Power 3D:
From technological promise to market validation

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ABSTRACT

Title: *Power 3D: From technological promise to market validation*

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This Thesis explores how an early-stage deep-tech venture can move from technological development to market validation when its resources, team capacity, and commercialization options remain limited. The Case focuses on Power 3D, a startup developing customized microbattery solutions based on 3D-printed electrode technology. By March 2026, the company had reached an early prototype stage and was considering potential applications in wearables, hearables, and medical devices. Yet, its limited resources and still-evolving technical validation made it difficult to advance several market opportunities at the same time.

The central dilemma was therefore which initial market and commercialization path could generate the most credible evidence of customer value. The analysis assesses the company's strategic options by considering market attractiveness, customer adoption dynamics, competitive conditions, resource constraints, and the credibility signals required by customers, partners, and investors.

The Dissertation concludes that Power 3D should prioritize a focused beachhead strategy, targeting an application where customized battery geometry creates clear customer value and pursuing validation through partner-led co-development, allowing the company to align technical development with real customer requirements, produce stronger market evidence, and build a credible foundation for future growth.

The Thesis is divided into three sections: Case Study, Literature Review, and Teaching Note. Together, they connect the empirical case with academic research on technology commercialization, beachhead market selection, strategic positioning, and early-stage venture development.

Keywords: Deep-tech venture; Technology commercialization; Beachhead market; Market validation; Strategic positioning; Early-stage startup; Competitive differentiation.

RESUMO

Título: *Power 3D: Da promessa tecnológica à validação de mercado*

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Esta Dissertação analisa como uma empresa deep-tech em fase inicial pode passar do desenvolvimento tecnológico à validação de mercado sob limitações de recursos, equipa e comercialização. O Caso centra-se na Power 3D, startup que desenvolve microbaterias personalizadas baseadas em elétrodos impressos em 3D. Em março de 2026, tinha atingido um protótipo inicial e avaliava aplicações em wearables, hearables e dispositivos médicos. Contudo, recursos limitados e validação técnica incompleta impediam explorar várias oportunidades simultaneamente.

O dilema central era identificar qual mercado inicial e qual caminho de comercialização poderiam gerar evidência credível de valor para o cliente. A análise avalia as opções estratégicas considerando atratividade do mercado, adoção do cliente, concorrência, restrições de recursos e sinais de credibilidade exigidos por clientes, parceiros e investidores.

A Dissertação conclui que a Power 3D deve priorizar uma estratégia de beachhead focada, selecionando uma aplicação em que a geometria personalizada da bateria crie valor claro e validando-a por meio de codesenvolvimento com parceiros. Isto permitiria alinhar o desenvolvimento técnico com requisitos reais dos clientes, produzir evidência de mercado mais forte e construir uma base credível para crescimento futuro.

A Dissertação inclui Estudo de Caso, Revisão da Literatura e Nota de Ensino, ligando o caso empírico à investigação sobre comercialização tecnológica, seleção de mercado beachhead, posicionamento estratégico e desenvolvimento de empresas em fase inicial.

Palavras-chave: Empresa deep-tech; Comercialização de tecnologia; Mercado beachhead; Validação de mercado; Posicionamento estratégico; Startup em fase inicial; Diferenciação competitiva.

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Lastly and most importantly, I would like to express my deepest gratitude to my family, especially my parents, for their unconditional love, guidance, and support. They have always given me the opportunity to shine and to pursue my ambitions; without them, I would be nothing.

To all of them, I would like to dedicate this Thesis.

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CASE STUDY [1]

March 2026, in Carnegie Mellon University's laboratories, Peter Scott, the CEO and founder of the American Power 3D startup, reviewed yet another wearable prototype and was struck by the same recurring bottleneck: in wearables, hearables, and medical devices, the battery often ended up being the widest, bulkiest, or thickest component, shaping comfort, aesthetics, and adoption. (see Exhibit 1)

Power 3D strongly believed that its single 3D printing customized approach could potentially change the market and establish itself in the high-tech market worldwide.

With its technical milestones, limited room for error, and need for progress, Peter Scott had to determine what the American startup would build, whom they would build it for, and what validation would mean for them in the future.

The foundation

In the founder's own words, Power 3D was founded in January 2023, in the setting of a university-born deep-tech venture, as a promising invention searching for the right problem to solve. Initially, the motivation was vague and intuitive: "batteries need more energy".

The challenge was not only a technical problem but also a management problem: to move from an invention developed in the university walls to a real company.

The venture was founded as a small entity with defined roles: Peter Scott as CEO and founder, Alex Sanchez as CTO, and two academics, Rahul Panat and Jonghyun Park, as technical advisors. The core technology that Power 3D used actually came from Professors Panat and Park. Their research labs at Carnegie Mellon University and the Missouri University of Science and Technology gave the startup a solid tech base and a research background right from day one.

The initial configuration of the founding team was a double-edged sword, since it was necessary to ensure the scarce technical skills and the continuity they provided. Moreover, the initial configuration of Power 3D was never intended to be stable for very long, and in September

[1] The company-specific information presented in this case is based on primary material provided directly to the author by Peter Scott, founder and CEO of Power 3D. This material includes written answers shared via email and Power 3D's pitch deck, both used for the development of this dissertation. Publicly available information, academic sources, and market data are cited separately where relevant.

2023, Alex Sanchez left as he needed a steady paycheck, while Jonghyun Park couldn't continue as an advisor since he was about to start a competing firm in batteries.

The new company needed to start considering how it wanted to approach the market, customers, and potential investors. Specifically, on the value proposition, which was based on the idea that 3D-printed electrodes made customization of battery shapes possible, allowing for better energy density in a small clarbattery. (see Exhibit 2)

The shape of the battery was far from a minor thing in smaller devices; in reality, it often dictated how the device itself would be made. Therefore, Power 3D was presenting its innovation as a way of getting around the limitations prevailing in the market.

However, they still needed to demonstrate their value, and that demanded a market focus, along with a sound market plan.

2023–2026: narrowing the market focus through customer discovery

Between 2023 and 2026, Power 3D carried out an extensive customer discovery process to connect its technology to a concrete market need: Power 3D conducted approximately 200 customer discovery interviews before narrowing its focus toward wearables, hearables, and medical-device applications

By March 2026, Power 3D operated at a micro-venture scale. The company employed 3 employees and relied on a small core team consisting of Peter Scott, Chunshan Hu (Chief Technology Officer), and Tameem Karrar (Battery Engineer), supported by a limited set of external advisors.

Engineers often preferred batteries that could better fit the product architecture, specifically curved, thin, non-rectangular, or even distributed across the device. Yet such form factors were rarely available in practice. As a result, product teams typically adapted device designs to standardized battery formats, rather than selecting or engineering a battery that matched the intended product geometry.

Funding enabling prototyping

As the market opportunity became clearer, Power 3D secured initial funding to move beyond the concept stage and in July 2025, the company raised approximately $450,000. These resources supported the development of an early prototype. (see Exhibit 3)

At this stage, Power 3D remained pre-revenue from product sales, as the technology had not yet reached repeatable customer deployment. However, the company's 2025 internal financial reporting recorded $166,000 in revenue, reflecting the accounting treatment of grant income, while net income remained negative at approximately -$27,500. (see Exhibit 4)

By early 2026, Power 3D had developed a working prototype, although it had not yet reached the required performance targets. This represented an important technical milestone, but it did not yet prove that customers would adopt the technology over existing battery alternatives. The company, therefore, needed to decide which application to prioritize first and which commercialization path could generate the most credible early validation.

The industry

In the mid-2020s, the growth of compact electronic devices increased the relevance of battery size, shape, and integration: wearables, hearables, and hearing-related devices represented important application areas since their design often depended on the ability to fit components into limited physical space. Public market data indicated significant volumes in both wearable devices and hearing aids, suggesting that compact battery solutions addressed markets with established demand and continuing product innovation.

According to Power 3D, getting custom battery shapes was rarely on offer: geometry was just not a secondary thought for a product; it was seen as a major factor driving whether a product lived or died.

Power 3D's customer base was mostly B2B. The actual "customer" for a wearable or a medical device was actually a manufacturer of that device, as well as internal groups involved in the selection and then integration of the component, such as product engineering groups, and power/battery engineering.

For the wearables / hearables markets, design and custom shapes were essential to guarantee that the battery could match the geometry of the device, long before the need for bulk purchasing had even occurred.

The other market, where the company was interested in delivering its products, was the market segment of the medical device, where it was vital to validate the ability of the product to cross certain thresholds deemed appropriate.

In both markets, the value proposition offered by Power 3D was based on the ability of the company to customize the geometry of the device as well as the density of the energy.

Power 3D faced competition on two levels: microbattery specialists and the indirect competition of standard batteries.

The most common option for B2B customers was not necessarily another startup. Device teams often stuck to the conventional battery sizes and designed the product to accommodate the conventional battery.

Power 3D was in a marketplace where several companies had already entered the microbattery arena or had developed thin-film/printed battery technology. Industry summaries of the thin-film battery marketplace included a litany of companies that had entered this arena, including Blue Spark Technologies, BrightVolt, Enfucell, STMicroelectronics, Imprint Energy, Ilika, Jenax, and others. Similarly, summaries of the marketplace for printed thin-film batteries included major players like STMicroelectronics, Panasonic, Murata, Ilika, and Blue Spark.

Incumbent technology manufacturing, which included slot die-coated electrodes, had a lot of velocity and control, but it was limited in terms of thickness and geometry. (see Exhibit 5)

3D printed electrodes, however, provided some good opportunities for better geometry and better energy density. (see Exhibit 6) This meant that differentiating Power 3D depended heavily on actually achieving specific performance metrics. For validation, customers would need to see the benefits of the geometry and performance as a real differentiator rather than just a gimmick. (see Exhibit 7)

By March 2026, Power 3D had started to get some sense of what the market needed, and a very clear message that the technology alone was not going to cut it. As Power 3D tried to figure out how to compete in this market, the big challenge was working out what the best path forward actually was. The company considered that what they needed was a plan of action that would give them the highest chance of being quickly and believably validated against other, more traditional approaches.

Present challenges

Cash was tight, and Power 3D was trying to raise $300K to pay for making prototypes and customer testing. With 3 employees and an estimated burn rate of approximately $35,000 per month (largely R&D-driven), the company faced binding constraints on how many market experiments and customer evaluations it could run in parallel.

It was key to move beyond whether the tech has worked, towards where, how, and with whom Power 3D should work to actually prove its worth. Power 3D's main challenge was not only about getting investors, but it was also about how best to position and sell a technology, the value of which depended on how and where it got tested and validated first. In its value proposition, Power 3D made a point of saying energy density would be higher and that the geometry would be customizable (plus additional technical features). (see Exhibit 8)

They connected that to small devices, mostly, where "size" and "custom shapes" were definitely what people needed. Strategically, Power 3D's core idea was not something that could be proven "in general." Instead, it needed to be proven within a very specific use case. This meant a clearly defined set of customer needs, specific expectations for prototype testing, hitting certain performance thresholds, especially knowing that the high-volume hearable markets (like earbuds and hearing aids) could also cover medical devices. The implication was that the "geometry and performance" niche was not a one-size-fits-all situation.

Management felt that chasing multiple markets at the same time would split their technical focus and probably slow down the learning process. And picking the wrong initial market could force them to optimize the product for niche requirements that just would not generalize well across different applications. The company, therefore, faced a decision: which beachhead market and go-to-market strategy should Power 3D prioritize first? The goal was to maximize the chances of getting early, credible validation for their value proposition, basically, the custom shapes and performance targets. But that validation depended on both meeting the distinct requirements of each segment and successfully beating out the existing alternatives.

This dilemma sat at the intersection of two choices:

1. **Market positioning choice (where to win first):** whether initial validation should be pursued primarily in wearables/hearables-type applications or in medical devices, each associated with different customer expectations and adoption dynamics.

2. **Commercialization path choice (how to win first):** whether initial validation should be built through deeper partner-led co-development (i.e., committing the technology roadmap tightly to an anchor partner's requirements) or through a broader sampling strategy in order to generate feedback across multiple potential customers

Knowing that execution constraints increased the cost of indecision, the company presented a near-term development cadence (a “3-month roadmap”) highlighting short-term resource pressure (including the need to fund prototype development and customer testing). (see Exhibit 9)

Those elements intensified the dilemma by limiting the number of strategic experiments Power 3D could run in parallel and by forcing prioritization and sequencing.

Strategic options

Peter Scott understood that having a good value proposition was not equivalent to having a strategy, and Power 3D was not able to validate everything at once.

Different questions with no answer came to the founder's mind: should they consider the wearables/hearables market, where the pain of form and size was huge, and the market was enormous, or, on the contrary, medical devices, where the market and adoption rates could be very different?

In addition to that, whichever segment Peter and his team chose, it was necessary to define if Power 3D should pursue a partner-led co-development path or, on the other hand, adopt a broader multi-customer sampling approach to learn faster across applications before committing to a single lane.

The dilemma translated into a small set of strategic options.

These options differed in where Power 3D would focus its validation effort and how it would organize its commercialization learning. These options were not "financing mechanisms". They were positioning and commercialization choices anchored in the company’s stated problem framing, relying on its incumbent comparison and its value proposition. So the focus was on how to get the product out there in the market.

Option 1. Hearables/Wearables-first beachhead (design-constrained compact devices)

The first strategic option was to concentrate commercial development efforts on the wearables and hearables segment, specifically, the earbud and consumer wearable device market. This choice was based on the market sizing data, which showed consumer wearables as being a market of about 1.24 billion units worldwide. And earbuds only accounted for 300 million units every year, with a battery market that could be worth $3 billion.

The size and custom shapes were found to be the two most important things that people wanted in the earbud market. And Power 3D's technology was especially good at those dimensions compared to companies already using slot die coating methods.

The reasoning was that wearables, and earbuds especially, had a faster design cycle than medical devices. Also, it was easier to get into that market from a regulatory point of view. Plus, there were enough product development teams out there working on this so that it seemed like there would be a good chance of finding a partner early on. The main offer was not really about how much energy the batteries could hold, but more about giving designers more freedom than they had before, something the bigger companies could not do.

But the main risk was a squeeze on margins: the supply chains for consumer electronics were famous for being all about cost; for a new company making low volumes of custom-printed batteries, that was concerning. Small volumes would likely face a structural disadvantage versus larger-scale commodity suppliers on a pure unit-cost basis. Even if Power 3D secured an early pilot, that success could create an implicit price expectation: customers might treat the pilot price as the future benchmark, while Power 3D still needed time and scale to bring costs down. In other words, the company could prove that the technology worked and still struggle to turn that proof into a sustainable business if it could not reach meaningful volume quickly enough.

In that context, “success” in the near term had been defined as landing a paying customer within 90 days, not just interest or technical feedback, but a concrete commitment. That could take the form of a signed joint development agreement or a paid pilot with a wearable device manufacturer willing to test Power 3D’s cells in a real device integration environment.

Option 2. Medical-devices-first beachhead (high-constraint, performance-threshold validation)

The second option was to focus commercial efforts on the medical device market; the company's website described that using their tech for medical tools was a key area, emphasizing the importance of reliability, compact form factors, and customization for applications in implantable or wearable medical electronics.

The segment was framed as representing 200 million units globally with an addressable battery market of $200 million.

Power 3D’s reasoning for prioritizing this path rested on how value and pricing typically worked in the medical device space: medical device manufacturers generally did not win customers by offering the lowest bill-of-materials cost; they competed on how well products functioned, how reliable they were over time, and whether the components they used could clear regulatory requirements. Therefore, a battery supplier that could deliver a tailored cell supported by documented electrochemical performance and proven consistency stood to occupy a stronger, more profitable position. Medical device makers were usually willing to pay more per cell and to co-develop the battery with the supplier to achieve the required fit and performance. This contrasted sharply with consumer electronics, where buying decisions were driven far more by volume targets and unit cost.

The major downside was how long and complicated it took to get approved. Medical devices were checked closely by the FDA in the U.S., and similar organizations in other countries, which meant batteries had to meet very strict rules for how they performed, how safe they were, and how consistently they were made. A startup with a prototype that was not even meeting its own performance goals yet, and also had not proven it could mass-produce them consistently, would have a hard time getting a real business relationship with a medical device manufacturer.

The certification and qualification timeline could easily extend beyond Power 3D's current funding runway. Success in this segment would be defined differently: not necessarily a paying customer within 90 days, but the initiation of a formal technical dialogue or a co-development scoping agreement with a medical device engineering team, which could serve as a milestone to anchor the next funding conversation.

Option 3. Partner-led co-development (anchor partner as the route to validation)

Regardless of which segment they went after, Power 3D had to figure out how to get started in the market.

This plan was based on how the company planned to grow. They needed to find two or three partners to get some early money coming in and pay for a small test production line.

Working together on development with a partner meant Power 3D would be working on what a real customer actually needed, so they would not waste time making something nobody wanted. It also meant they could eventually get a formal deal, a real business agreement. That agreement would show investors that people actually wanted what Power 3D was making. The CEO felt that they had already found their starting point, and the next thing was to find a good customer to test things out with. So it seemed like working with a partner on development was what they wanted to do first.

On the other hand, there were risks too: if Power 3D worked with just one partner, all their eggs would be in one basket. If that partner took too long, or changed their mind, or decided the tech was not ready yet, Power 3D would be in trouble. It made the company exposed, especially if the partner decided to move in a different direction. It also risked creating a dependency in which the product roadmap was effectively steered by the partner's priorities rather than by the broader market opportunity.

Success under this model, within a 90-day window, would be represented by a signed co-development agreement or letter of intent with a hardware manufacturer, accompanied by agreed technical milestones for the battery prototype.

Option 4. Broad multi-customer sampling (learning breadth before commitment)

The other possible go-to-market strategy involved more widespread sampling. It meant giving prototype cells to a bigger group of potential buyers in both target areas at the same time. This was to get market feedback faster and not to rely too much on just one client.

The thought here was this: Power 3D's prototypes were still in early stages, and it was not clear yet which specific device application would be the most valuable first target, so casting a wider net would help find the customers who were most eager to move ahead quickly.

Power 3D had to produce a sufficient number of repeatable cells to distribute to multiple prospective customers' engineering teams. That was not easy given the prototype's current status and the company's limited operational capacity. In addition, Power 3D needed a clear communications plan to present its value proposition consistently to a diverse set of potential customers, each with different design requirements.

The possible risk was that resources could get stretched too thin, and instead of working closely with one customer to get a paid deal, they would have lots of conversations that could not really lead anywhere. However, the potential benefit was significant. A wider sampling approach could produce a richer and faster set of indicators coming from the market. This data could show which device types, performance features, and commercial terms were most appealing to potential buyers. This would allow Power 3D to make a more informed decision on its beachhead market within a shorter timeframe, rather than committing deeply to a single partner before that market signal was available.

Success within 90 days would be defined as a documented set of customer conversations with qualified engineering leads across two or three companies, accompanied by at least one formal expression of interest in receiving prototype samples for evaluation.

The future

Each of the four options described was, in essence, a different way to deal with the same basic problem. That problem was: how do you show that 3D-printed electrodes are both technically sound and also commercially viable? All this needed to happen with not much time or money. Successfully navigating this would let 3D-printed electrodes get past current limits, particularly regarding thickness and shape. If it worked, they could offer a unique mix of custom designs and better energy storage in small devices.

So, the real question was deciding which approach would give Power 3D the best shot at creating convincing proof, both technical proof and commercial data, and doing it quickly enough so they could secure a strong position in their initial target market.

The options were not mutually exclusive in the long run; Power 3D would, eventually, need to work in both wearable tech and medical devices. And they would need both strong partnerships and a wider market reach. But for now, these choices had to be made. The allocation of engineering resources, management focus, and funding meant they could not pursue everything at once.

LITERATURE REVIEW

The following chapter presents a review of the literature about the issues raised by the Case Study. The first cluster of themes looks at how to commercialize new tech and select beachhead markets when things are uncertain. The literature illustrates which initial segment should be assessed, the severity of customer pain, the adoption friction associated with regulatory and organisational constraints, the completeness of the value proposition, and the generativity of the segment as a source of transferable learning. Moreover, the concept of a beachhead market emphasizes the importance of selecting an initial application context in which the venture can deliver a compelling solution, achieve meaningful validation, and generate signals that support subsequent expansion.

The second thematic cluster concerns competitive dynamics, the defensibility of differentiation, and credibility in emerging technology markets reflect the recognition that market entry and competitive positioning cannot be treated as separable analytical problems for a venture at Power 3D's stage: the choice of where to seek validation shapes the kind of differentiation the company can credibly claim, and the credibility signals generated by early engagements determine the company's competitive trajectory well beyond the initial segment.

Taken together, these streams provide a coherent analytical framework for examining the central question raised in the case: how an early-stage technology venture should structure its initial market entry and commercialization approach in order to maximize the likelihood of credible validation.

According to this, the review aims to ensure that the theoretical material introduced here serves a directly analytical rather than merely illustrative function in the Teaching Note.

1. Beachhead market selection and market entry strategy

1.1 Technology commercialization in ventures built around novel Technologies

A first relevant stream concerns the commercialization of new technologies and how that process actually works. The literature shows that technological superiority on its own is rarely enough to guarantee any real economic success: Teece (1986) demonstrated that commercial returns from innovation accrue less to inventors than to whoever controls the downstream capabilities like production, distribution, and market access, required to deliver the technology to paying customers. When such assets are specific and difficult to replicate, cooperation with established players becomes not just commercially attractive but strategically necessary.

The foundational challenge that is confronting any early-stage venture is not only a technical challenge, but also an organizational one. Stinchcombe (1965) documented that young organizations fail at disproportionately high rates precisely because they begin without the routines, trust relationships, and reputational capital that incumbents have accumulated over time. This liability is compounded for deep-tech ventures, which must simultaneously prove technical feasibility and commercial relevance, often to customers who remain skeptical of both. Aldrich and Fiol (1994) distinguish between two forms of legitimacy that new ventures must establish: cognitive legitimacy (being recognizable and interpretable as a valid organizational form) and socio-political legitimacy (being accepted as appropriate by the institutional actors whose support matters). Deep-tech entrants face both deficits at once.

Taken together, this literature suggests that for a resource-constrained venture, commercialization cannot be separated from strategic positioning. The first market entered is not just a source of revenue; it is also the environment in which the technology will be interpreted, tested, and valued. The key question is therefore not whether the technology was interesting in abstract terms, but in which application setting it could be validated most credibly and with the fewest complementary-asset gaps.

1.2 Beachhead market selection: criteria under technological and market uncertainty

A second literature stream concerns beachhead market selection. The concept of the beachhead market was most influentially articulated by Moore (2014) in the context of technology adoption. Moore (2014) argues that early-stage ventures most often stall not from technical weakness but from dispersed commercial focus. Addressing multiple segments simultaneously prevents any single customer from receiving a complete enough solution to justify adoption. The prescription is deliberate concentration: win one segment decisively before expanding. Customers purchase solutions to specific problems, not technologies in the abstract and incomplete solutions, however technically impressive, consistently fail to convert interest into commitment.

The challenge for early-stage deep-tech ventures is that the criteria for beachhead selection are themselves uncertain. Gruber et al. (2008) investigated how entrepreneurs identify and evaluate market opportunities in technology firms, finding that the breadth of market domains considered at founding was positively associated with performance, but that eventual focus, committing to a defined segment, was a necessary condition for translating broad opportunity recognition into commercial traction. Their findings highlight a temporal dimension: early exploration and eventual concentration are complementary rather than competing activities. However, the benefits are not unlimited: more options are useful up to a point, after which returns diminish; it suggests that early opportunity exploration is valuable, but endless openness is not; therefore, a venture must eventually concentrate its limited resources on one initial path.

Additionally to that, the recent work by Camuffo et al. (2020) suggests that under uncertainty, startups benefit from a more disciplined, hypothesis-driven approach to experimentation rather than from diffuse trial-and-error. This implies that even a broader sampling strategy would only be strategically useful if it were organized around explicit hypotheses: which segment shows severe pain, which customer values geometry over cost, which application can reach a credible validation milestone within the firm's runway, and which engagement generates the strongest signal for future fundraising. Otherwise, breadth risks producing noise rather than learning.

Several criteria emerge from the literature as particularly relevant. First, the degree of customer pain and the urgency of the problem being solved: the most productive beachhead markets are those in which customers have an active, recognized problem for which existing solutions are inadequate, not merely those in which the technology can theoretically add value. Second, the customer's ability to evaluate and adopt the solution within the startup's resource and time horizon: markets characterized by long qualification cycles, stringent regulatory pathways, or complex organizational buying processes impose costs on a resource-constrained entrant that may outweigh the benefits of higher willingness to pay. Third, the degree to which early success in one segment provides referenceable evidence transferable to adjacent segments: Gruber et al. (2008) in particular observed that initial commercialization contexts shape the technological and organizational configurations that firms develop, making some trajectories more generative than others.

Gans and Stern (2003) argue that the best initial strategy for a startup hinges on three variables: how well the technology is protected intellectually, how much the venture relies on complementary assets it does not control, and how intense competition in the product market already is. The firm's commercialization problem was not simply about finding customers, but about deciding whether early validation should be built through direct market engagement, deeper co-development, or a sequence that combined both. For deep-tech ventures where the technology is novel and where complementary assets, including manufacturing infrastructure, customer relationships, and regulatory expertise, are largely held by established players, the cooperative route to commercialization tends to be more viable in early stages.

Rothaermel and Hill (2005) extended this analysis, demonstrating that when a technological discontinuity is introduced, incumbents possessing complementary assets frequently co-opt new entrants through partnerships, thereby capturing a portion of the value created. The practical implication is that a single, committed co-development partner could provide access to device integration expertise, regulatory knowledge, and a structured testing environment, capabilities that startups cannot usually self-fund but need to achieve meaningful validation.

However, exclusive reliance on a single anchor partner introduces dependency risks that the literature has documented carefully. Sarasvathy (2001) talks about the decision-making logic characteristic of expert entrepreneurs, in which affordable loss, rather than expected return, becomes the guiding principle under uncertainty. One implication of effectuational reasoning is that commitment to a single partner, particularly early in commercialization when uncertainty is high, exposes the venture to the risk that the partner's requirements diverge from the broader market's, or that the relationship stalls or terminates, leaving the startup without either a commercial agreement or transferable market knowledge. This risk is amplified when the startup's product roadmap becomes effectively co-determined by the partner's engineering priorities rather than by an independent assessment of market demand.

2. Competitive dynamics and positioning in the emerging technology market

2.1 Competitive dynamics in emerging technology markets

A foundational insight in the literature on technology competition is that the nature of competitive advantage available to an entrant depends critically on where an industry sits in its technology cycle. Murmann and Frenken (2006) develop a systematic framework for understanding how dominant designs emerge from periods of competing architectures, showing that before a dominant design consolidates, competitive rivalry is primarily fought along technical dimensions, and entrants with genuinely novel approaches can gain a foothold that is structurally inaccessible once a design standard has been established. The competitive window, in other words, is not permanent: the architecture that is contestable today may become the taken-for-granted template of tomorrow, at which point competition migrates to efficiency and cost, where established scale economies favour incumbents.

Suarez and Lanzolla (2007) show that first-mover advantages are most durable when technological and market evolution proceed at a pace that rewards early commitment without enabling rapid leapfrogging by later entrants. Crucially, they show that in contexts of rapid technological change, the advantage from moving early is frequently eroded by subsequent technical generations, whereas in markets where technology-performance trajectories are steep and continuous, early capability development in a specific application domain can compound into a durable informational and relational lead over potential imitators.

More recently, Kapoor and Furr (2015) studied how entrants in a new technology generation choose between competing on the core technology alone versus competing through the combination of novel technology and a complementary component. Entrants facing strong incumbent competition in the core technology space are more likely to invest in complementary components as a way of bundling their offering and making it harder for incumbents to replicate on the same competitive terms. This finding suggests that competitive positioning in technology markets is often a bundle decision, not a single-dimension choice: entrants compete not only by improving performance on the primary dimension of comparison but by redefining what dimensions of performance are salient.

At the ecosystem level, Adner (2017) argues that competitive dynamics in technology markets are increasingly determined by the structure of interdependencies among firms rather than by the capabilities of individual actors. He proposes treating the ecosystem as a structural construct, a set of alignment relationships among producers, complementors, and end users whose co-specialisation determines the feasibility and pace of value creation. A technology that is superior in isolation may fail commercially if the ecosystem actors required to deliver it to end users are not co-aligned, and an entrant that correctly reads the ecosystem structure can gain a competitive advantage by sequencing its alliances and positioning choices in a way that progressively draws those actors into alignment. For market entry decisions, this implies that segment selection should incorporate an assessment of ecosystem readiness, the degree to which relevant downstream actors are structurally positioned to adopt and deploy the new technology, and not merely a demand-side analysis of end-user pain.

2.2 Defensibility of differentiation in technology markets

The literature suggests that differentiation in emerging technology markets is not defensible merely because a venture offers a novel technical feature. Gans and Stern (2003) provide perhaps the most precise treatment of this question in the context of technology startups, offering a framework that distinguishes between two fundamentally different commercialisation logics. In the first, the startup competes directly in the product market, building its own complementary assets and seeking to displace incumbents through superior performance. In the second, the startup competes in the market for ideas, treating its technology as a tradable asset and seeking to license, partner with, or be acquired by an established firm. The choice between these paths depends on the appropriability regime governing the technology, the strength of intellectual property protection, the degree of tacit knowledge, and the importance of co-specialised complementary assets, and on the startup's capacity to independently build those complements. Crucially, Gans and Stern show that direct competition in the product market is most likely to create durable value when the appropriability regime is strong and the startup can accumulate sufficient complementary assets before incumbents respond; otherwise, collaboration strategies that leverage the incumbent's existing complements often generate superior returns for the innovator.

Teece (2007) extends the resource-based logic of competitive advantage by introducing the concept of dynamic capabilities: higher-order routines that enable a firm to sense new opportunities, seize them by reconfiguring its resource base, and continuously transform its position to stay ahead of imitation. In technology markets, where the environment changes rapidly, and the value of specific capabilities can be quickly eroded by technical progress or competitive response, the durability of a differentiated position depends less on any particular resource and more on the organisation's ability to continually recombine and redirect its capabilities. This has direct implications for early-stage technology ventures: the initial market chosen and the first customer relationships established shape the learning trajectories that become the firm's future dynamic capabilities. An early engagement in a high-constraint, performance-demanding context, one that forces rapid iteration against specific and exacting requirements, accelerates the capability-building process more than an engagement in a low-constraint context would, even if the latter offers faster short-term commercial closure.

Pisano (2010) examines the particular challenges of what he calls science-based business ventures whose competitive positions are grounded in a proprietary scientific or engineering knowledge base rather than in established product-market formulas. He argues that science-based businesses face a systematic mismatch between the timescales on which knowledge is created and validated and the timescales on which markets demand commercial proof. This creates a tension between depth and speed: deep technical development produces more defensible knowledge but slower commercial validation, while rapid commercial engagement produces market signal but may under-invest in the knowledge foundation that makes the position durable. Pisano suggests that the resolution lies in selecting initial markets whose technical requirements are demanding enough to force genuine capability development rather than tolerant enough to allow a premature commercial claim and whose customer relationships provide the feedback richness needed to accelerate learning. The implication is that the strategically correct initial market for a science-based venture is not necessarily the largest or the most accessible, but the one whose technical demands are most precisely aligned with the knowledge the venture most needs to develop.

Henderson and Clark (1990) added an organizational dimension to defensibility: because organizations build knowledge and capability around recurrent tasks, and because technical evolution is usually characterized by experimentation followed by the acceptance of a dominant design, firms learn to invest more heavily in component refinements within a stable architecture. When architectural innovation occurs, however, some of what established firms know becomes not just less useful but potentially handicapping. Their routines and information-processing structures are adapted to an older architecture. This means that differentiation may be defensible when it rests on a reconfiguration that incumbents find difficult to interpret and absorb, even if the underlying components are familiar. In this sense, defensibility can stem from architectural change itself, because the challenge is not simply copying a component but reorganizing the relationships and knowledge structures through which the product is developed.

Katila et al. (2008) address the strategic management of interorganizational relationships in technology markets through the concept of co-opetition with corporate partners. Using the metaphor of swimming with sharks, they show that technology ventures that enter collaborative relationships with larger, established corporations face an inherent tension: the partner provides access to complementary resources, manufacturing, distribution, application knowledge, and market reach, but simultaneously acquires insight into the startup's technological capabilities, potentially enabling imitation or competitive displacement. They identify the conditions under which such relationships are net positive for the venture, emphasising the importance of deal structure, knowledge compartmentalisation, and the venture's capacity to move along its own technology roadmap faster than the partner can absorb and replicate. This analysis is directly relevant to the choice between partner-led co-development strategies and broader multi-partner engagement approaches, since the depth of a co-development relationship with a single partner introduces both the greatest resource benefits and the most acute appropriation risks.

2.3 Credibility & Legitimacy

A third body of literature addresses a challenge specific to early-stage ventures competing in markets where the technology is novel and its commercial performance unproven: the problem of credibility. In such markets, technical superiority is insufficient on its own; potential customers, partners, and investors must also believe that the venture and its technology are what they claim to be. This is not merely a communications problem; it is a structural competitive problem because the absence of an established track record means that the market cannot evaluate the venture's claims through conventional signals of quality.

Navis and Glynn (2011) argue that entrepreneurial identity formation involves a tension between two imperatives: the need to demonstrate categorical conformity — to be recognisable as a legitimate member of an established or emerging product category, and the need to project distinctive value, to offer something that existing category members do not. They show that investor judgments of venture plausibility are shaped by both dimensions simultaneously: ventures that are entirely novel are too difficult to evaluate, while ventures that are merely incremental offer no reason to be preferred. The most compelling positioning, they argue, is one of legitimate distinctiveness, a claim that is novel enough to be interesting and conventional enough to be comprehensible. For ventures introducing a technology that has no established category, this has a direct implication: the choice of which reference category to anchor to which comparison technology, which segment, which use case, is not merely a marketing decision but a legitimacy construction decision with competitive consequences.

Überbacher (2014) provides a systematic review of the legitimation literature as applied to new ventures, synthesising research across sociology, organisational theory, and entrepreneurship to identify the mechanisms through which ventures actively construct legitimacy. He distinguishes between technical legitimacy, the perception that the venture's technology actually works and can deliver what it claims, and institutional legitimacy, the perception that the venture operates in accordance with the norms, rules, and expectations of the relevant field. He argues that technology ventures frequently invest disproportionately in the former while underestimating the importance of the latter, and that institutional legitimacy is often the binding constraint on early commercial traction rather than technical performance per se. Importantly, he identifies the choice of validation partner as one of the most powerful single mechanisms for institutional legitimacy construction: associating with an established and respected actor in the target domain confers borrowed legitimacy that can substitute, in the short run, for the accumulated track record the venture does not yet possess.

Fisher et al. (2017) add an important complication by showing that legitimacy is audience-specific: the signals and narratives that generate credibility with one audience, for instance, a product engineering team evaluating component performance may not generate the same credibility with a different audience, such as a procurement organisation evaluating supplier reliability or an investment committee evaluating commercial viability. Ventures that position themselves with a single audience in mind risk constructing a legitimacy profile that is locally coherent but globally unconvincing. Their work suggests that commercialisation decisions, in particular, the choice of initial target segment and initial partner type, should be evaluated partly in terms of the breadth and transferability of the legitimacy signals they generate. A successful validation in a demanding, high-visibility context produces legitimacy signals that are more broadly transferable across audiences than an equivalent success in a low-constraint, niche context.

Hallen and Eisenhardt (2012) examine how entrepreneurial firms form high-quality relationships with established partners that confer legitimacy and resource access. They identify a set of catalyzing strategies, deliberate actions through which ventures create and accelerate tie formation with potential partners, and show that the most effective such strategies involve demonstrating technical traction in a way that is visible to and valued by the partner, while simultaneously managing the social dynamics of relationship formation to build trust and reduce partner-side uncertainty. Critically, they find that the quality of the first high-value partnership a venture establishes has a compounding effect: it changes the signal sent to subsequent potential partners and shifts the level at which future relationship formation conversations begin. This implies that the first anchoring relationship is disproportionately important, and that the strategic priority of resource-constrained ventures should be to catalyze that relationship rather than to disperse effort across multiple lower-quality interactions.

Final considerations

The literature reviewed converges on a consistent and coherent insight: for early-stage ventures operating in emerging technology markets, the central challenge is not the creation of technological novelty, but the achievement of credible validation within a specific commercial context. Across the different theoretical perspectives, a common emphasis emerges on the interdependence between technological development, market selection, and strategic positioning.

The first and perhaps most fundamental takeaway concerns the inseparability of technical and commercial credibility for deep-tech ventures: for a venture whose technology is novel and whose commercial performance is unproven, the absence of an established track record is not merely a reputational inconvenience but a structural competitive constraint. Customers and partners cannot evaluate the venture's claims through conventional quality signals, and the gap between technical potential and commercial credibility cannot be closed through communication alone. It can only be closed through the accumulation of verifiable validation events, demonstrations in real product integration environments, engagements with established and respected actors in the target domain, and the progressive construction of a performance record that third parties can assess.

The second key takeaway concerns that emerging technology markets are not in a state of stable competitive equilibrium: architectural standards have not yet consolidated, and the competitive window available to genuine innovators is real but finite. The early entrant that chooses its validation context wisely can accumulate informational, relational, and reputational advantages that compound over time and become progressively harder for later entrants or incumbents to replicate. Conversely, an early entrant that disperses its effort or seeks premature scale in a cost-sensitive market may exhaust its resources before it has built a defensible position.

Finally, and at the level of integrative synthesis, the literature reviewed here collectively supports a view of commercialisation as a legitimacy-building process rather than merely a revenue-generating one.

TEACHING NOTE

Learning objectives

The case is suitable for courses in Strategic Management, Entrepreneurship, Technology Commercialization, Innovation Management, and New Venture Strategy. It can be particularly useful in sessions focused on early-stage ventures, market entry decisions, differentiation strategy, and the commercialization of science-based technologies under uncertainty.

After analysing the Case Study, students should be able to:

- Evaluate the value proposition of an early-stage deep-tech venture and assess its degree of market and technology readiness;
- Identify and assess the critical resource constraints and core strengths of a science-based startup, distinguishing between what enables and what limits strategic action;
- Understand the concept of a beachhead market and compare candidate segments (wearables/hearables versus medical devices) on dimensions such as buyer power, regulatory complexity, validation timeline, and strategic fit;
- Evaluate the central strategic dilemma of market positioning and commercialisation path selection facing a resource-constrained technology venture;
- Draw broader lessons about how early-stage deep-tech ventures can balance the need for rapid validation with the risk of premature or misaligned market commitment.

Analysis

1. Evaluate Power 3D's value proposition and identify its current stage of technological development.

Power 3D has constructed its value proposition around a distinct technological and commercial problem: in small electronic devices, the battery is not just another component; rather, it is often the main design constraint that shapes the entire product. The essence of the firm’s proposition was that 3D-printed electrodes would enable greater customization of battery geometry while also permitting improved energy density in small and space-constrained devices. These two dimensions (customizable geometry and energy density) define specific dimensions on which Power 3D seeks to differentiate itself, and they map directly onto the design bottleneck that its target customers consistently encounter. Designs for wearable and medical devices are usually based on pre-made batteries created by other manufacturers. They rarely get to design a product with the perfect battery shape in mind from the beginning. Power 3D's proposition inverts this relationship, offering the battery as a design-conforming rather than design-constraining component.

It is equally important to understand to whom the value proposition is directed. Power 3D's commercial model is fundamentally B2B: the relevant customer is not the end consumer of a wearable or hearing device but the manufacturer of that device, and more specifically, the product engineering, power engineering, and manufacturing teams within that organization who bear responsibility for component selection and integration.

As for Power 3D's technology, they were past the very first invention stage. Power 3D had a working prototype, which was a substantial tech milestone for a university-based deep-tech start-up by early 2026. Nonetheless, the prototype fell short of demonstrating the company's full commercial promise. The case plainly states that, while the prototype worked, it failed to satisfy the required performance criteria. Furthermore, in terms of product sales, Power 3D was pre-revenue, having not achieved repeated customer deployment. The present phase of technology development can be viewed as an early prototype and pre-commercial validation phase. Power 3D had made enough progress to attract strategic interest, but not quite enough to fully reassure potential customers. They still needed to prove that their technology could deliver real, measurable benefits in a specific situation, meeting the performance expectations of an actual customer.

2. What is your assessment of Power 3D’s competitive landscape?

Assessing Power 3D's competitive landscape requires a more precise analytical lens than a conventional market overview would provide. The company competes simultaneously on two distinct fronts, firstly within the microbattery and printed battery technology space, where it faces established direct rivals, and secondly within the broader component supply market for wearable and medical device manufacturers, where the most pervasive competitive pressure originates not from other startups but from the institutional inertia of standardised battery formats and the engineering conventions organised around them.

For this reason, Porter’s Five Forces framework (Porter, 1979) provides a useful tool to assess the structure of an industry:

Threat of new entrants (Low to Moderate)

The battery technology space presents meaningful structural barriers to entry, particularly for ventures seeking to compete on electrochemical performance and manufacturing consistency. Capital investment for electrode manufacture, process innovation, and qualification for particular applications is considerable; knowledge within the advanced battery production process exhibits some form of tacitness and specificity that makes replication difficult; and qualification costs in the medical devices industry add another dimension to those that discourage credible contenders.

Bargaining power of suppliers (Moderate)

The bargaining power of suppliers and complementary actors is more difficult to evaluate directly from the case, but it remains relevant. Looking at a deep-tech venture, the critical dependencies extended beyond just material suppliers. The company was also dependent on complementary capabilities, such as prototyping, testing procedures, device integration itself, manufacturing know-how, and just getting access to credible customer evaluation environments. Seeing as it had a limited team, constrained funding opportunities, along with an early technological stage, Power 3D was unable to internally control all of the various capabilities that were required to actually move from just a prototype to true market validation. As a result, partnerships with technical collaborators, plus customer-side engineering support, were all likely to play a crucial role in actually determining whether the company could realistically transform its technological promise into credible commercial evidence.

Bargaining power of buyers (High)

Power 3D's potential customers were not final consumers, but manufacturers of wearables, hearables, and medical devices, together with their internal product-development, engineering, battery, and manufacturing teams. These customers were technically sophisticated and likely to be cautious in adopting an unproven battery technology. Power 3D still had only early prototypes and had not shown it could deliver repeatable results in the real world. Potential buyers wanted to see hard evidence that justified that the batteries actually worked reliably, and could be integrated and customized to fit their needs. Moreover, these customers could continue relying on conventional batteries or alternative microbattery solutions. As a result, buyer power placed significant pressure on Power 3D to prove that its differentiated technology created clear value in a specific application context.

Threat of substitutes (High)

The threat of substitutes constitutes the most strategically consequential force in Power 3D's competitive landscape, and it was particularly strong and represents one of the most important forces in the case. The primary substitute for Power 3D’s solution was not necessarily another advanced microbattery startup either. In a lot of cases, the substitute was just the continued use of the conventional battery formats and all of the established product-design compromises associated with them. Because device manufacturers were already quite accustomed to adapting product architecture around the available batteries at hand. Power 3D, in this way, was competing not only against other firms but also against an existing engineering logic. For customers, remaining with standard batteries could appear safer, less costly, and less risky than adopting a novel battery architecture whose performance and scalability had not yet been fully validated.

Industry rivalry (High)

Power 3D faced direct competition from firms already developing small-scale battery technologies, including microbattery specialists and companies active in thin-film or printed battery solutions. These players represented relevant comparison points for potential customers, especially because they addressed similar needs around miniaturization, energy storage, and integration into compact electronic devices. However, rivalry in this context was not purely based on price or production volume: since Power 3D was still at an early stage of technological development, the most important competitive dimension was credibility. Customers would need to be convinced that Power 3D’s 3D-printed electrode approach could offer a superior combination of battery geometry, energy density, and integration flexibility compared with available alternatives. This makes rivalry a strong negative force, as Power 3D must demonstrate a clearly superior basis of differentiation before customers compare it directly with better-established alternatives.

Finally, the five Porter’s Forces framework suggests how Power 3D is entering a market that is moderately attractive, from a competitive point of view. There was an opportunity in the market because manufacturers that build compact devices have to deal with definite limitations in battery shape and size, which in turn creates an opening for a solution that is different from the norm. But the high power of buyers, a considerable risk of substitutes, not to mention the intense competition from current microbattery and printed-battery companies, made the industry less appealing. So, the industry was not that attractive in general for a company just entering the battery market. It was attractive for Power 3D only under specific conditions, especially if the company targeted a specific application where a unique battery shape offered the customer significant value and that their uniqueness could be shown to be real. This all goes back to a wider issue at the heart of this: Power 3D needs to figure out where it could best show its advantage over its rivals before deciding how to sell its technology, for instance.

3. **What are the most critical resource constraints the company faces, and what are its main strengths and resources?**

Analysing Power 3D's resource base requires a clear distinction between the restraining strategic constraints and the main strengths it can deploy to build a credible commercial position.

Main constraints

The most critical constraint was financial capacity. By March of 2026, Power 3D was still small and did not have any real revenue from selling products. They had access to some initial funding, which let them start prototyping. However, the company was still short on cash and was working hard to raise more money to pay for developing prototypes and testing them with customers.

A second major limitation was the ability to handle loads of customer evaluations, technical adjustments, and sales conversations at the same time. This created strong dependence on a few individuals and limited the firm’s ability to grow.

The third constraint concerned technological readiness. Power 3D had moved past just being a research concept; they actually had a working prototype to show. However, the case suggests that the prototype still did not meet all of the necessary performance benchmarks. This also encompasses the capacity to produce and deliver at a cost level compatible with the value chain of customers. This means that the company had achieved a meaningful technological milestone, but not yet a fully validated product. The strategic implication is that Power 3D could not depend only on the appeal of their idea. They still had to demonstrate that their unique battery design and possible advantages in power density could actually be delivered consistently, especially in real-world applications. Until they did, their competitive advantage remained just a maybe, not something fully proven.

Main strengths

Power 3D also had meaningful strengths. Its first and most important resource was its differentiated technological proposition. The company's use of 3D-printed electrodes allowed it to position itself around customized battery geometry and potentially improve energy density in compact devices. This gave Power 3D a possible basis for differentiation against standardized batteries and other battery technologies.

The university origins of the venture represent a second important resource. Power 3D's differentiated technological proposition was reinforced by its academic origins, which strengthened the perceived scientific credibility of the venture. Its roots in Carnegie Mellon University and the Missouri University of Science and Technology provide access to research infrastructure, academic networks, and institutional credibility that a purely commercial startup would need years to accumulate. For an early-stage deep-tech company, this matters because scientific credibility can help reduce skepticism among partners, customers, and investors.

A third strength was the company's customer discovery process. Power 3D had conducted around 200 interviews between 2023 and 2026, which helped it move from a broad technological idea toward more specific market possibilities. This was an important resource because it reduced some of the uncertainty around where the technology might matter. The company had learned that battery constraints were particularly relevant in wearables, hearables, and medical devices.

Taken together, Power 3D's resource profile is characteristic of what the literature describes as a science-based early-stage venture: technically credible, informationally grounded, but operationally constrained across the financial, human, and manufacturing dimensions that commercial engagement requires.

4. Evaluate the central strategic dilemma facing Peter Scott in March 2026.

By March 2026, Peter Scott faced a strategic dilemma that, at first sight, it could appear to be mainly financial, but the deeper issue at hand was essentially strategic: Power 3D's technology had finally matured enough that it justified a serious commercial push, even though it still had some limitations. Trying to tackle multiple markets at the same time was not realistic yet, and that meant Power 3D had to decide where its differentiated technology should be validated first and, equally important, how this should be accomplished.

Basically, the dilemma was not a single binary choice, but rather the intersection of two interdependent decisions: each decision had significant consequences affecting the other. The first decision concerned market positioning, specifically: which application segment should Power 3D target first? The goal being to maximise the likelihood of achieving meaningful and transferable validation within the company's realistically available runway? The second decision concerned the approach they would take to commercialization. Should Power 3D try to achieve validation through a deep, partner-led co-development relationship, one with a single anchor customer, or should they use a broader multi-customer sampling strategy that was designed to generate market feedback from several potential customers at the same time?

5. **How do the wearables/hearables market and the medical devices market compare as beachhead candidates for Power 3D?**

According to Moore (2014), the beachhead market is a carefully defined initial area where a business concentrates its efforts just enough to attain dominance and produce outcomes that can be compared before attempting to expand. Power 3D should answer to the question "Which segment has the best chance of converting Power 3D's technological superiority into reliable early proof is the true question?" The prototype had not met all of the performance goals, the company had few resources, and it was not yet marketable. So, the ideal beachhead candidate would have to be a market segment where battery geometry is a clear and pressing customer problem, where customers can actually test the technology within a realistic timeline, and where early wins would give Power 3D credibility for the next steps.

Firstly, the wearables and hearables market appears to be one of the most attractive because the problem Power 3D was trying to solve is highly visible in this segment: specifically, the battery affects the size and thickness of wearable technology such as smartwatches, headsets & other compact consumer devices. Power 3D's proposed solutions for custom shape batteries and potentially higher energy density batteries for small compact devices are very attractive to engineers and product teams as they perceive tangible benefits when the battery is designed to fit in with the overall design of the device. Power 3D cannot afford a protracted, uncertain validation procedure, therefore this market allows for speedier technical conversations, faster prototype tests, and fewer regulatory requirements than medical devices. A successful test in a wearable or hearable could actually prove the tech solves a real design challenge, and also help Power 3D fine-tune its product with hands-on customer feedback.

Alternatively, medical devices provide a different rationale for establishing a beachhead. Here, miniaturization, reliability, and custom geometry might not just be desirable; they might be crucial. For many medical device applications, the battery's ability to be designed into the device directly relates to the operation of the device, the patient's experience with the device, and/or whether the device can be manufactured at all. Therefore, Power 3D's advantages can be viewed as more than a design benefit. If Power 3D achieves success in medical devices, it will achieve a level of prestige that is greater than in consumer electronics. Additionally, a strategy involving targeted differentiation could apply to medical devices. Customers care more about performance, reliability, and tailored design than just low price, so Power 3D gets more room to defend a specialized solution critical for avoiding the generic battery supplier trap.

In both two beachhead candidates' cases, the key customers are not end users; they are manufacturers, along with their engineering, product development, and manufacturing teams. When looking at wearables and hearables makers, they can have considerable bargaining strength. These companies work in tough, price-driven markets where they expect component suppliers to be reliable, able to scale, and offer good prices. That pushes Power 3D into a tough spot, even if having the right battery geometry matters a lot. Medical-device companies are demanding too. They want reliability, certification, and solid technical validation. But when it comes to certain uses where only custom battery shapes make the device work or feel right, Power 3D can actually have the upper hand over off-the-shelf batteries. Therefore, the most promising beachhead is not always the biggest or fastest-growing market. It is where the customer has a real problem, and Power 3D can keep buyer power in check to secure solid proof that their solution works.

Ultimately, the most significant aspect of the following analysis is that neither segment can be identified as having a clear and strong advantage over the other as a potential beachhead. The comparison shows that wearables and hearables give Power 3D a quicker, easier way to get early tests done, but they also open the door to tougher buyer negotiations, more price pressure, and direct competition with big-name battery suppliers. On the other hand, medical devices take longer and demand more, but some niche uses could give Power 3D an advantage, especially if custom battery shapes really matter and there are not many good alternatives.

6. What is your assessment of each of the options open to the company?

Having established the competitive landscape, the resource constraints, and the beachhead market comparison, it is now possible to evaluate the four strategic options that Peter Scott identified as the most concrete paths available to Power 3D in March 2026. These options are not fixed as separate paths for the whole life of the venture, but right now, with not much money, a small group of people, and a prototype that is still not quite right, Power 3D cannot try to do all of them at once.

Option 1: Wearables and hearables-first beachhead

The first approach outlined involves Power 3D concentrating its initial commercialization efforts on the market segment covering wearables and hearables. For these particular manufacturers, the dimensions and overall shape of batteries present a frequent and well-understood design problem. The primary rationale behind selecting this specific strategy is straightforward: this is a genuine issue, it is one potential customers are already very aware of, and Power 3D's capacity for customising geometry offers a direct solution. Design teams who are involved in creating earbuds and other wearables encounter this limitation regarding battery form-factor during essentially every product development cycle. So, Power 3D would not need to spend significant time convincing prospective clients that a problem even exists before presenting their solution. This significantly reduces the amount of time and effort required to initiate a meaningful commercial discussion. In addition, it increases the probability of securing either a signed joint development agreement or a paid pilot project within a 90-day timeframe, which the case study refers to as a considerable short-term accomplishment.

Nonetheless, this particular option does introduce a structural risk: the supply chains in consumer electronics are all about cost and volume efficiency. In this industry, purchase decisions are mostly driven by unit cost and supply reliability, not by new geometric tricks or innovation. Since Power 3D makes low-volume custom cells using a 3D-printed electrode process that has not scaled up yet it is a structural cost disadvantage compared to established commodity battery suppliers, and that gap will not close anytime soon.

Option 2: Medical devices-first beachhead

The second choice involves starting with medical devices as the target segment. The main benefit in this particular area is the way value and pricing are structured within the medical devices industry. Manufacturers do not simply compete on unit price; what is truly important is how well a component functions, how reliably it adheres to safety and regulatory requirements, and how consistent the supply remains throughout product lifetime. If a battery supplying company offers a custom cell shape, with robust electrochemical performance details and proven consistency, they will be in a much better negotiating position in comparison to consumer electronics. This entire method actually aligns with what Power 3D project offers: custom shapes, high energy density, and the capacity to deliver within fine tolerances. Also, medical device manufacturers often work very closely with their suppliers, establishing performance goals together, and that matches where Power 3D is currently in its development stage.

Despite these advantages, the actual challenge for this option is timing-related. Getting through FDA qualification and similar regulatory steps in other regions takes ages, costs a lot, and demands serious consistency and documentation from manufacturers. Right now, Power 3D is still working on a prototype, and they have not even hit their own performance goals yet. They also do not have a proven record for dependable manufacturing. At this stage, they are just not ready to take on those intense requirements.

Option 3: Partner-led co-development

This one particular option has the potential to generate a very strong validation signal. Should Power 3D's battery technology genuinely address an existing design problem prevalent within this industry, then the company stands a much better chance at establishing a considerable competitive advantage, rather than simply being perceived as just another run-of-the-mill battery provider. Pursuing a strategy driven by partnerships appears logical, given Power 3D's rather limited resources, as they could collaborate with a selected customer for a particular application, one that is well documented.

However, concurrently, this specific option is likely to be slower and perhaps more demanding. Businesses in the medical device sector expect concrete evidence, assurances of safety, and unwavering reliability; all of the necessary certifications, along with data indicating these batteries maintain performance over longer periods. Even if this opportunity presents well, the process for validation may extend beyond what Power 3D is capable of managing because the company required demonstrable progress within the immediate future. If the medical device approach becomes protracted and ultimately fails to yield tangible results, Power 3D might deplete its resources without securing the necessary proof needed for fundraising or acquiring new customers. Consequently, this path offers significant potential upside but is also laden with risk, primarily because it may not align with the company’s rather restricted timeline.

Option 4: Broad multi-customer sampling

The fourth option would be to focus on medical devices through broader multi-customer sampling, which allows Power 3D to explore different medical-device applications and understand where customized battery geometry is most critical, keeping the company from locking into the wrong medical niche too early. In theory, this helps Power 3D learn a lot, since medical devices cover a wide spectrum and their battery needs can vary a ton.

However, this is probably the least suitable option for Power 3D at this stage. Medical devices are already tough to handle, and broad sampling would just make things even more complicated. With a small team and limited cash, they would end up moving too slowly and trying to juggle too many conflicting demands. So, broad sampling in medical devices is tough to justify unless they stick to just a few carefully chosen applications

Overall, these four options are not really equally appealing. Wearables and hearables, because they allow for broader sampling, do offer speed and also some learning, but there is always a risk that you lose focus with that approach. Medical devices through co-development offer strong credibility, but may be too slow and demanding. On the other hand, at present, medical devices that try to use broad sampling seem to be the toughest way to go because it joins the detailed complexity of medical uses with the general lack of concentration that comes from wide-ranging testing. Based on all this, the most well-rounded choice would likely be a partnership where development is led by a partner, focusing on a specific application area where battery shape is a very clear issue, and probably starting with wearables or hearables if getting validation quickly is the main goal.

7. What are your recommendations for the management of Power 3D?

Based on the analysis conducted in the previous questions, which allow us to move from diagnosis to treatment, the suggestions listed below are actions that Peter Scott and the Power 3D team should tackle immediately after March 2026.

Recommendation 1: Prioritise the medical devices segment as the primary beachhead

The medical devices area should be Power 3D's lead beachhead. However, this does not imply that the company needs to go after the entire medical-device market at one time: rather than trying to find an area in the market where Power 3D can utilize the natural advantages gained from adapting its power pack to a specific battery configuration inside a medical device, Power

3D will find an application already present in the market that needs a battery made for a medical device and then design a battery around the device's configuration. This difference in the approach could give Power 3D a greater technical advantage than just being able to lower costs. It provides Power 3D with the opportunity to protect its differentiated technology through the battery's design. Power 3D's focus on differentiation logic in the medical device market will also serve to support this approach: even though customers in the consumer electronics market are looking for products with different shapes, they also care a lot about cost, volume, and having suppliers they can trust. The same type of customer expectation exists for medical device manufacturers. Nonetheless, medical device manufacturers may value reliability, small physical size, and custom designs even more than what people in some of the other specialized markets might. If this is the case, then Power 3D's differentiated technology could be solving a real technical problem and not just adding a nice design feature to the product. Nonetheless, Power 3D should not wait until the technology is fully mature before approaching medical-device customers, since adoption takes time and the company cannot afford to discover customer requirements too late.

Recommendation 2: Adopt a partner-led co-development model

Power 3D ought to be on a partner-led co-development structure because the business currently lacks the needed resources to commercialize its products alone. Its current technology needs to be thoroughly researched in an actual product setting. This will require getting access to customer needs and their experiences, plus a lot of the technical specifications, and comments on how it all integrates with different products. A proper place for product testing will also be crucial. Partners will help Power 3D obtain direct knowledge from clients and enable their small team to focus solely on one vital test. This approach is particularly suitable when you are dealing with medical devices. Customers in this field typically need strong confirmations, proof, and a certain level of dependability before they will even think about trying a new component. Power 3D cannot get all of this needed data by itself. A successful development partner could also help Power 3D set reasonable performance goals since they could conduct simulated tests for the battery, making sure those tests reflect real-world usage conditions. On the other hand, the co-development approach does need careful management. The primary danger in this case is represented by the possibility that Power 3D might become overly reliant on a single partner or tailor its technology too narrowly for the specific needs of just one customer. If this happens, the company may lose strategic flexibility and develop a solution that is difficult to transfer to other customers.

Recommendation 3: Align the capital raising narrative with the chosen strategy

The additional $300,000 in capital that Power 3D needed is not just a standalone financial action; it represents a strategic communications effort that will succeed or fail based upon the company's ability to connect with its customers and investors and to communicate a compelling case for where the company is headed and why. Success in this stage will be based entirely on the company's ability to clearly articulate its direction and rationale. Investors at this stage are not providing funding for a completed product; Instead, their investment comes from their faith and confidence in the management team's judgment. This means they believe the leaders at Power 3D will make good decisions, and for the right reasons. If there is confusion concerning the target market, or if the go-to-market strategy, as explained in the fundraising story, lacks clarity, that can lead early-stage investors to decide not to pursue an investment opportunity. When an investor approaches the Power 3D world, it must have the perception of a focused, verifiable outcome in a market segment where the company truly stands out. That is way more reassuring than hearing a broad technology pitch aimed at a vague market.

8. What broader lessons does the Power 3D case offer about how early-stage deeptech ventures should balance the need for rapid validation against the risk of premature or misaligned market commitment?

A first broader lesson is that rapid validation should not be confused with any kind of validation. For a deep-tech venture, a positive customer conversation or general market interest is not enough: what matters is if the company can show proof that its technology actually fixes a particular problem better than what is already out there. In Power 3D's case, they had to show that their unique battery shapes actually brought value in a specific, real-world scenario. More generally, early validation needs to be specific, measurable, and trustworthy; otherwise, the company might just gather signals that appear promising but do not actually help lower the uncertainty about things.

A second lesson from the Power 3D case is that choosing which market to enter first is inseparable from the current state of the technology A lot of founders look at market selection as if it was only a business or marketing concern but they should ask if the technology itself is truly ready to compete reliably in that segment regarding the important aspects to those customers. With Power 3D, the connection between prototype performance and target market was clear: the prototype's present performance status directly indicated which market segments they could realistically enter without harming the company's reputation, and also which ways of engaging with clients were truly practical given the resources they had. Trying to enter a demanding market with a prototype that is not performing is not a smart risk to take; it represents a cost to Power 3D's reputation, which will be hard to bounce back from, especially if the company is trying to build up its credibility for the first time.

A third lesson relies on how founders deal with limited resources. The natural reaction to limited money and a small team is to try to do a lot with little. But Power 3D shows a smarter move: let those constraints sharpen your strategy. Their inability to go after multiple markets was not just a drawback; it forced discipline. They had to pick, and making that choice count by selecting the market where their technology truly fit was way better than spreading themselves thin.

Taken together, the lessons from the Power 3D case point toward a single overarching principle: for early-stage deep-tech startups, commercializing is not a race to be fastest, it is about moving with purpose within the time you have. Move quickly enough to learn from actual customers, but do not go so broad that you end up learning nothing useful, or get so focused on one path that a single customer's needs define your whole company. The broader lesson here is that picking an early strategy is not just about finding a market; i tis about picking the right experiment, the one that gives you a real opportunity to turn your technology into real business evidence.

CONCLUSION

The Case of Power 3D highlights the difficult road an early-stage deep-tech company has to travel, moving from a good idea to actual commercial success. Power 3D story makes it clear that just having great technology is not enough on its own: the key question for them was how to take this technical promise and turn it into something that customers would actually validate in the market.

The main challenge for Power 3D was not finding a promising market, but rather identifying the right initial context where their unique selling points could actually be demonstrated. They have a few directions they could go: one of them was a choice between wearables or hearables and medical devices. Another decision point was whether to pursue co-development with a specific partner or try a broader approach with samples for multiple customers.

The primary recommendation that came out of this case was that Power 3D needed to focus. Power 3D should prioritize a specific medical-device application as its initial beachhead while engaging potential customers immediately. A co-development model that uses a partner would be the correct way to approach the market, seeing as the company requires customer insights, proper testing conditions, and technical advice to go from an early prototype to a reliable, validated product.

What I found most interesting is that the case is not simply about a new battery technology, but about the strategic choices that determine whether a scientific innovation can become a viable business. The main difficulty was balancing the attractiveness of different markets with what Power 3D could realistically execute.

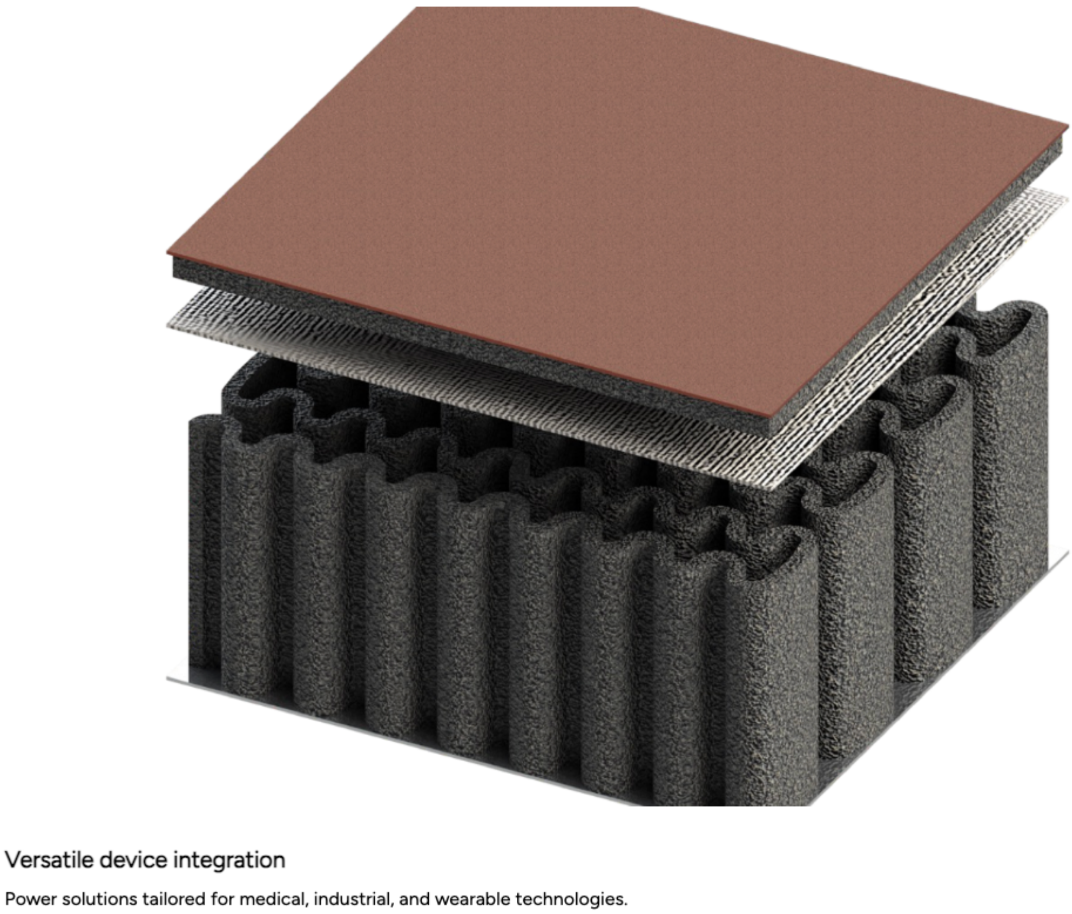
In the future, I personally believe that the most important aspect to follow will be whether the company can close the gap between prototype performance and customer-level validation. Ultimately, the Power 3D case shows that early-stage deep-tech ventures must move fast, but not blindly: their success depends on choosing the right experiment, the right customer context, and the right evidence to prove that the technology deserves to become a market solution.

EXHIBITS

Exhibit 1: Market Problem: Battery Form-Factor Constraints in Wearables, Hearables, and Medical Devices

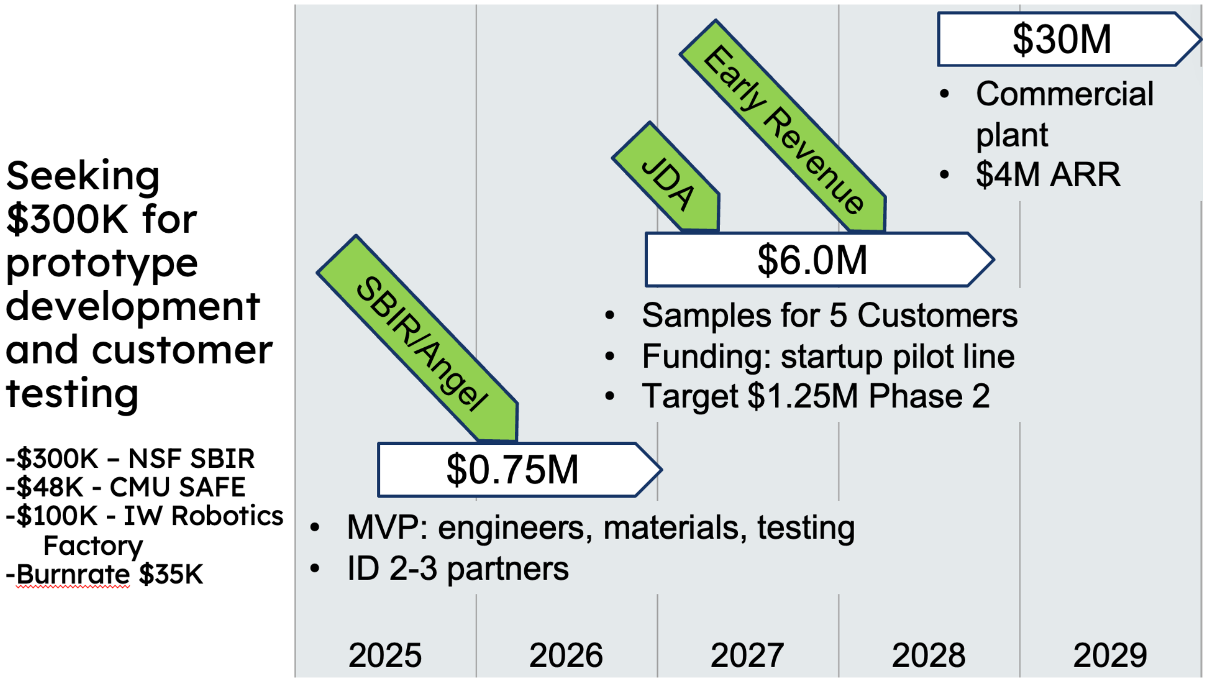
Source: Power 3D Pitch deck slide 2, provided by Peter Scott, founder and CEO, to the author.

Exhibit 2: Power 3D Microbattery Architecture: "Microbattery Innovation at Scale"



Source: Power 3D website. "Home" section.

Exhibit 3: Execution Constraints: Funding Needs and Burn Rate



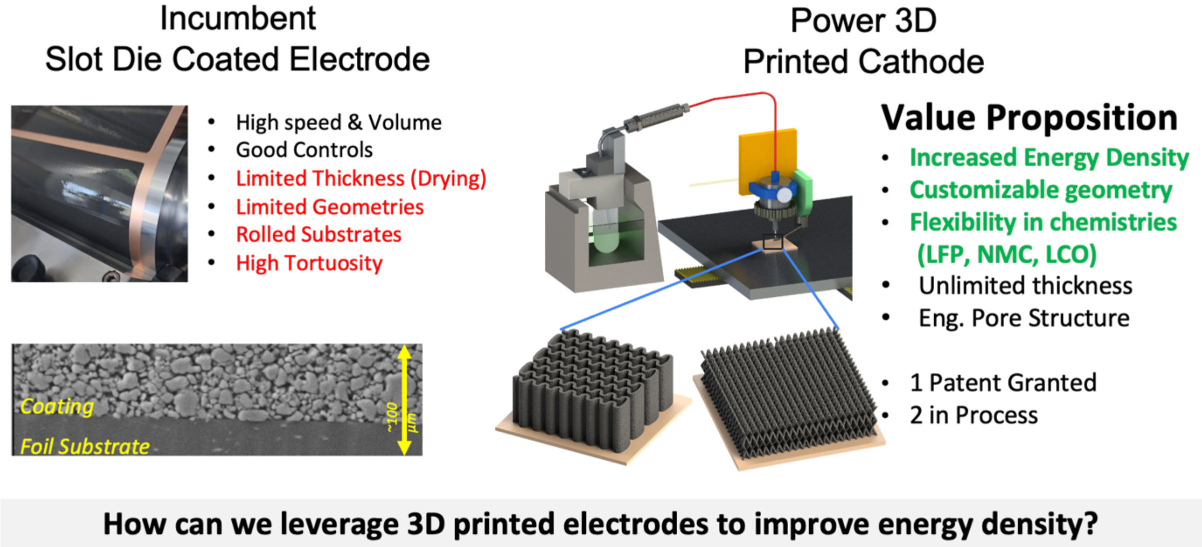
Source: Power 3D Pitch deck slide 10, provided by Peter Scott, founder and CEO, to the author.

Exhibit 4: Simplified 2025 Profit & Loss Statement (Internal Estimate)

P&L CATEGORY	AMOUNT
Revenue (grant income counted as revenue)	*$ 166.000,00*
COGS (all R&D)	*$ 121.000,00*
Overhead (SG&A) - R&D	$ 6.000,00
Overhead (SG&A) - Taxes (payroll)	$ 16.000,00
Overhead (SG&A) - GA Labor	$ 12.000,00
Overhead (SG&A) - Professional services (legal/accounting)	$ 30.000,00
Overhead (SG&A) - Travel	$ 4.000,00
Overhead (SG&A) - Subscriptions	$ 3.500,00
Overhead (SG&A) - Other	$ 600,00
Total Overhead (SG&A)	*$ 72.500,00*
Net Income	**-$ 27.500,00**

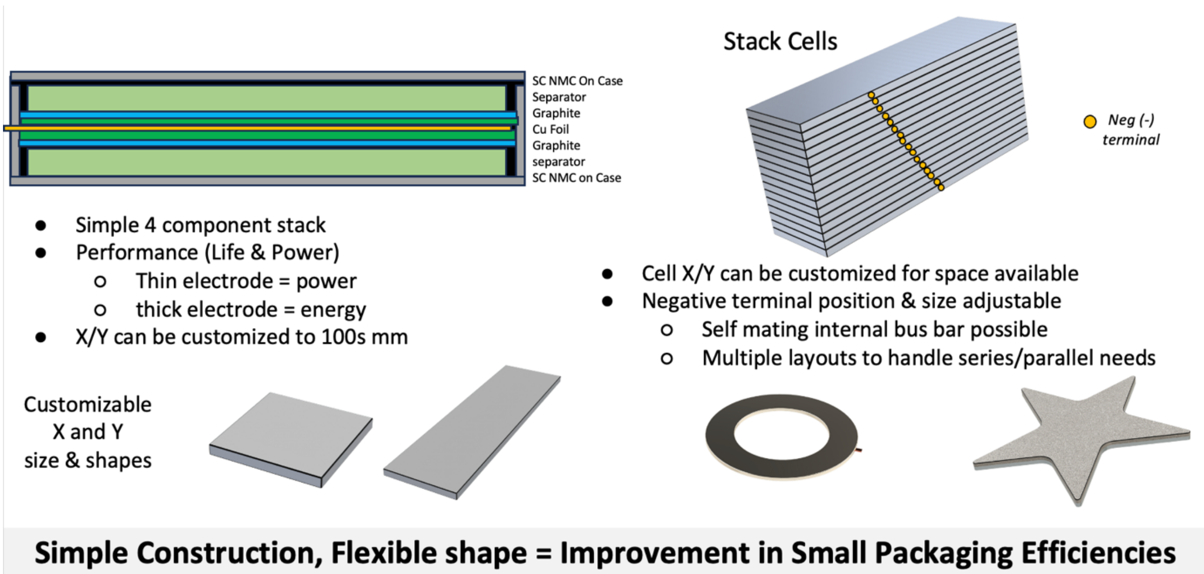
Source: CEO correspondence (internal P&L), provided by Peter Scott, founder and CEO, to the author.

Exhibit 5: Incumbent Slot-Die Coated Electrode vs Power 3D Printed Cathode



Source: Power 3D Pitch deck slide 4, provided by Peter Scott, founder and CEO, to the author.

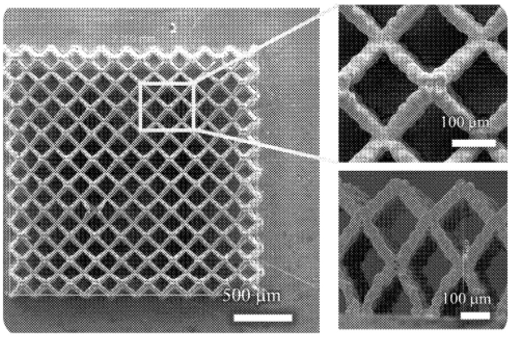
Exhibit 6: Why 3D Printed Electrode



Source: Power 3D Pitch deck slide 5, provided by Peter Scott, founder and CEO, to the author.

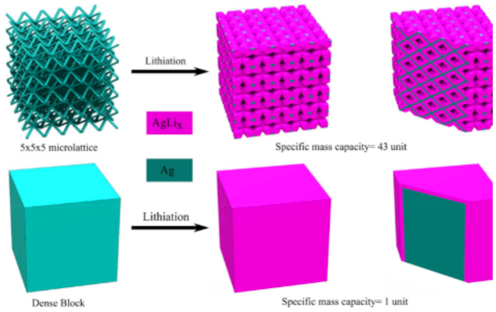
Exhibit 7: Power 3D Technology Background: Selected Publications and Patent

Selected Publications



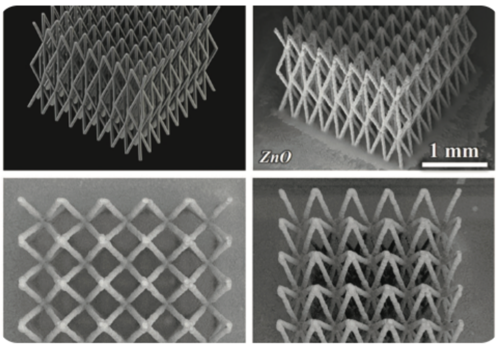
Advancing Microbattery Technology

Explore breakthroughs in 3D-printed cathodes and scalable manufacturing.
U.S. Patent 11,817,588



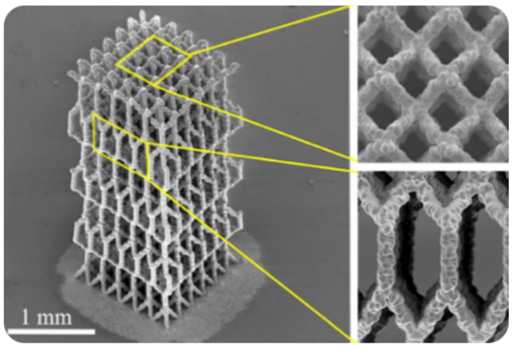
Robust 3D Micro-Architecture

Strain tolerance under 20% size change.
DOI: 10.1016/j.addma.2018.07.006



Additive Manufacturing

Prints complex ceramics with low shrinkage, no support.

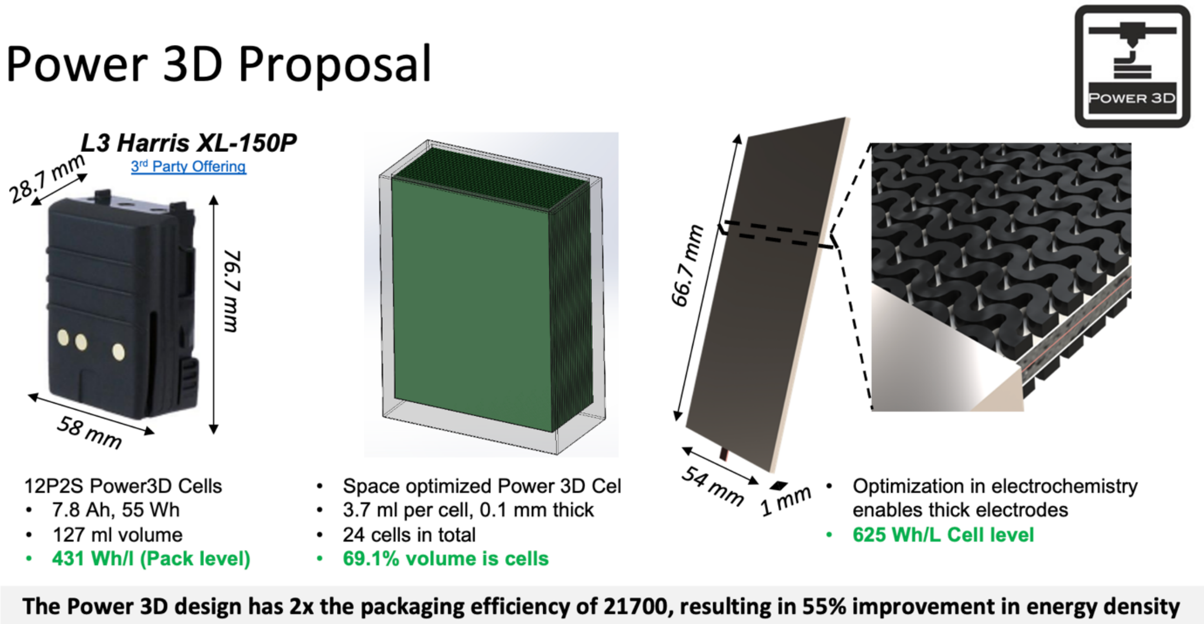


3D Technology At Scale

Discover how it works microscale.

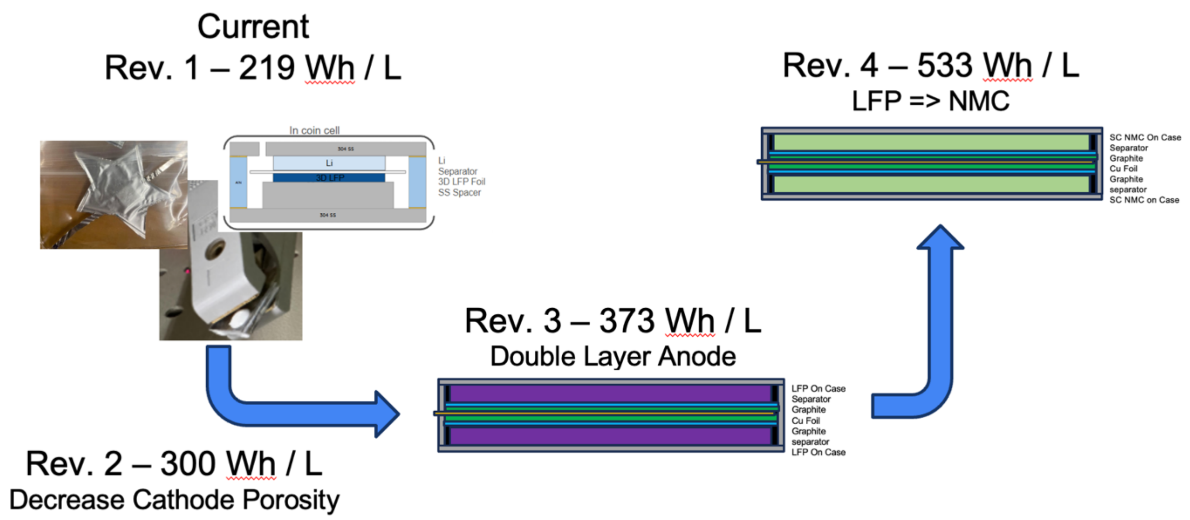
Source: Power 3D website, "Technology" section.

Exhibit 8: Power 3D Customizable Geometry and Higher Energy Density for Space-Constrained Devices



Source: Power 3D Pitch deck - L3 Harris, slide 7, provided by Peter Scott, founder and CEO, to the author.

Exhibit 9: Product Status 3-month



Source: Power 3D Pitch deck, slide 7, provided by Peter Scott, founder and CEO, to the author.

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