Ensurge Micropower

Technical Follow-Up Report

Executive summary

Ensurge Micropower ("Company", "Ensurge"), a solid-state battery company specializing in very small batteries for microelectronics applications, reports significant progress in recent months in refining its innovative product. Ensurge's efforts aim to strategically position the company for potential large-scale manufacturing in the future.

This follow-up report seeks to monitor and spotlight the advancements in product development since our initial technical assessment published in September 2024. Ensurge Micropower reports significant advancements in its product development process, driven by increased manufacturing volumes and enhanced technical expertise. The company reports that these improvements have significantly accelerated the learning cycle and product enhancement cycles from weeks to just days. Key product development variables as reported by the company are:

- ***Stack yield improvements***

Ensurge reports significant improvements in the yield of their multi-layered batteries ("stacks"), with over 80% yield for cells using a 10µm stainless steel substrate (targeted for future commercial sales) and over 90% for those using a 75µm stainless steel substrate (for learning purposes). They have increased the achievable stack layers from 11 to 28, enhancing overall commercialization potential. These gains are credited to process improvements such as eliminating trapped air pockets in the lamination adhesive.

- ***Improvements in charging speed and pulse performance***

The company reports improvements in charging speed. It now only takes 8 minutes to charge an Ensurge battery to 80% capacity and less than 24 minutes to fully charge. The company also reports improvements in pulse performance. The batteries can now deliver up to 50mA pulses. This is a significant result for electronic devices with intermittent signal and data transmission profiles, such as Bluetooth devices. The company reports that the charging speed and pulse performance enhancements are due to manufacturing improvements that have reduced the battery impedance levels.

- ***Parasitic leakage issues have been addressed***

Ensurge reports that parasitic leakage (undesired discharge processes) experienced with the previous products has now been addressed. The leakage was traced to moisture intrusion and residue from the production process. The solution involved optimizing laser processing and a new patent-pending process. Surface engineering and a new layer within the stack were also introduced. Having identified and addressed these issues makes the lifetime, reliability and viability of Ensurge's batteries much greater.

- ***Improved cycling and higher coulombic efficiency***

The totality of improvements in surface engineering, parasitic leakage, stack yield improvements, and identified production improvements to be implemented have led to a consistently high coulombic efficiency, i.e. the ratio of charge in to charge out, directly translating into batteries that live longer and perform more as per expectation.

The technical advancements that Ensurge Micropower has shown over the last few months show great promise in their ability to deliver on both their technology- and production aspirations. Meaningful technical performance improvements have been demonstrably shown over multiple cycles and production batches, showcasing that the company is making strides and entering a very exciting phase towards full commercialization. However, as with all scale-ups, especially in the solid-state battery industry, the path forward is also full of risks, and investors are encouraged to monitor the progress and make independent assessments also in the time ahead.

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Key highlights

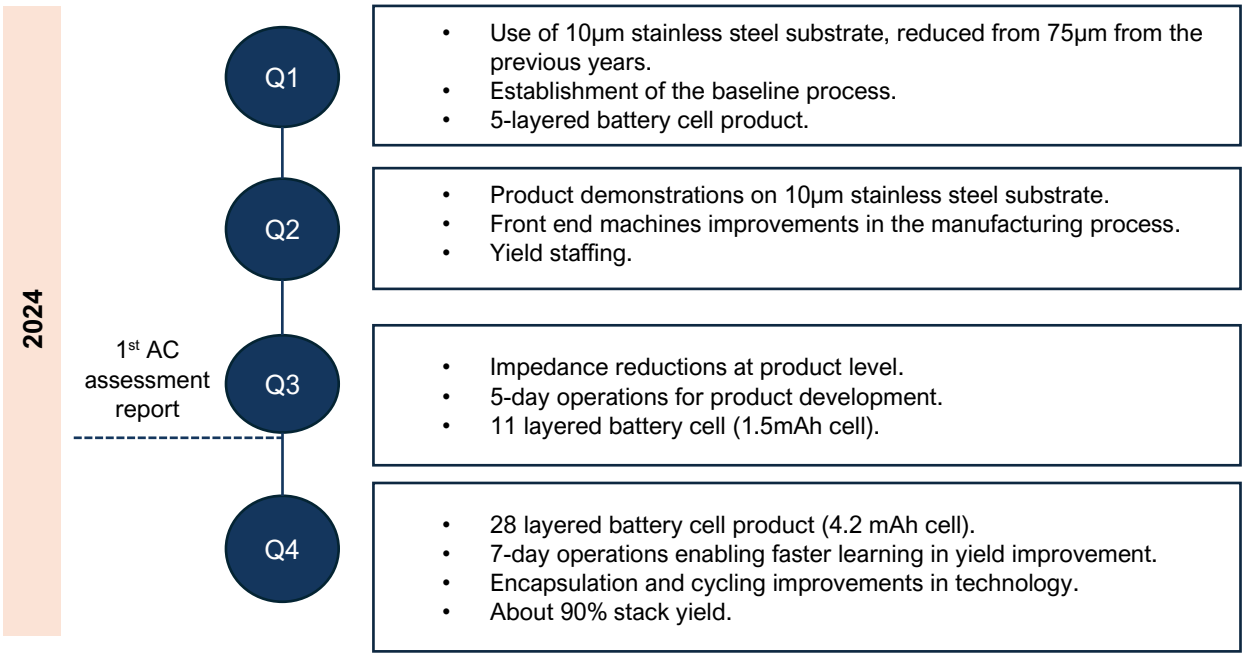
Background

In September 2024, Accelerate Capital ("AC"/ "We") conducted an independent technical assessment of Ensurge Micropower ("Ensurge"/ "Company"). The findings of this assessment were published in a comprehensive report detailing the company's profile and market segment for its technology, technology innovation and differentiation, potential market share for its solid-state micro battery, production- and scaling ambitions, and key technological variables worth improving. This document serves as an updated follow-up to that initial report, reflecting recent developments implemented by Ensurge Micropower as of January 2025. We recommend reading the first report to fully comprehend this follow-up report as it builds directly on aspects comprehensively elaborated in the first report. It is essential to clarify that this follow-up report is based exclusively on documentation provided by Ensurge Micropower and interviews with senior leadership of the company to highlight recent product developments within the company. This report does not include physical verification, on-site inspection, or third-party validation of the technical updates reported at the product development level. Moreover, this update report only focuses on product-related development changes and does not include broader parts of the Company's assessments, such as offtake agreements, licensing agreements, or cost components, some of which were evaluated in the first report.

Status Timeline

The product development milestones reported by Ensurge Micropower in 2024 demonstrate continuous efforts to enhance both overall cell performance and manufacturing processes as outlined below.

Product Development Status



Source: Ensurge Micropower, Accelerate Capital Research ™

The September 2024 report reported the technical and commercial status of Ensurge with risks and opportunities.

As of September 2024, the first Ensurge Technical Evaluation report provided critical insights into the Company's product development trajectory. The achievement of an 11-layered cell on a 10µm flexible stainless steel substrate marked a significant milestone. Ensurge also highlighted over 500 cycles at a 5C pulse discharge rate as their target, a notably ambitious but promising durability and performance metric. The report clearly stated both opportunities and risks associated with the company's development stage at the time, which the following report will also elaborate upon.

Product Development Challenges as of September 2024

In September 2024, Ensurge's batteries were evaluated to be an advanced proof-of-concept.

As of September 2024, Ensurge's progress thus far was evaluated to be an advanced proof of concept, with the key goal going forward being the ability to scale production at a reasonable yield. Increasing the number of layers within a stack to enhance overall capacity remained a priority, alongside improving stacking yields. At the time, we highlighted that stacking yield was a key factor in scaling up battery size, as any defective layer in a stack could compromise the cell's capacity or render the entire battery unusable. Furthermore, minimizing failure rates of individual unit-cells (single layers) was identified as essential to reducing scrap rates and, consequently, optimizing material, energy, and manufacturing efficiencies.

We proposed the following product variables as critical metrics for assessing Ensurge's product development progress.

- **Increasing number of layers within a stack**: Ensurge Micropower stated their ambitions to increase the number of layers within a stack from 11 to a higher number so as to improve capacity and expand the pool of addressable applications.
- **Improving quality control of unit-cells:** The ambitions to increase the number of layers within a stack directly necessitated improving quality control of the performance of individual unit-cells to reduce high uncertainty of faulty layers and improve overall stacking yield.
- **Increasing success rate of unit-cells:** It was also important for Ensurge to increase their understanding of why certain unit-cells worked and others didn't to increase manufacturing yields and to improve material efficiency.

Product Development Highlights

Ensurge has quicker learning cycles due to strategic staffing and higher manufacturing throughput.

As of March 2025, Ensurge Micropower reports significant advancements in their learning cycles, achieved by prioritizing yield optimization and product performance enhancements in Q4 2024. These improvements reported by the company have been facilitated by strategic operational adjustments, including the implementation of a seven-day operations schedule. Ensurge has added new competence to the team, such as a dedicated yield engineer to focus on yield improvements, as well as strengthening the team with product-, process-, and equipment engineers. As a result, manufacturing volumes were substantially increased according to the company. Consequently, the overall learning cycle, which previously spanned several weeks, has been reduced to days, accelerating product development and operational efficiency. Ensurge reports improvement in the following technical product parameters.

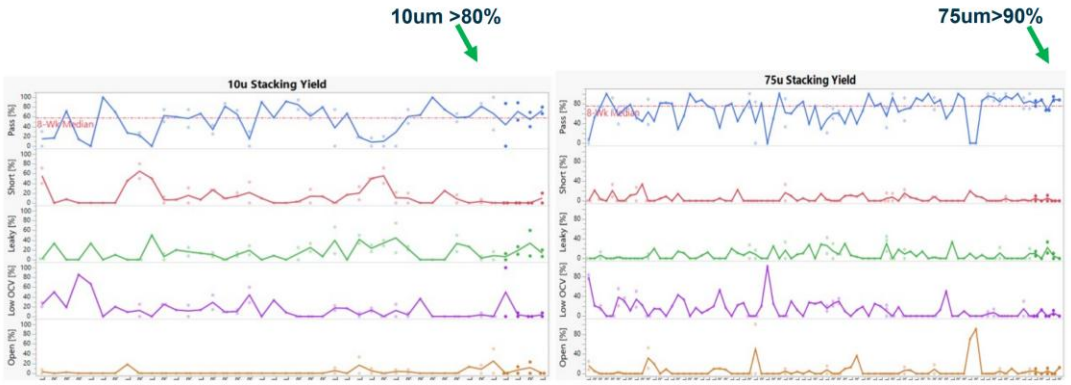
1. Stack Yield Improvements

Stack yield has improved to 80% for the 10µm substrate cells and 90% for the 75µm substrate cells.

Yield improvements have facilitated the move towards 28 layer cells, up from 11 layers.

What has been improved?
Ensurge reports they achieved significant improvements in stack yield, which is the percentage of functional multi-layered battery cells that are successfully produced. They now report achieving over 80% stack yield for 10µm substrate-based cells and over 90% for 75µm substrate-based cells. The use of the 75µm substrate appears to be primarily for learning and process optimization, while the 10µm substrate is the main sellable product. This is a crucial step, given the need for high yields in multi-layer stacking to achieve viable battery capacities. The improved stack yield has enabled the company to move towards 28-layer batteries, which is a substantial increase from the 11-layer batteries previously focused on and marks a significant milestone achieved.

Stack yield metrics



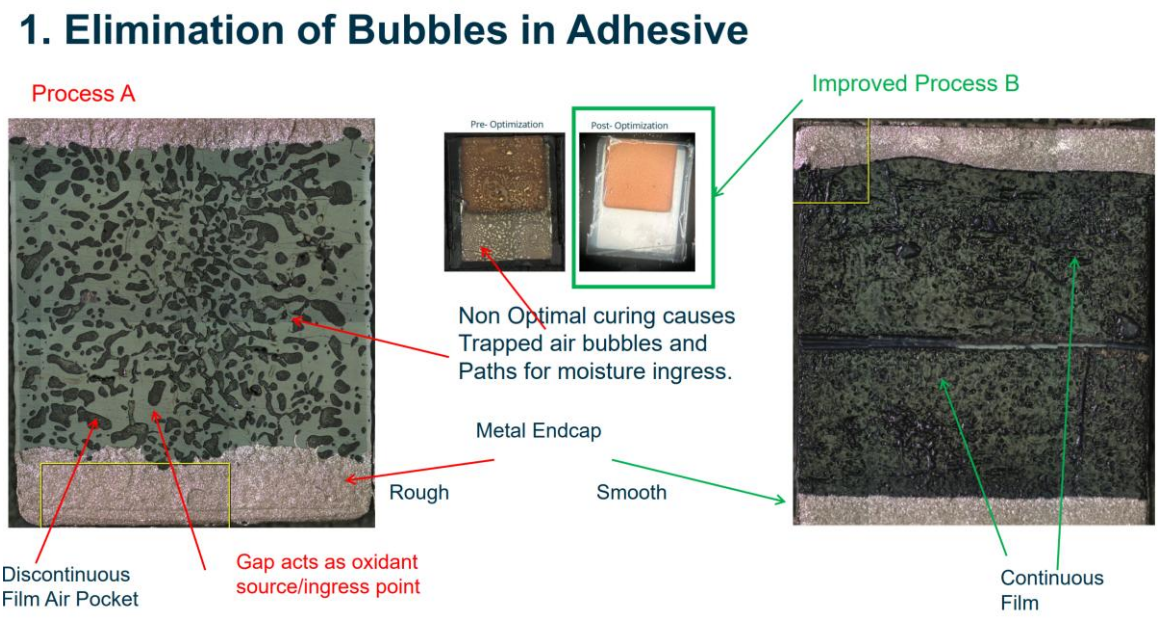
Source: Ensurge Micropower

Both optimized process control and sourcing higher quality materials have led to better yields.

How was this achieved?

A key factor in improving stack yield was identifying and eliminating the issue of trapped air pockets in the adhesive used for laminating the layers. This was achieved through optimized vacuum curing and annealing processes. Improvements in materials also played a role, with the introduction of pre-coated stainless steel eliminating in-house processing steps and increasing reliability. The implementation of statistical process control (SPC), combined with a dedicated yield engineer and stack engineers, enabled better understanding and control of the manufacturing process. Furthermore, a new, innovative way to remove the stacked cells from their carrier without introducing stress has also been implemented.

Elimination of Bubbles in Adhesive



Source: Ensurge Micropower

Better stack yields directly translates into more sellable products, an expanded product range with a larger addressable market, and reduced costs.

What are the broader implications for the company?

The improved stack yield is fundamental for scaling up production, as it directly impacts the number of functional batteries that can be produced. This also allows for a greater possible battery capacity by enabling larger stack heights without an increased failure rate. These aspects translate directly into increasing their addressable markets and open market segments which could pay meaningfully higher for the technical performance of the larger stack sizes. The shift towards 28-layer batteries demonstrates that the company is progressing materially beyond the initial stages of development. The combination of material and process innovations indicates that Ensurge is demonstrating a deeper understanding and mastery of the complexities involved in manufacturing solid-state batteries than in September 2024. Improved yields will also reduce scrap rates, directly decreasing costs, material usage, and energy consumption.

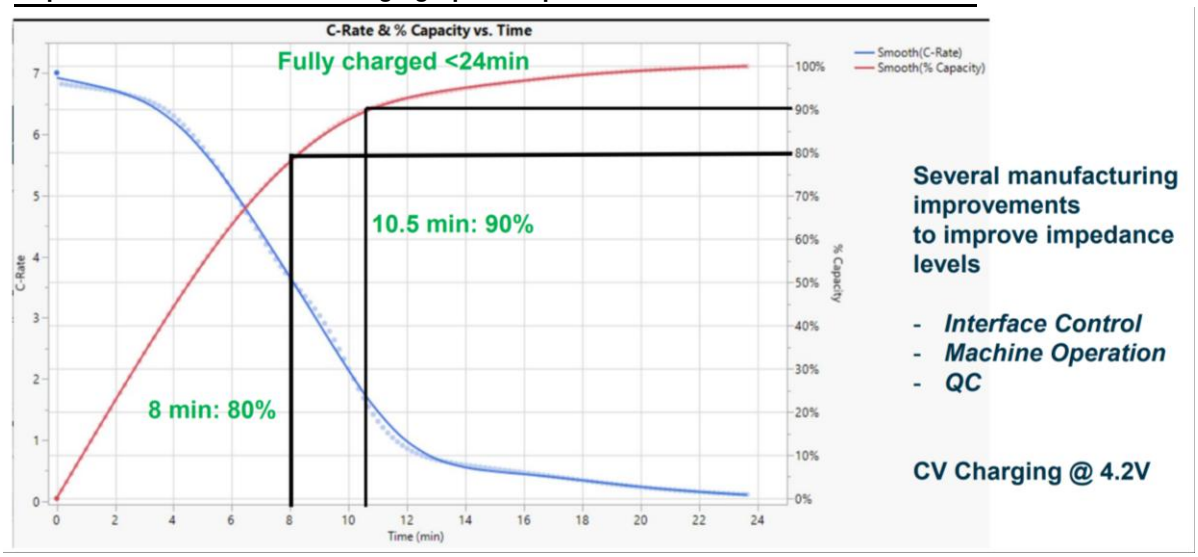
2. Improved Charging Speed and Pulse Performance

Charging speed is now only 8 minutes for 80% capacity.

Pulses of 50 mA (12.5C), up from 20mA (5 C) has been achieved.

What has been improved?
Ensurge reports that they have carried out several manufacturing improvements to reduce impedance levels through interface control, machine operation and quality control. As a result, this has dramatically improved the charging speed of their batteries. It now takes only 8 minutes to charge a battery to 80% capacity and less than 24 minutes for a full charge. The battery's pulse performance has also been enhanced. They can now deliver 50mA pulses (12.5 C), up from the previously reported 20mA (5 C). This level of pulse performance is crucial for applications like wearables that require short bursts of high power.

Impedance Reduction and Charging Speed Improvement



Source: Ensurge Micropower

Reduced impedance leads to a higher battery quality. This was achieved through better interface control.

Faster charging and higher pulse rating improves commercial viability, especially for Bluetooth devices and consumer electronics.

How was this achieved?
The reduction in charging time is attributed to various manufacturing improvements that reduced impedance levels within the battery. These improvements include better interface control, optimized machine operation, and enhanced quality control. The increase in pulse performance is related to better overall cell design as well as the reduction in impedance, which allows for the delivery of higher currents.

What are the broader implications for the company?
The faster charging speed makes Ensurge's batteries more appealing for consumer electronics where quick charging is a key selling point. The ability to handle higher pulse currents makes them well-suited for demanding applications like Bluetooth-enabled wearables that require intermittent high power draws. These performance improvements suggest an improved efficiency in the cell electrochemistry, kinetics, and advancements in the cell manufacturing process. The high C-rate (up towards 12.5 C) capabilities are likely attributed to high surface-to-volume ratios of thin films.

3. Encapsulation to Improve Packaging and Reduce Leakage Issues

Multiple complicated issues led to parasitic losses in the battery.

What has been improved?
A major challenge faced by Ensurge's battery was parasitic leakage within the cell and stack during the charging process. This issue has now been addressed, with the problem traced to moisture intrusion and residue from the production process. The leakage was caused by a combination of air pockets in the adhesive layer and residual contaminants from the patterning of the LiPON electrolyte and subsequent metallization. These factors created unintended conductive pathways between the cathode and anode, leading to short circuits.

An updated design and optimized production processes have eliminated much of the problem causes.

How was this achieved?
The solution involved eliminating trapped air pockets through optimized vacuum curing and annealing methods. Surface engineering and a new layer within the stack was introduced to eliminate issues with the lithium and residue from the production process, with a new design to prevent short circuits forming. The company also determined that the external encapsulation of the battery was not the root of the problem, allowing them to focus on internal battery issues. Furthermore, the Ensurge team is now

Quality assessments are done during three separate phases: after unit-cell singulation, after stacking and for the finished product.

validating the product quality at three separate steps of the production process; after unit-cell singulation, after stacking, and the finished, shippable product.

What are the broader implications for the company?

Solving the leakage problem significantly improves the reliability and lifespan of the batteries, which is critical for commercialization. The improved encapsulation methods also enhance the overall safety of the batteries. The ability to diagnose the source of the problem, and solve it without reinventing the encapsulation process, demonstrates a solid understanding of the battery's internal dynamics. The current process is also potentially generating new IP that Ensurge could protect, with further potential for long-term advantages. Higher throughput and shorter learning cycles combined with a rigid and extensive testing scheme is critical to the success of the product, and ultimately the company. Encapsulation however remains one of the main focus areas that the company needs to solve in order to arrive at products which will be accepted in the market. Current progress on this front is promising, but needs to remain under observation.

Safety, reliability, and lifespan of the batteries are all improved with solved leakage.

Encapsulation remains a key issue to observe for the company.

4. Other Technical and non-Technical Details

Additive Processing

Implementation of additive processing improves production- and machine utilization efficiency.

The implementation of additive processing for manufacturing thinner and faster layers is highlighted by Ensurge to be a key innovation that significantly improves production- and machine utilization efficiency. Ensurge also mentioned several processing conditions that have greatly enhanced its stack yield efficiency which include pressure control lamination, stack release methods, and optimized and simplified atmosphere control. Improved tape quality has also been an outsourced factor which has benefited the process.

Dedicated Staff, Training and Standardized Procedures

Much of the success of the company hinges on the quality and skills of the staff.

The senior leadership team at Ensurge attributed much of their technical product development success to strategic investments in staffing, training, and the implementation of standardized procedures. These initiatives have significantly enhanced the organization's overall technical performance. To date, Ensurge has onboarded a team of 33 highly skilled engineers, researchers, scientists, and manufacturing technicians whose expertise and contributions have been instrumental in driving advancements in the development process.

5. Key Variables to Evaluate Ensurge Going forward

Ensurge has demonstrated encouraging advancements in product development, showcasing several promising features. However, it is imperative to closely monitor progress to ensure that the achieved technical parameters are consistently reproducible, particularly when scaling for high-volume production. Below, we outline critical variables essential for maintaining quality, reliability, and operational efficiency at scale – factors that should be carefully considered and monitored when evaluating the company's progress and future developments.

Sustained High Stack Yield

Maintaining and continuously improving high stack yields, exceeding 80% for 10µm substrates and 90% for 75µm substrates is paramount for achieving scalability in large-scale production. These benchmarks are essential to ensuring operational efficiency, minimizing waste, and optimizing overall manufacturing performance. It also translates directly into more sellable products.

Pre-Stacking Quality Control

While the current strategy prioritizes singulation and collection of high-quality unit-cells, developing a reliable method to predict the performance of individual unit cells prior to stacking is critical for long-term optimization. This capability would significantly reduce scrap rates, enhance stacking efficiency, and further improve overall yield in large-scale production. This becomes particularly critical at scale, as the material costs associated with faulty cells prior to stacking can have a substantial impact on the overall economics and cost-efficiency of Ensurge's production process.

Cycling Consistency and Reliability

Demonstrating consistent and reliable cycling data under various operating conditions and charge rates is crucial to proving performance for potential customers. Depth-of-discharge data is also essential. For most solid-state battery companies, the ultimate benchmark is the ability to showcase cycling lives that exceed the life expectancy of their target products. Achieving this is a monumental task. While solid-state batteries currently offer fewer cycles compared to traditional lithium-ion batteries, their larger capacities can somewhat offset this limitation by requiring fewer cycles to achieve the same product lifetime.

Sustained Leakage Prevention

Ensurge has developed several innovative methods to address parasitic leakage in their stacks, with the added potential to generate valuable intellectual property. To ensure scalability for large-scale production, the long-term effectiveness of these solutions must be rigorously validated. Data should consistently demonstrate reliable cycling performance, with leakage consistently maintained below defined thresholds, across multiple samples and production batches. This will be critical in establishing and maintaining product quality and reliability over time.

Process Stability

Monitoring the stability and consistency of new manufacturing processes, such as vacuum curing, annealing, additive printing, and lamination processes, is essential for identifying potential areas of optimization. Ongoing assessment of these processes will enable the early detection of inefficiencies and support continuous improvement efforts to enhance overall production quality and yield.

6. Additional Observations

Ensurge has reported promising progress in product development, positioning the company on a trajectory toward delivering a market-ready solution capable of meeting the demands of wearables and other micropower applications. However, as is often the case in product development, long-term success hinges on the ability to scale manufacturing operations. Ensurge has yet to reach this critical stage. Large-scale manufacturing introduces a range of challenges, including optimizing production speed, refining supply chain efficiencies, navigating manufacturing and process complexities, ensuring robust quality control at scale, and securing offtake agreements to support sustained growth. Though not elaborated upon in this follow-up report, addressing these factors will also be important parameters for Ensurge to unlock the full potential of the product in the market.

While Ensurge's product improvements are commendable, it is important to acknowledge that the company is still in the scaling phase. As such, the risks associated with large-scale production, as outlined above, remain inherent and will need to be managed moving forward. As far as the authors can ascertain, the company has made significant progress in delivering on multiple technical and manufacturing milestones compared to its status in September 2024. The insights provided in this report are intended to equip readers with tools to critically assess the company's future developments; however, any conclusions drawn remain subject to individual interpretation and evolving circumstances.

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With our exceptional combination of skills, knowledge, and networks, we are committed to providing and supporting innovative and sustainable solutions to the most pressing climate-related challenges. Whether it's developing promising startups or supporting established businesses with business development and funding to grow and scale, we strive to make a meaningful impact in the fight against climate change

Accelerate is a comprehensive and multifaceted platform that provides an all-encompassing suite of services for businesses operating in the climate-related sectors including support within strategic decisions, technical due diligence, market analysis, R&D, business development, customer acquisition, partner development, industrial establishment in new markets, public funding and regulatory and political insights. Our main office is in Norway while our partners and clients span USA, Europe, Asia and Africa.

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