing that you need to understand about the dendrites is this separator that they have in that photo, it's thinner than a strand of hair. If you're not careful and a dendrite does form and creates a spike in the battery, you're just going to shatter that. It's thinner than a piece of paper, and it's got the solidity. They're trying to find out what's the good balance of whether it should be hard, whether it should be soft, what type of materials that they should be looking at.” – Another former employee

6) Red flags around scaling and manufacturability render QuantumScape's cells a pipe dream

Red flag 2: QS states their separator is made of a “magical” ceramic, but ceramic separators are highly problematic to manufacture, requiring a process called “sintering” at ~2400 °F. Ex-employees: QS “having problems” even at coin-cell size; “very difficult problem”

A former employee outlined the process of sintering – common to any type of ceramic material – and the super-human difficulties that arise at the impossibly thin levels required for a solid separator, especially at commercial scale over square miles of surface area.

The process of sintering explained

“Imagine a piece of paper that’s ridiculously thin, and you need to heat it up into a ceramic. Any ceramicist will tell you that you need to sinter and solidify that in an oven. You’re taking it to a couple of thousand degrees so that ceramic can harden, stiffen, and typically shrink.” – Former employee

The super-human difficulties that arise in trying to make a thin separator

“But when you’re doing something that’s so thin over that big of a form factor, it makes an irregular shape, or it shrinks too much in certain areas. If there’s a defect or debris, you can create a pinhole. Imagine if there’s even a particle of dust that gets onto the surface. Trying to get the chemistry right to put into a furnace at that high of a temperature, and have it perfectly come together in order to make something that’s super uniform, super-flat - imagine if the sample isn’t 100% flat and you put it into a battery. If it’s not flat, it’s not going to interact with the cathode and anode in different places, and the pressure points are where you can definitely see a crack or a pinhole forming. Those pinholes will instantly short the battery.” – Former employee

6) Red flags around scaling and manufacturability render QuantumScape's cells a pipe dream

Red flag 2 (cont'd): Former employees indicate that sintering hurdles escalate exponentially with cell size, making it difficult to scale from tiny prototypes to commercial dimensions: “biggest reason why it’s hard to get from one size to another one”

We quote two former employees below, who explain the magnitude of the challenge – both exhibited significant skepticism at QuantumScape's ability to solve the problem.

Sintering is “biggest reason” why it’s hard to increase cell size

“**Sintering is the biggest reason why it's hard to get from one size to another one.** A smaller size is easier to get it uniform, flat, and precise. The chemical uniformity across the entire thing is much simpler. But as you go bigger in size, especially if you're going from something that's a square to a rectangle, different shapes, you can imagine that there are different types of interactions, stresses focusing on each of the corners, and things like that. It makes it more difficult to accomplish something as you're trying to scale up.” – *Former employee*

QS was having difficulties with sintering even at coin-cell size

“It is a ceramic electrolyte. It's easy to make well as a bulk powder. But when you put it into a film, the form factor for a battery, things become harder. You're balancing thickness versus number of defects; the defects are the ones with the dendrites....**They were having problems at the coin cell level...it is a very difficult problem** because they're taking ceramic and grinding it down to little particles. They're casting this formulation into a thin freestanding film, and making this freestanding film, and you have to have zero defects for that. One way to combat a defect is to make it thicker, but making it thicker has its consequences, so there's a fine balance’ – *Another former employee*

6) Red flags around scaling and manufacturability render QuantumScape's cells a pipe dream

Red flag 3: Our research interviews lead us to believe that the specific ceramic separator material QS is using is LLZO. Experts: “challenging material to work with”; similar LLZO projects have failed due to sintering and dendrite difficulties; LLZO was “a mess”

A recent investigative article that was highly skeptical of QuantumScape's claims discussed a similar LLZO-based solid-state effort, and quoted the principals involved who indicated the technical challenges in working with the material. A solid-state expert we interviewed provided similar color.

Solid-state expert explains why LLZO is a “challenging material” and “difficult to synthesize”
“LLZO is a challenging material to work with. It's a little difficult to synthesize, and it can be difficult to get good interface transport of lithium across the boundaries. It's difficult to sinter and to then sod that because, at the temperatures at which it's sintered, you tend to lose lithium. You'd probably have to do that in a CO₂-free environment because if you don't, you end up with lithium carbonate at the surface, and that's a terrible lithium-ion conductor, so you might have a good lithium-ion conducting material, but then you've got a barrier layer that doesn't conduct lithium on top of it.’ – Solid state expert

An Ultra-Secret Battery Startup → Hints That It's Blown Past Tesla — But Won't Show the Goods

Experts question the claim by QuantumScape, backed by \$500 million from Bill Gates, Silicon Valley venture capitalists, and VW

 Steve LeVine Sep 21, 2020 · 15 min read *



Quotes from article that discussed failure of previous attempts at using LLZO

“It was not smooth, but a mess”... “In 2013, the project ended in failure”... “When the battery began to cycle, the metallic lithium burrowed, atom by atom, underneath and between the mass of tiny grains that made up the LLZO. And once wedged in there, the atoms eventually broke through the material and shorted the battery.”

6) Red flags around scaling and manufacturability render QuantumScape's cells a pipe dream

Red flag 4: Former employee indicates that LLZO is heavier than competing solid electrolyte materials, making a LLZO-based battery 10-15% worse on energy density: “The implication is that’s not competitive”

Another key disadvantage of LLZO is inferior energy density versus other types of solid separator materials.

“LLZO is a garnet and it’s heavy. It’s got heavy elements in it and so the watt hours per kilogram of a battery, everything else the same, would be worse than their competitors maybe by 10% even or maybe 15%. *The implication is that’s not competitive. It’s like weighting cars. If you need to put in a lead-acid battery, you’re not happy. If you can put in a lithium battery, you’re happy. That exaggerates it, but that’s the point.” – Former employee*

Source: Scorpion Capital consultation calls with experts;

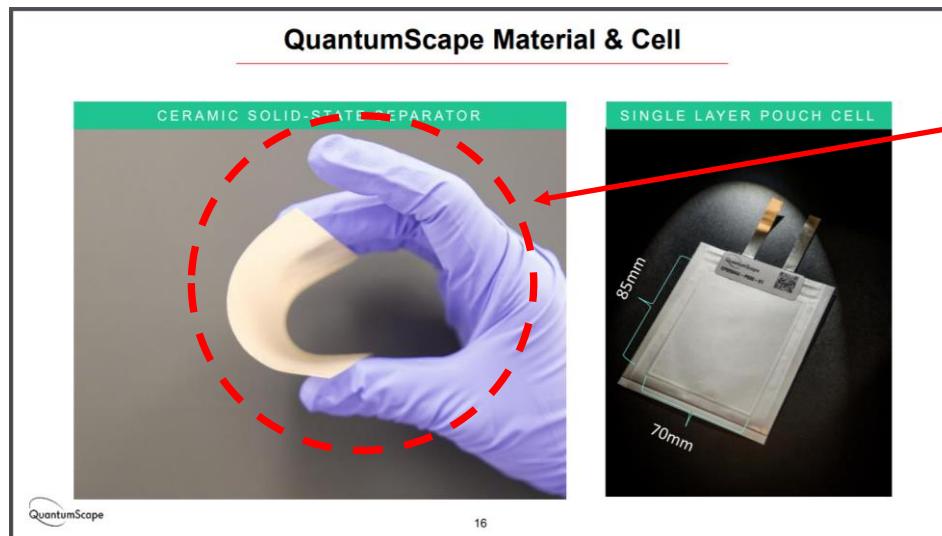
6) Red flags around scaling and manufacturability render QuantumScape's cells a pipe dream

Red flag 5: QS must scale from one-off coin and credit-card sized separator prototypes to making square miles of separator material. Former employee elaborates on daunting magnitude of the problem.

A former employee pointed to a picture of the solid-state separator in QuantumScape's Battery Day presentation, highlighting the challenge of scaling up from credit card-sized dimensions.

"They show a little membrane, and people are flexing it between the blue glove. That membrane is the solid electrolyte. They've got to scale that from that little credit card that he's pinching in his fingers to sheets, literally hundreds and hundreds of meters long, and being able to produce that all day long every day. There's an area scale up. And they have to be able to do that defect-free. Any hole or any crack in that membrane is going to be a place where the battery will short." – Former employee

Slide 16 from QS December 8th "Battery Showcase"



Credit card-sized
"Ceramic Solid-State
Separator"

6) Red flags around scaling and manufacturability render QuantumScape's cells a pipe dream

Red flag 5 (cont'd): Scaling the manufacturing of ceramic separator is a colossal challenge compared to standard liquid-based Li-ion: “One tiny defect doesn’t kill a liquid battery”; need “square miles” of “very perfect” ceramic.

A former employee and an expert pointed to the unique challenges of solid separators.

Former employee explains why solid separators are “much less tolerant” of any defect than liquid Li-ion

“Today’s lithium-ion batteries are made with all kinds of layers and laminates, and electrodes. One lithium-ion manufacturer was making electrodes at 100-meters per minute. It all has to be defect-free. The lithium-ion battery manufacturers today - Samsung, LG, and Panasonic - they’re all doing that today. **But one tiny defect doesn’t kill a liquid battery.** If you’ve got liquid filling any of those holes and that electrolyte, the battery will still work, so it’s more tolerant to any kind of defects. **What they’re finding with solid-state batteries is that it’s much less tolerant.**” – Former employee

Expert questions if QS can scale up to “square miles” material with no defects

“Can you actually scale this up to square miles of very thin, very uniform, very perfect kind of ceramic? This is not like doing tape casting of alumina or something like that. It’s going to be harder than that. Even after you do that, you have to worry about how it is going to work in a stacked arrangement, and there’s risk there.” – Solid-state expert with extensive experience in LLZO and ceramic separators

Source: Scorpion Capital consultation calls with experts

6) Red flags around scaling and manufacturability render QuantumScape's cells a pipe dream

Red flag 5 (cont'd): Scaling challenge is not only 2-dimensional – from coins and credit cards to vast, flat surface areas – but also 3-dimensional: trying to then stack large separator surfaces into multi-layer cells

We earlier discussed what we believe to be fatal obstacles in QuantumScape's ability to make 100+ layer cells. A former employee indicated that the scaling and manufacturing challenges for flat separators are multiplied by having to stack them up.

"Yes, that's what they call the dendrite issue. So, that's a challenge. **That's the two-dimensional. Then you go three-dimensional, and you start stacking these up.** They're going to cut these sheets; they've got to mass-produce these sheets meters and meters and meters long per minute, and then they're going to cut them up. Right now, a standard electric vehicle battery, it's about a foot and a half in length, so they're going to cut that in foot-and-a-half long sections and stack 40 or 50 of those stacks on top of each other to make a 50Ah battery that's in the BMW i3, for example. They need to get to meters-long, and then they need to start getting to 40 or so stacks." – Former employee

Source: Scorpion Capital consultation calls with experts

7. Doomed by cost: the “magic material” that we believe QS is using is too expensive to ever replace Li-ion

7) Doomed by cost: the “magic material” that we believe QS is using is too expensive to ever replace Li-ion

Interviews with experts and ex-employees lead us to believe that the ceramic separator QS is using is LLZO, which is far more expensive to manufacture than the separators used by competing solid-state efforts: “they’re not cost competitive”

Like other ceramic-based solid separators, LLZO requires a manufacturing process called sintering at temperatures approaching ~2400 °F. An ex-employee and an expert explained that sintering is extremely expensive and not cost-competitive compared to the materials other solid-state players are using.

“The process used to make a thin ceramic layer is expensive. It's more expensive than what their competitors are using. So, they could have a cost structure issue. It also turns out that it's hard to achieve that thin dense layer, so there could be quality issues in addition to cost issues. That's the biggest risk they face. The thin ceramic layer is expensive because it uses high-temperature furnaces to essentially keep the crystals near their melting point so that they can flow, and it's through that flow that they stick to each other. The sulfide, another electrolyte that Solid Power and Sion are using, doesn't require the same high temperature, so it's cheaper. Finally, the Ionic material is plastics, and that's the cheapest of all.” – Former employee

“Because they use an oxide-type, it's a true ceramic-type separator material, and they have to sinter that material. **Sintering is a high-temperature process. It's not something that's commonly done.** I have not investigated at length the CAPEX and throughput required in a way that it can be achieved with sintering. However, **it is an additional step, it is an additional CAPEX item,** and it is not something that's commonly done in lithium-ion manufacturing. So, at the very least, they're adding a not insignificant step of **sintering the separator layer in order to densify it.**” – Solid state expert

7) Doomed by cost: the “magic material” that we believe QS is using is too expensive to ever replace Li-ion

Ex-employee: Far-fetched that QS would ever be competitive with rapidly falling Li-ion battery costs; Li-ion was \$200/kWh 10 years ago when QS started and set a cost to get to, but will soon be \$80/kWh; QS approach “orders of magnitude” more expensive.

An ex-employee indicated that Li-ion costs are a rapidly falling moving target that makes it difficult for QS to be cost competitive. He suggested that when QS started, they benchmarked themselves to a Li-ion cost that's now obsolete – implying their entire technological premise is based on assumptions that are no longer relevant.

Former employee indicated skepticism that QS can be price competitive

*“The challenge is, can they scale it up? Do they have all the right pieces and approach to scale it up? And more importantly, **can it be manufactured cheaply enough** that it'll fit where the market is right now? There's a number out there for lithium-ion batteries for electric vehicles that **the price point needs to be below \$100/KWh.**” – Former employee*

The target cost to be competitive with Li-ion is “getting more and more difficult”

*“In a couple of years, the market thinks that lithium ion batteries are going to get down to \$80/KWh. I think back to when QuantumScape started 10 years ago; \$200/KWh was what lithium-ion batteries were going for. When they started the business, the cost they were trying to get to was a lot higher, and the longer it takes for any new technology to come into this business, **the breakeven point to enter the market is going to keep getting more and more difficult.** They're at small demonstration cells .It's like a credit card kind of size. There's just a lot of work to be done.” – Former employee*

QS may be 100x more expensive, when we asked for ex-employee's opinion of cost disadvantage

“100. Orders of magnitude [more expensive than current Li-ion costs]. They're not doing any manufacturing yet, so they don't know what their manufacturing-based costs will be.” – Former employee

7) Doomed by cost: the “magic material” that we believe QS is using is too expensive to ever replace Li-ion

Former employee explains the challenge of being cost-competitive with a niche technology versus high-volume “giga-factories” devoted to conventional Li-ion batteries: “so much cheaper to make huge volumes of liquid-filled lithium-ion batteries”; other ex-employees indicate that at the end of the day, auto OEM’s just care about price.

An ex-employee noted the massive cost advantage for conventional Li-ion created by the current global infrastructure and already-depreciated capital expenditure.

“Right now, there are Tesla’s giga-factories, and there are hundreds of gigawatt-hours of worldwide production capacity for lithium batteries, conventional liquid electrolyte batteries, and all of that manufacturing capex is already installed, and it’s already partially depreciated. So, just the depreciation costs alone on the capital equipment are already being brought down to the point that it becomes so much cheaper to make huge volumes of liquid-filled lithium-ion batteries.” – Former employee

*“A solid-state battery in initial manufacturing is going to cost because the equipment’s totally different. The way you would assemble solid materials together is different than injecting in a liquid fluid, so at least part of the manufacturing process is going to be different, and **that means different facilities, different capital equipment, all new capital expenditure**, and when they start producing, none of that is going to be depreciated.” – Former employee*

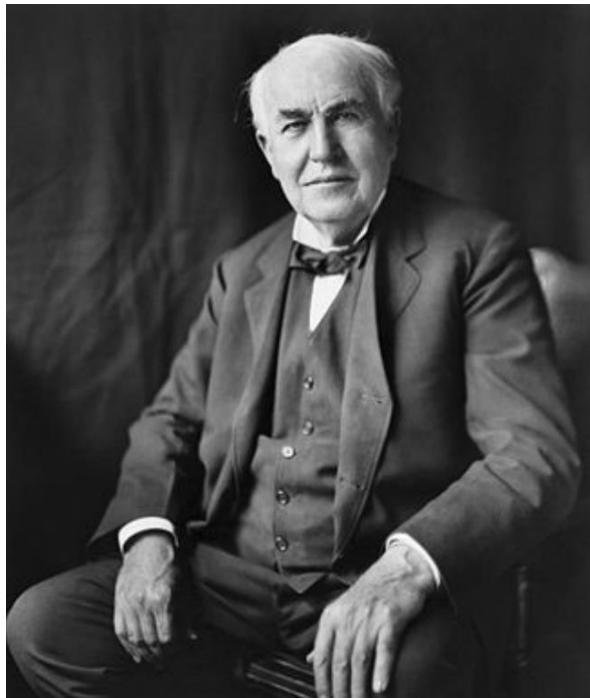
Source: Scorpion Capital consultation calls with experts

8. The battery space has a long history of stock scams based on exaggerated or false claims of a scientific breakthrough

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Thomas Edison on battery stock frauds in the 1800's

Publicly traded battery companies have been making too-good-to-be-true claims of a material, chemistry, or other scientific discovery for over a hundred years, starting with the advent of electricity and lighting in the late 1800's. This led Thomas Edison to warn the public about battery stock "swindlers." Vintage stock certificates from long-extinct battery companies are now collectibles.



"The storage battery is, in my opinion, a catchpenny, a sensation, a mechanism for swindling the public by stock companies.
The storage battery is one of those peculiar things which appeals to the imagination, and no more perfect thing could be desired by stock swindlers than that very selfsame thing. ... Just as soon as a man gets working on the secondary battery it brings out his latent capacity for lying. ...
Scientifically, storage is all right, but, commercially, as absolute a failure as one can imagine." – Thomas Edison, 1883

8) The battery space has a long history of stock scams based on exaggerated or false claims of a scientific breakthrough

“Fraud in the battery world” is still a major problem

Thomas Edison’s warning – the “peculiar” power of battery stocks to bring out their promoters’ “latent capacity for lying” – was prophetic. It remains a well-known and much-discussed problem in the battery industry today. Academics and industry experts have proposed ways to fix the “clear pattern of fraud and scandals permeating the battery startup world,” such as the recent article below which notes that “the industry is naturally prone to misinformation and misrepresentation.”

Preventing Fraud in the Battery World



BatteryBits [Follow](#)

Nov 28, 2020 · 12 min read



This story is contributed by [Nicholas Yiu](#), [Crystal Jain](#), [Melissa Zhang](#).

- There is a clear pattern of fraud and scandals permeating the battery startup world, with key examples like Envia, Sakti3, and most recently, Nikola Motors.
- The industry is naturally prone to misinformation and misrepresentation due to flaws in entrepreneur-investor relationships and policies governing battery testing and quality regulation.

“However, despite academic success of battery research, **the commercial battery world has suffered from a reputation of fraud. Key examples include Envia in 2013, Sakti3 n 2017, and Nikola Motors n 2020,** ranging from misrepresentation to investors to various forms of sugarcoating promises of their new technologies. **It seems to be becoming too commonplace to see once-celebrated startups succumbing to the fate of fraud and scandal.”**

8) The battery space has a long history of stock scams based on exaggerated or false claims of a scientific breakthrough

A root cause of fraud is reliance on small, prototype pouch cells as evidence, just like QuantumScape

One of the root causes of battery fraud identified by this article is the use of lab-scale prototypes like coin cells or pouch cells – “which are significantly different from a working battery” - as the basis for far-reaching claims. The article compared Nikola and Theranos, using a biotech analogy. We characterize the use of pouch cells as similar to pre-clinical, pre-phase 1 mouse data. Hyping pouch cells as evidence that commercial scale-up is right around the corner – as QS is doing – is as absurd as a biotech using rodent data to proclaim that Phase 3 success, FDA approval, and drug sales are now a done deal.

Preventing Fraud in the Battery World

“Equipped with only benchtop characterization data of a coin cell or a few pouch cells — which are significantly different from a working battery — and without proof of full scale-up, how can we — and importantly, early stage investors — accurately evaluate a battery’s merits? The majority of early stage battery startups spotlight coin and pouch-cell performance to formulate their pitch decks. Startup CEOs are used to giving “optimistic projections” on the technology and how it will scale in five to ten years time.”

QS lab tests are based on a small pouch cell. For some tests, QS doesn’t even disclose the size, suggesting it’s even smaller than the one below.

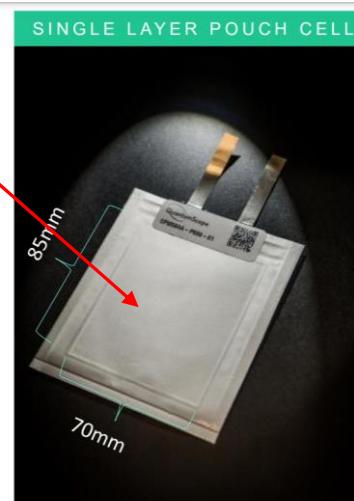


Image from
QuantumScape
presentation

8) The battery space has a long history of stock scams based on exaggerated or false claims of a scientific breakthrough

We earlier shared an industry checklist to prevent data fraud, QS has shown almost none of the items required for a credible claim

The problem of data fraud and lack of reproducibility is so common that one battery journal has proposed a checklist with “standardized battery reporting guidelines” – basically an “oath of honesty” that anyone making claims about battery performance must sign. The editors decried the lack of transparency and cherry-picked information when researchers report battery performance. The checklist is short and lists the bare minimum of data for a claim to be credible and considered for publication. QS has shown almost none of this data.

Joule Battery Checklist: [https://www.cell.com/pb-assets/journals/research/joule/Checklist_Batteries_v1_\(006\)-1608320062.pdf](https://www.cell.com/pb-assets/journals/research/joule/Checklist_Batteries_v1_(006)-1608320062.pdf)

Standardized data reporting for batteries



Revision 1.0, Last updated: Nov 10, 2020

Standardized data reporting for batteries	
Revision 1.0, Last updated: Nov 10, 2020	
If a key point of your paper is the performance of a battery, complete the below form. Authors are encouraged to include this completed document as supplemental information at the time of submission. Not doing so may result in rejection of the manuscript.	
Please confirm that each item in the list is present in the manuscript or supplemental information by checking the corresponding box. For any items that are not present, please provide details in the text box for the editorial team and reviewers to consider.	
Battery assembly reporting	
Thickness of current collector, conductive additive, and binder on anode	<input type="checkbox"/>
Thickness of battery components	<input type="checkbox"/>
Cylinder pressure when applicable	<input type="checkbox"/>
Amount of electrolyte (either volume or mass) used as electrolyte component in the cell	<input type="checkbox"/>
Mass of all components of the battery (casing, separator, electrodes etc.) as well as the weight of the cell	<input type="checkbox"/>
Areal mass (mg/cm ²) loading of active material on current collector	<input type="checkbox"/>
For Li metal cells, the amount of excess lithium, its thickness and capacity of the excess salt	<input type="checkbox"/>
Diagram of battery architecture or reference to architecture being used	<input type="checkbox"/>
Electrochemical reporting	
Temperature at which electrochemical tests are run	<input type="checkbox"/>
Indicate whether full-cells or half-cells are used for electrochemical tests. Full-cells are preferred when possible	<input type="checkbox"/>
First cycle or any cycling electrochemical data	<input type="checkbox"/>
Average charge and discharge voltage are reported for the primary cycling cell	<input type="checkbox"/>
Volumetric and gravimetric stack energy densities with calculation methodology C-rate	
Capacity or capacity reported on the figure or in the figure caption for every electrochemical test	<input type="checkbox"/>
Capacity for at least 3 cells with the capacity for each cell reported individually and the average capacity and standard deviation reported	<input type="checkbox"/>
The basis for capacity measurements should be clearly stated. If electrode-level capacities are preferred, active material capacities may be accepted. Note that the active material fraction is provided	<input type="checkbox"/>
Coulombic efficiency for at least 3 cells with the Coulombic efficiency of each cell reported. If capacity or average capacity and standard deviation reported	<input type="checkbox"/>
Coulombic efficiency and capacity vs cycle graphs should use reasonable y-axis scales. For example, the capacity scale should not be reported on a y-axis scale of 0-100 but rather 90-100%	<input type="checkbox"/>
I verify that this form is completed accurately in agreement with all co-authors, to the best of my knowledge <input type="checkbox"/>	
Submitting author name: _____	
For general queries or feedback regarding this form please email ouled@cell.com	

Source: [https://www.cell.com/pb-assets/journals/research/joule/Checklist_Batteries_v1_\(006\)-1608320062.pdf](https://www.cell.com/pb-assets/journals/research/joule/Checklist_Batteries_v1_(006)-1608320062.pdf)

8) The battery space has a long history of stock scams based on exaggerated or false claims of a scientific breakthrough

Battery researchers publish guide to “avoid being swindled,” QS checks off every red flag on the list

Another paper listed the four types of games that battery companies typically play as part of the “swindle” – to use the paper’s characterization. QS plays each of them: 1) claiming both high energy and high power (that is, volume of water in a tank vs. rate of flow from its tap – can have one or the other but not both); 2) claims of a new “super material” electrolyte; 3) overstating cycle life; and 4) obstacles to commercialization.



High energy versus high power

How super are super materials?

Overstating cycle life

Obstacles to commercialisation

"Watch out for claims that a new battery is high-energy and high-power. Researchers and engineers can design battery materials and electrodes to be suitable for either high-energy or high-power uses, but generally not both."

And then there are the bold claims made about a battery's cycle life. This is the number of times you can charge and discharge a battery before it dies. Many companies define this cycle life for themselves, which means they could create a self-serving test that effectively allows their battery to last forever. Often new battery testing is done with coin cell batteries, which are similar to the batteries you might find in a watch. In other words, they're great for research but don't resemble batteries you'd actually use to run an electric car.

8) The battery space has a long history of stock scams based on exaggerated or false claims of a scientific breakthrough

Recent high-profile battery frauds and flops – despite major corporate backers: Nikola, A123, Ener1, Envia, Sakti3, Exide

The list of scandals and bankruptcies involving much-hyped battery companies is long, in spite of their “validation” from large automakers and other major partners. GM announced a \$2B deal with Nikola, which boasted of an EV battery that appears to be fake. A123 was the hot QS-like IPO of 2009, spun out MIT with backing from Ford, Chrysler, GM, and GE. It went bankrupt three years later. GM invested in Envia, which was soon also accused of fraud.

The mysterious story of the battery startup that promised GM a 200-mile electric car (Envia article)

Source: <https://qz.com/158373/envia-the-mysterious-story-of-the-battery-startup-that-promised-gm-a-200-mile-electric-car/>

The Cautionary Tale of A123 Systems

Gee-whiz technologies don't trump market realities

Source: <https://spectrum.ieee.org/nanolast/semiconductors/nanotechnology/the-cautionary-tale-of-a123-systems>

Nikola reveals new energy density doubling battery

CEO Trevor Milton called the prototype cell “the single most important advancement in electric vehicle history.”

Source: <https://www.fleetowner.com/equipment/article/21704504/nikola-reveals-new-energy-density-doubling-battery>

Former Exide CEO sentenced to 10 years in battery fraud case

Source: https://zeenews.india.com/home/former-exide-ceo-sentenced-to-10-years-in-battery-fraud-case_72178.html

Xtreme Power, Grid-Scale Energy Storage Startup, Files for Bankruptcy

Source: <https://www.greentechmedia.com/articles/read/xtreme-power-grid-scale-energy-storage-startup-files-for-bankruptcy>

Nikola Motor's Bombshell Battery Claim Irks Experts, Who Think Its Secret May Lie In Sulfur

Source: <https://www.forbes.com/sites/alanohnsman/2019/11/24/nikola-motors-bombshell-battery-claim-irks-experts-who-think-its-secret-may-lie-in-sulfur/?sh=2402d9c57d89>

Fraud case at battery manufacturer Ener1

Source: <https://marketingreports.blogspot.com/2019/03/fraud-case-at-battery-manufacturer-ener1.html>

9. QuantumScape's lead investors have a track record of backing frauds and failures in the EV battery and cleantech space

9) Quantumscape's lead investors have a track record of backing frauds and failures in the EV battery/cleantech space

Quantumscape's lead investors are key drivers of its credibility and \$16B valuation, hyping a \$250B opportunity and boasting of its impact on their fund's returns. However, we find their track record in the EV battery space troubling.

Quantumscape was initially backed by Vinod Khosla of Khosla Ventures and John Doerr of Kleiner Perkins, two Silicon Valley venture capitalists with a legendary track record. They were listed among its largest holders in the S-1. Without their “celebrity endorsement” and star power, we believe QS would trade at a fraction its \$15B valuation. When QS announced its SPAC transaction in September, Khosla did a victory lap on Twitter stating that this one deal could return his entire VC fund and that its battery could be charged in 15 minutes.



...

Quantumscape incubated at [@khoslaventures](#) with 5 time CEO and EIR Jagdeep Singh. Took patient 10yrs to deep technology, bold first product risk but can return the fund and make huge dent in EV consumer experience (2x range, 15min charge)!

11:32 AM · Sep 4, 2020 · Twitter Web App McAfee SECURE

Khosla promoting QS in Barron's on February 1, 2021 as \$250 billion opportunity

[Khosla] believes that Quantum is in the lead. ‘Is there a competitor that will have a comparable battery in the next five years? Extremely unlikely,’ he says. ‘That gives us the ability to be dominant in the battery market.’ Dominance for Khosla translates into higher-than-average profit margins. If the car industry reaches 30 million electric vehicles by 2030, as Tesla CEO Elon Musk suggests it will, that would add up to roughly \$1 trillion in annual EV sales. By Khosla’s math, that amounts to \$250 billion in annual battery sales.”

9) QuantumScape's lead investors have a track record of backing frauds and failures in the EV battery/cleantech industry

In perhaps a classic case of “when genius failed,” their Midas touch as legendary investors has failed to translate to cleantech and EV batteries, where their actual track record is marked by a decade of high-profile scandals and duds

The struggles have been the subject of press articles going back years.

Clean Tech VC: A Decade of Failure

*“Khosla Ventures II and Khosla Ventures III had dismal returns, at less than 5% IRR as of March, 2016.^[13] This track record **reduced their credibility** and made their future fundraising efforts much more difficult. Although Khosla Ventures is still alive today, many other smaller clean tech funds went out of business completely.”*

Source: <https://digital.hbs.edu/platform-rctom/submission/clean-tech-vc-a-decade-of-failure/>

How the Kleiner Perkins Empire Fell

*“Once the very embodiment of Silicon Valley venture capital, the storied firm has suffered a two-decade losing streak. It missed the era’s hottest companies, **took a disastrous detour into renewable energy....**”*

Source: <https://fortune.com/longform/kleiner-perkins-vc-fall/>

Insight: How cleantech tarnished Kleiner and VC star John Doerr

Source: <https://www.reuters.com/article/us-kleiner-doerr-venture-idUSBRE90F0AD20130116>

Note: We have not verified the accuracy of the Khosla Ventures II and III IRR's referenced above, nor the Preqin data they cite as their source. The information may be inaccurate and we encourage readers to independently verify its authenticity before accepting it as factual.

9) QuantumScape's lead investors have a track record of backing frauds and failures in the EV battery/cleantech industry

We note a “60 Minutes” expose on Khosla, where he pumped his investment in publicly traded Kior just as he’s now pumping QuantumScape

One expert described Khosla’s investments in the space as “a debacle, with billions of investor dollars and tax dollars flushed down the toilet.” In 2014, 60 Minutes aired an investigation that painted these companies as fleecing state and federal governments with over-hyped promises. On air, Khosla heavily pumped his biofuels investment in a company called Kior. He said it had a “magic catalyst” that turned wood into oil “in seconds.” When asked if his outlandish claim of instant “clean green gasoline” was too good to be true and must have a downside, he replied “There is no downside.”

THE CLEANTECH CRASH

Despite billions invested by the U.S. government in so-called “Cleantech” energy, Washington and Silicon Valley have little to show for it



Letter From Sand Hill Road: Vinod Khosla’s Cleantech Portfolio

*“Robert Rapier has some biofuel expertise and has referred to Khosla Ventures’ biofuel efforts as “a debacle, with billions of investor dollars and tax dollars flushed down the toilet. What Khosla didn’t appreciate is that he isn’t smarter than the people in the oil industry.” Rapier suggests that Khosla has **not had a single success** in the advanced biofuels arena, defined as “economically producing biofuels at scale.” – Greentech Media*

1/8/2016

9) Quantumscape's lead investors have a track record of backing frauds and failures in the EV battery/cleantech industry

Case study #1: Kior stock fraud, Bill Gates invested

Khosla appeared apoplectic at the 60 Minutes story, penning a lengthy diatribe where he called them “pontificators” doing “National Enquirer” and “Benghazi-style reporting.” However, the 60 Minutes story was prescient, as Kior – which peaked at \$1.7B market cap - filed for bankruptcy within months. The Attorney General of Mississippi sued Khosla for fraud. The state had loaned Kior \$75MM based on representations it called “false and misleading” and accused him of a “cover-up of the actual yields being achieved in Kior’s pilot and demonstration units.” The complaint is troubling, with the COO saying the CEO had “cooked the books” and telling them he was not “going to be part of this scam.” In our opinion, the complaint makes it obvious Khosla knew Kior’s claims were a hoax, long before he pumped it anyway on 60 Minutes. We believe a pattern similar to that laid out in the complaint may now be playing out with Quantumscape.

SEC Hits Bankrupt KiOR With Fraud Suit Over \$150M IPO

Lawsuit alleges fraud by KiOR executives, investors

Source: <https://www.clarionledger.com/story/business/2015/01/14/lawsuit-fraud-kior-khosla/21765049/>

Excerpts from 67 page complaint, where sections regarding Khosla's role appear to now be heavily redacted

4.69 On February 8, 2012, O'Connor requested that Vinod Khosla and Samir Kaul schedule a time to speak with him concerning the matters outlined above. In an effort to conceal his role and the role of his boss, Vinod Khosla, in the cover-up of the actual yields being achieved in KiOR's pilot and demonstration units, [REDACTED]

Our key takeaways from the fraud complaint

- The “central representation” upon which investor interest in Kior was based - its yield rate – was a hoax. Kior went public based on its claimed yield rate, promoted in its IPO prospectus (S-1).
- The Chief Operating Officer, a Senior Scientist, and others inside the company concluded the company had “misrepresented” yield data in the S-1, which in reality were far lower and therefore unviable.
- The internal investigations conducted by these employees were met with a massive cover-up and what strikes us as retaliation.
- Aside from the Kior's own COO calling the company a “scam,” a Board member also resigned in reaction to the cover-up. Another individual filed a whistleblower action.

9) QuantumScape's lead investors have a track record of backing frauds and failures in the EV battery/cleantech industry

Case study #2: Sakti3, another secretive solid-state startup backed by Khosla, was a fraud with eerie parallels to QS

Sakti3, in which Khosla was the lead investor, claimed have a solid-state battery for the EV market with twice the energy density of lithium-ion batteries. Sakti3 and QS are his two highest profile battery investments. Similar to QS, it was ultra-secrecy with a promotional founder making audacious claims – even being praised by Obama at the White House. Our interviews indicate that it was well-known among battery experts that it was a fraud, The company was dumped for a pittance. A Sakti3 co-founder stated that Khosla's firm "demanded little hard data" and that he sought an investor who "didn't demand a lot of detail" and that he got the investment "with no questions asked."

"In an industry riven with exaggeration and outright lying, Sastri's resistance to sharing even seemingly innocuous performance data...has prompted suspicion that she is evasive for reasons no more complicated than that she has little impressive to disclose." – Steve LeVine article in Quartz, 10/21/2015



Sakti3's quest for a better battery: Hype, funding, promises, and then a surprise sale

“

“The way she was talking, I thought she had already made a battery a meter square.”

”

Source: <https://qz.com/524268/sakti3s-quest-for-a-better-battery-hype-funding-promises-and-then-a-surprise-sale/>; image <https://qz.com/525623/vacuum-cleaner-maker-dyson-is-buying-experimental-battery-startup-sakti3/>

9) QuantumScape's lead investors have a track record of backing frauds and failures in the EV battery/cleantech industry

Case study #2 (cont'd): Sakti3 red flags then are identical to QS red flags today: “there was no one in the battery R&D community that did not think that Sakti3 was a fraud”

The parallels between Sakti3 and QuantumScape are striking: 1) Claiming a solid state battery breakthrough with a novel separator, which a skeptical Scientific American article likened to “the God Battery”; 2) high profile founders with previous R&D credibility; 3) technological “validation” because a large automaker invested (GM), similar to VW’s “validating” QS; and 4) drip-feeding scraps of “data” from tiny, single-layer, non-commercially relevant prototype cells and hyping them as groundbreaking with commercialization right around the corner.

Sakti3 article in Scientific American, 8/20/2014

Secretive Company Claims Battery Breakthrough

The Michigan start-up Sakti3 says its solid-state cells more than double the energy density of today's best Li-Ion batteries

Recent article on QuantumScape, 9/21/2020

An Ultra-Secret Battery Startup Hints That It's Blown Past Tesla — But Won't Show the Goods

Experts question the claim by QuantumScape, backed by \$500 million from Bill Gates, Silicon Valley venture capitalists, and VW

“There was no one in the battery R&D community that did not think that Sakti 3 was a fraud and was not angered by it. Everyone knew. GM invested, and I think, thanks to Khosla, found a greater fool in Dyson to dump it on. They had very, very small cells. They never really showed any performance data. It seemed to be a manufacturing process that would be expensive or impossible to scale up, and it never scaled.” – solid-state expert

“Sastry's peers in the battery industry were intensely skeptical... Among their questions: How many battery layers had Sakti3 stacked? (If it was a single layer, the claim was hardly worth reporting because it would lack a crucial feature known as specific energy density.)” – Quartz article 8/21/2015

9) Quantumscape's lead investors have a track record of backing frauds and failures in the EV battery/cleantech industry

Case study #3: Seeo, another Khosla-backed solid-state flop that also made dramatic claims, had Samsung “validation”

Khosla was the lead investor in a third solid-state startup that also claimed a novel solid electrolyte that doubled the range of EV batteries and had two to three times the energy density. The pattern is again similar to Sakti3 and Quantumscape: dangling groundbreaking data (“testing to over 2,000 cycles”, “commercially viable formats”, “high yield”); promoting its “first pilot line” just as QS has begun to do in recent weeks; and pointing to a major strategic investor, Samsung, as “a vote of confidence.” Bosch bought Seeo for peanuts and killed it off shortly thereafter, in what appears to be a greater-fool transaction like Sakti3.

“...Seeo, one of the hottest advanced battery startups in Silicon Valley

...” Source: <https://qz.com/489123/bosch-is-acquiring-the-advanced-battery-tech-start-up-seeo/>

Dramatic claims...that turned out to be hype

“It’s an all solid state battery. Solid interfaces lead to a more reliable battery. We have groups of cells that have undergone cycle testing to over 2,000 cycles, which is excellent, and we are continuing to improve on that.”

“We have a solid state battery and are developing a product that is targeted at 400 Wh/kg, which is an energy density that is two to three times that of existing products out there,” said Zarem. “When you double the energy density, you almost cut the cost of manufacturing in half.”

Source: <https://cleantechnica.com/2014/12/28/will-seeos-400-whkg-battery-fulfil-expectations/>

Following the acquisition of Seeo, Bosch expects to bring solid-state battery cells to market in 5 years

Fred Lambert - Sep. 16th 2015 7:47 am ET  @FredericLambert

Source: <https://electrek.co/2015/09/16/following-the-acquisition-of-seeo-bosch-expects-to-bring-solid-state-battery-cells-to-market-in-5-years/>

Bosch to discontinue battery research; sell Seeo unit

Source: <https://teslamotorsclub.com/tmc/threads/bosch-to-discontinue-battery-research-sell-seeo-unit.112948/>

9) Quantumscape's lead investors have a track record of backing frauds and failures in the EV battery/cleantech industry

Case study #4: Pellion, a “zero-lithium” battery similar to QS, a “scam” now scrubbed from Khosla Ventures website

Khosla Ventures invested in a lithium-metal battery startup called Pellion. The headlines tell the same story: hype around dramatic claims, followed by failure. A Glassdoor post by what appeared to be a current employee at the time called the company a “scam.”

Glassdoor employee review

Current Employee, less than 1 year

Another MIT scam. A123 was not enough.

Source: <https://www.glassdoor.com/Reviews/Employee-Review-Pellion-Technologies-RVW4400629.htm>

Khosla Ventures website 3/5/2014

“Battery technologies like Quantumscape, Seeo, and Pellion continue to get better, with leaps in energy density and faster charge times.”

Source: <https://www.khoslaventures.com/cleantech-investment-insight-andrew-chung-exploring-decentralization>

Predictable pattern of hype and failure

The next major innovation in batteries might be here

Source: <https://qz.com/1349245/the-next-major-innovation-in-batteries-might-be-here/>

The death of a promising battery startup exposes harsh market realities

Source: <https://qz.com/1717201/khosla-ventures-pulled-the-plug-on-pellion-technologies/>

Khosla Ventures, which has [scrubbed the name](#) of Pellion from its [portfolio](#), did not reply to Quartz’s questions. Its other battery startups are QuantumScape and Natron Energy. It lists two more battery companies, Sakti3 and Seeo, as “alumni” after they were



9) QuantumScape's lead investors have a track record of backing frauds and failures in the EV battery/cleantech industry

Case studies ad nauseum: one flop or scandal after another by venture capitalists now hyping QuantumScape

QuantumScape is little more than a bet on the validation provided by its “smart money” venture capitalists and VW. Their history of involvement in solid-state startups that turned out as frauds and/or failures should give investors pause.

Lightsail Energy - Khosla and Bill Gates investment that claimed success “where Edison and others have failed.”

**“LightSail Energy Storage and the Failure of the Founder Narrative:
A fish rots from the head down.”**

Source: <https://www.greentechmedia.com/squared/letter-from-sand-hill-road/LightSail-Energy-Storage-And-The-Failure-of-The-Founder-Narrative>

Range Fuels – WSJ slams Khosla, who rebuked the paper as “less than ethical.” Range shut down later that year and was sold for a reported \$5MM

The Range Fuels Fiasco

“...Range Fuels has all the plot elements—splashy headlines, subsidies and opportunistic venture capitalists.

Source: <https://www.wsj.com/articles/SB10001424052748704364004576132453701004530>; <https://www.greentechmedia.com/articles/read/WSJ-Bigotry-Lies-and-Abuse-of-Power-or-a-Range-Fiasco>

Fisker – Kleiner Perkins investment burned through \$1.4B, sold in bankruptcy for \$149MM

“As the years rolled by, Fisker observers became increasingly suspicious that the company didn’t even possess a working car...The delays, the secrecy, and the general sketchiness surrounding the company...”

Source: <https://blogs.scientificamerican.com/observations/three-thoughts-on-the-fisker-debacle/>

10. Retail investors are at major risk as the lockup expires and insiders can dump the shares they're pumping

10) Retail investors are at major risk as the lockup expires on April 24th and insiders can dump the shares they're pumping

QS has an early lockup expiration that we believe is fast approaching. We expect insiders to dump stock and race for the exits, as is their pattern. For a preview of what may occur, we note two consecutive trading days – Fri Dec 31, 2020 and Mon Jan 4, 2021 - when the stock crashed ~50%.

On Thursday December 31, 2020, the stock opened at ~\$97/share. By the end of the next trading day, the stock closed at ~\$50. We note that Friday Jan 1 was a market holiday.



10) Retail investors are at major risk as the lockup expires on April 24th and insiders can dump the shares they're pumping

The sudden crash was a mystery to most retail investors.

Even Barron's was confused: "It isn't clear what is driving Quantum stock down." The answer, we believe, was simple.

On Nov 25, QS issued 50MM "PIPE Shares" for \$500MM as part of its SPAC. Holders became free to dump those shares as of 12/31 on 4pm, which we believe they did at the next market open – barely a month after buying them.

QS indicates in SEC filings that it gave resale registration rights to holders of its PIPE shares. At the company's request, the SEC issued a Notice of Effectiveness, effective as of 4pm on 12/31, allowing those shares to be sold. We believe it is obvious that holders of the PIPE shares – purchased at \$10/share – raced for the exits the very next trading day, crushing the stock. Given that the stock traded ~85MM shares that day, we believe all 50MM shares were instantly dumped – barely a month after they were issued.

QS SEC filing indicates 50MM "Pipe Shares" sold on Nov 25 for \$500MM

On November 25, 2020, a number of subscribers (each, a "Subscriber") purchased from the Company an aggregate of 50,000,000 shares of Class A Common Stock (the "PIPE"), for a purchase price of \$10.00 per share and an aggregate purchase price of \$500.0 million (the "PIPE Shares"), pursuant to separate subscription agreements (each, a "Subscription Agreement") entered into effective as of September 2, 2020. Pursuant to the Subscription Agreements, the Company gave certain registration rights to the Subscribers with respect to the PIPE Shares. The sale of PIPE Shares was consummated concurrently with the Closing.

SEC issued Notice of Effectiveness at 4pm on 12/31

UNITED STATES SECURITIES AND EXCHANGE COMMISSION Washington, D.C. 20549	
Notice of Effectiveness	
Effectiveness Date:	December 31, 2020 4:00 P.M.
Form:	S-1
CIK:	0001811414
Company Name:	QuantumScape Corp
File Number:	333-251433

10) Retail investors are at major risk as the lockup expires on April 24th and insiders can dump the shares they're pumping

The largest holders of QuantumScape's stock are its venture capital/private equity backers and insiders – sitting on ~120MM shares or ~30% of the company. At a \$15B market cap, we expect they will be trigger happy to cash in when the lock up expires – much like the PIPE holders on Jan 4th.

Breakdown by holder type, per CapitalIQ

Ownership Summary ¹			
Type	Common Stock Equivalent Held	% of Total Shares Outstanding	Market Value (USD in mm) ²
Institutions ⁵	109,030,469	28.80	5,167.0
Corporations (Public)	86,216,539	22.78	4,085.8
Corporations (Private)	1,340,582	0.35	63.5
Individuals/Insiders	47,630,500	12.58	2,257.2
VC/PE Firms (>5% stake)	55,722,534	14.72	2,640.7
Public and Other ³	78,585,646	20.76	3,724.2
Total	378,526,270	100.00 ⁶	17,938.4

Table of largest holders

Holder ▼	Common Stock Equivalent Held ▼	% Of CSO ▼	Market Value (USD in mm) ▼
Porsche Automobil Holding SE (XTRA:PAH3)	86,216,539	22.777	4,257.4
Khosla Ventures, LLC	35,440,404	9.363	1,750.0
Capricorn Investment Group LLC	24,359,316	6.435	1,202.9
Kleiner Perkins Caufield & Byers	20,282,130	5.358	1,001.5
Singh, Jagdeep Co-Founder, Chairman, President & CEO	17,577,153	4.644	868.0
Qatar Investment Authority	14,308,051	3.780	706.5
Holme, Timothy Co-Founder & CTO	13,484,992	3.563	665.9
FMR LLC	12,500,000	3.302	617.3
Prinz Ph.D., Friedrich Co-Founder,	12,143,959	3.208	599.7

10) Retail investors are at major risk as the lockup expires on April 24th and insiders can dump the shares they're pumping

Key QS holders appear to have a pattern of dumping their stock when lockups expire. The QS CEO's only other IPO was Infinera (ticker: INFN), in June 2007. The largest holders – venture capitalists like Khosla/Kleiner Perkins – appear to have dumped 100% of their stock within 5 months – presumably right at lockup expiration.

Largest INFN holders right after IPO – most of them sold down to zero shortly thereafter, per CapitalIQ

Holder	Jun-30-2007	Sep-30-2007	Dec-31-2007	Mar-31-2008
Kleiner Perkins	6,422,311	6,422,311	6,422,311	0
Caufield & Byers				0
Mobius Venture Capital, Inc.	5,364,334	5,364,334	5,364,334	
FMR LLC	4,198,900	4,923,251	13,565,081	13,777,791
RWI Ventures	3,450,269	3,450,269	0	-
Singh, Jagdeep Co-Founder	2,693,143	2,524,393	2,524,393	2,412,393
Benchmark	2,657,763	2,657,763	2,657,763	2,657,763
Marsico Capital Management, LLC	2,647,140	2,738,135	2,201,505	0
Advanced Equities Investments XXVII, LLC	2,443,494	2,443,494	2,443,494	0

11. A fake timeline and fake projections to grease the pump

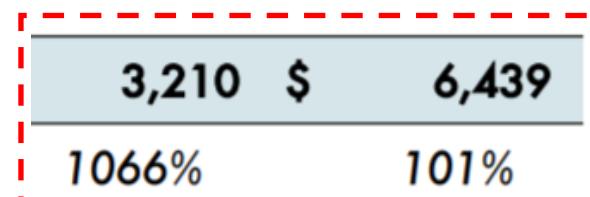
11) A fake timeline and fake projections to grease the pump

SPAC's are free to promote absurd financial projections and timelines that are illegal in a typical IPO. The current SPAC mania is partly fueled by insiders exploiting this loophole to lure retail investors, setting them up as bagholders for the pump and dump, when the lockup expires and they cash in. We think QS is a textbook case.

Quantumscape projects a hockey stick revenue ramp in 4 years, reaching \$3.2B and \$6.4B by 2027/2028 with \$808MM and \$1.6B in EBITDA, respectively – approaching Google and Apple margins.

Summary Financials						
\$ in millions	2022E	2023E	2024E	2025E	2026E	2027E
Manufacturing capacity						
Total Production Capacity (GWh)	0	0	0.25	0.75	6	46
QS-1 Pilot (1 GWh)	0	0	0.25	0.75	1	1
QS-1 Expansion (20 GWh)	0	0	0	0	5	15
QS-2	0	0	0	0	30	70
Income Statement						
Revenue	-	-	\$ 14	\$ 39	\$ 275	\$ 3,210
% Growth			NM	181%	614%	1066%
Gross margin	-	-	\$ 0	\$ 2	\$ 73	\$ 1,006
% Margin			1%	5%	26%	31%
EBITDA	\$ (102)	\$ (114)	\$ (130)	\$ (120)	\$ (59)	\$ 808
% Margin			NM	NM	NM	25%
FCF (after project financing)	\$ (137)	\$ (169)	\$ (222)	\$ (691)	\$ (1,346)	\$ (533)
No Capacity After QS-1 Expansion (20GWh):						
FCF (after project financing)	\$ (137)	\$ (169)	\$ (222)	\$ (312)	\$ (289)	\$ (17)
2H2020E - 2021E FCF: \$(184)mm						
Quantumscape	Note: Non-GAAP financial metrics. Figures represent 50% of revenue and 50% of costs for QS-1 cell factory. Revenue includes margin for sale of separator to QS-1 cell factory. Adjusted EBITDA is defined as earnings before interest expense, interest income and other income, taxes, depreciation, amortization, and stock-based compensation. FCF is defined as cash provided by operating activities less purchases of property and equipment net of asset / project financing.					

Revenue 2027, 2028



EBITDA 2027, 2028



11) A fake timeline and fake projections to grease the pump

QuantumScape's valuation of \$15B requires a leap of faith from making lab prototypes to selling billions of dollars of batteries within 5-6 years, with Google-like margins.

However, all 9 ex-employees we interviewed painted this as a mirage. We asked one if QS would have a product in a car in 10 years: “Absolutely not”

Our research interviews suggest that even if the scientific claims were real, simply meeting the required steps to work with an automotive OEM are at least a decade away, with meaningful commercialization even further out.

Q&A during our research consult call

Q: “Is QuantumScape going to have a product in a car in the next 10 years?”

A: **“Absolutely not.”** – Former employee

Adding up the timelines for each step implies at least a decade

“Let’s just talk about where they’re at. They’re at this pre-pilot stage, and then they’re going to need to build. So, they’re going to spend a couple of years on pre-pilot, and then they’re going to spend a couple of years on the pilot, and then they have to prove that that works, and then they have to get it designed into a vehicle, which if it’s Tesla, it’s three years. If it’s Volkswagen, it’s 5 or 6 years. They have to build a factory. They have to qualify the factory. The factory is making something that’s never been made before on any kind of industrialized scale. In parallel, they need to set up the supply chain for whatever material system they land on.” – Former employee

11) A fake timeline and fake projections to grease the pump

Ex-employees assess any shot at commercialization as over a decade away – sometime in the 2030's – and underscored the difficulty “to make solid-state batteries real”: “a super-difficult problem, like, basically, Nobel Prize-winning work needs to be done,” per an ex-employee quoted earlier.

To believe QuantumScape's timeline and financial projections, one has to assume that this “Nobel Prize-winning work” has already been done and that giant solid-state factories are around the corner.

“If you talk about commercializing QuantumScape's cell, I feel like it's a good decade away, if not more. I mean, you can build all of your concept cars and take them to the test track, but for a conventional passenger car to come out with your batteries, I think it's going to be quite some time before people see that mainly because of two things. Handling lithium metal requires a whole new infrastructure, in general. You can build all of these coin cells, scale it up to single-layer pouch cells, that's possible. But getting to multi-layer from single-layer and then the production part of things, that's actually going to be a huge step.” – Former employee

Source: Scorpion Capital consultation calls with experts

11) A fake timeline and fake projections to grease the pump

VW employees we consulted also disputed the CEO's projections and promotional claims: “Realistically speaking, there's nothing before 2030”; 2028 as earliest possible date for solid-state “show car” for testing; “we don't have the solid-state battery in the pipeline”

A VW employee in the EV battery group was completely dismissive of and rejected QuantumScape's purported timing, indicating there are so many questions about solid-state batteries that it's at least a decade away.

“We will start with a solid-state vehicle, a show car for testing, going into homologation at the earliest in 2028 and maybe have the first press announced in 2026. Physically and as far as life cycle, it's not possible to talk about this technology earlier. It's connected with so many other things and long-term contracts...So, realistically speaking, there's nothing before 2030.” – VW employee

“We don't expect to utilize solid-state batteries for the mass market before 2030. Maybe there are some small series in premium cars. We still have a roughly 5 to 8-year road ahead of us. So for the next five years, certainly not, because for the next five years, everything is basically already set with established suppliers and with current cells and cell technology.” – VW employee

Source: Scorpion Capital consultation calls with experts

11) A fake timeline and fake projections to grease the pump

Our VW consults indicate that suppliers and contracts are already locked in for next 5 years – and don't include solid-state batteries. Given 5-year OEM roadmaps, VW must commit to ~\$10B in QS batteries within a year or two for 2027/2028 revenue ramp and timeline to be true – a delusion, given VW skepticism of QS lab-scale cells.

We fail to see how QS will ramp sales to \$275MM in 5 years and to \$3.2B and \$6.4B in the 2 years thereafter, given 5 year lead times in the auto industry. QuantumScape's projection of ~\$10B in revenue booked in 2027/28 means that VW has to commit to substantial purchases of solid-state batteries by 2022/23 – an absurd notion, given the VW concerns and questions we detailed earlier.

"First of all, for the next five years, at least until 2025/2026, the contracts and roadmap in the entire automotive industry, maybe except for Tesla, but everybody else who has an established system and supply chain, it's all set already. I can tell you exactly what cars with which battery will be produced and sold in 2025, and it's definitely not - we don't have the solid-state battery in the pipeline." – VW employee

Source: Scorpion Capital consultation calls with experts

11) A fake timeline and fake projections to grease the pump

VW indicates that just getting comfortable with solid-state cells is years away - “this foundation will take at least 5 more years and then production needs to be planned”. Even if VW commits to QS at that point, 5-year lead times for production roadmaps imply a QS revenue ramp between 2030-2040 - if the science is real.

The combination of VW's current skepticism of Quantumscape's technology and 5-year advance planning for production schedules, supplier contracts, etc. in the automotive industry suggest that even if the science was real, and all questions related to manufacturability, scalability, cost, etc. were resolved favorably, then Quantumscape has a shot at ramping revenue sometime in the 2030's.

“Vehicles need to be homologated in each and every single market, and **there are so many questions** also when it comes to the lifetime and other aspects of solid state batteries. **We have no clue how solid state technology behaves** in extreme temperatures, in crash situations, over a longer period of time, and this needs to be tested and evaluated. **This foundation will take at least five more years, and then production needs to be planned, ramp-up, the facilities, and so on.”** – VW employee

Source: Scorpion Capital consultation calls with experts