LUISS

Degree Program in

Course of Executive Master in Advanced Management – Major in Space Business Management

STRATEGIC ENTREPRENEURIAL BUSINESS FRAMEWORK FOR BISMUTH ION SOLID-STATE BATTERY TECHNOLOGY IN THE SPACE ECONOMY & RELATED INDUSTRIES

Prof. Anthony Nardone

Supervisor

Co-Supervisor

Vicente Giliberti

Candidate

Academic Year 2023 / 2024

ABSTRACT

This project evaluates the challenges (technical, cost, manufacturing, sustainability, IP, safety, commercialization, regulatory and workforce) and solutions faced by entrepreneurs entering the solid-state battery landscape, focusing on technologies that can disrupt the battery market in the space economy and related industries.

Binergy, the name of the hypothetical startup, aspires to become a key player through its pioneering development of bismuth ion solid-state batteries (BIBs), offering safer, longer-lasting energy storage for space applications, electric vehicles, and renewable energy industries. By emphasizing sustainability and innovation, Binergy addresses technical and scalability challenges while leveraging strategic partnerships and diverse funding, such as government grants and venture capital, to secure its market position.

A key part of Binergy's strategy is fostering collaboration between the space community and broader industries to drive societal benefits within a supportive regulatory framework. By aligning its objectives with global needs, Binergy seeks to contribute to economic and technological advancements.

To guide early success, three essential frameworks have been developed:

- **The Business Case**: Outlines the strategic business framework, market demand, multiple challenges, and solutions critical to develop a bismuth ion battery technology business.

- **The Project Management Plan**: Provides actionable steps for tackling technical feasibility, regulatory compliance, risk management, IP strategies, and ESG (Environmental, Social, and Governance) reporting, all vital for building trust and securing competitive advantages.

- **The Post-Project Phase**: The "Post-Project Phase" analysis focuses on operational costs, sales strategies, cash flow challenges, and the financial trajectory needed to achieve profitability in the solid-state battery (SSB) market.

In this evolving environment, sustainability-driven business models and ecosystem engagement are essential for long-term viability. Startups like Binergy are encouraged to use strategic tools such as the Business Model Canvas (BMC) and Value Proposition Canvas (VPC), scenario planning, Death Valley Curve Analysis, regulatory compliance, and stakeholder engagement, to align with customer needs and optimize operational efficiency.

This project underscores the significance of sustainability-focused models, ecosystem collaboration, and regulatory support in the space economy, while emphasizing the crucial role of solid-state batteries in advancing technology across multiple sectors.

ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to my mentor, Professor Anthony Nardone, Global Executive and Academic Leader in Strategic Management and Operations, whose invaluable guidance, patience, and unwavering support have been instrumental in the success of my entrepreneurial journey with the Binergy project and my broader entrepreneurial endeavours. His insightful advice and encouragement have greatly contributed to the development and realization of this project work in Space Business Management.

I am also profoundly grateful to the esteemed faculty of the Luiss Business School. While all of the professors have contributed significantly to my education and personal growth, I would like to give special mention to Professor Nardone, along with Professors José D'Alessandro, Entrepreneur and Head of Business at Luiss Business School; Joris Ebbers, Academic Dean at Luiss Business school Amsterdam, Marco Ossani, Co-Founder of Complexity Surfers; Alberto Petrucci, Professor of Macroeconomics and International Economics at Luiss Guido Carli; Paola Belingheri, Lecturer at Luiss Guido Carli; Luca Del Monte, Senior Executive at the European Space Agency; Alberto Castelvecchi, International Communication Strategist; Karim Parra Rodriguez, Experienced Finance Professional and Adjunct Professor; Roberto Fraticelli, Chief Financial Officer and Head of Italy at Eurocommercial; and Veronica La Regina, Open-Minded Business Professional. Their wisdom and expertise laid the foundation for my understanding of business and entrepreneurship. Their teachings have been pivotal in shaping my approach to the challenges and opportunities that have come my way.

Special thanks to my teammates from the Master's in Space Business Management program: Suman Kasani, Laura Ramos, Giannis Biglianis, Barnabas Jenofi, Asli Gencosmanoglu, Ilaria Angelino, Jacob Pasqualotto, and Ricardo Marchetto. Your collaboration, ideas, and relentless dedication have made this journey both rewarding and enlightening. Together, we have navigated numerous challenges, and I am truly appreciative of the camaraderie and teamwork we have shared.

I would also like to extend my sincere thanks to the support team at Luiss Business School Amsterdam, especially Martina Fontanarosa, Alessandro Barcaro, and Roxana Popa. Your assistance in various logistical and administrative matters has been indispensable, allowing me to focus on the core aspects of my project.

My heartfelt thanks go to my family, especially my beloved wife, Martha, whose patience, understanding, and encouragement have been my pillars of strength throughout this endeavour. To my children, Luís Vicente, Victoria Eugenia, David Santiago, and Vicente Ignacio, your love and joy have been a constant source of motivation. Your smiles have given me the energy to persevere through the toughest times.

Finally, I owe an immense debt of gratitude to my parents, Luís and Belén, whose unwavering belief in my abilities and continuous support have been crucial in helping me pursue and achieve my dreams. Without your love and guidance, none of this would have been possible.

Thank you all for your incredible support in making this entrepreneurial journey a reality.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ASSB: All-Solid-State Battery	**AC:** Actual Cost	**QA:** Quality Assurance
ASSLB: All-Solid-State Lithium Battery	**CV:** Cost Variance	**QC:** Quality Control
BIB: Bismuth-Ion Battery	**EV:** Earned Value	**R&D:** Research and Development
EV: Electric Vehicle	**ESG:** Environmental, Social, and Governance	**SV:** Schedule Variance
LIB: Lithium-Ion Battery	**BMC:** Business Model Canvas	**SPI:** Schedule Performance Index
SSB: Solid-State Battery	**PV:** Planned Value	**CPI:** Cost Performance Index

LIST OF APPENDICES

1. INTRODUCTION

The global shift toward renewable energy, particularly solar and wind power, presents a significant challenge: the intermittent nature of these energy sources causes instability in electricity grids and raises the risk of blackouts without reliable energy storage solutions. Currently, conventional lithium-ion batteries are widely used for energy storage in devices ranging from smartphones to electric vehicles (EVs). However, these batteries have notable limitations, including performance degradation over time, safety risks due to liquid electrolyte leakage, and the formation of lithium dendrites, which can lead to short circuits and even explosions.

All-Solid-State Batteries (ASSBs) have emerged as a promising solution to these challenges. By replacing liquid electrolytes with solid ones, ASSBs eliminate the risks of leakage and dendrite formation, resulting in improved safety, higher energy density, faster charging times, and greater durability. These advantages make ASSBs particularly attractive for next-generation energy storage, including their use in electric vehicles and the rapidly advancing space sector.

However, ASSBs still face significant obstacles, such as manufacturing complexity, stability issues, high production costs, and scalability challenges. Optimizing solid electrolytes and improving the interfaces between electrodes are critical hurdles that must be overcome. Additionally, the high cost of production and difficulties in scaling up manufacturing processes remain major barriers to widespread commercialization. Solutions under exploration include the development of novel solid electrolytes, better materials for enhanced conductivity, and refining production methods to reduce costs and improve scalability. Recent advancements in these areas are promising and could accelerate the commercialization of ASSBs.

The potential for ASSBs goes beyond the EV market and extends into other industries, notably the growing Space Economy. Driven by technological innovation and increasing public-private partnerships, the space sector is experiencing rapid growth, particularly in the deployment of small satellites and advanced propulsion systems. In this context, energy storage technologies, particularly bismuth-ion solid-state batteries (BIBs), present exciting possibilities. BIBs offer superior environmental safety, enhanced conductivity, and improved cycling capabilities, making them ideal for space applications and other industries that require high-performance energy solutions.

Workforce development is also a critical challenge in the commercialization of ASSBs and BIBs. The industry requires a highly skilled workforce capable of addressing the technical complexities of battery innovation, from material science to advanced manufacturing techniques. Training, education, and strategic investments in workforce development will be essential for scaling up production, reducing costs, and meeting the increasing demand for sustainable energy storage solutions.

Startups focusing on solid-state battery technologies, including those leading the development of BIBs, are well-positioned to drive breakthroughs in sustainable energy storage. By employing strategic entrepreneurial frameworks, these companies can address commercialization, market entry, regulatory hurdles, and cost challenges while overcoming scalability issues and ensuring compliance with environmental standards. As they succeed in these areas, they will play a crucial role in shaping the future of industries such as electric vehicles, renewable energy, and space exploration, contributing to the broader transition toward sustainable and efficient technologies.

2. LITERATURE REVIEW

2.1. The Energy Storage Challenge: A California Case Study

The shift from carbon-intensive to renewable energy is accelerating, with traditional coal, oil, and gas systems giving way to decentralized sources like solar photovoltaic (PV) and wind energy. Two decades ago, renewables played a minor role; today, they are vital to many grids. However, their intermittent nature poses challenges. Unlike coal or gas plants, solar and wind depend on weather, making reliable energy storage crucial for grid stability.

Energy storage systems are key to addressing this intermittency by storing excess renewable energy during high production periods for later use. The goal is to integrate sufficient storage capacity to supply power during low generation periods, driving innovation in storage technologies.

California's experience highlights the importance of storage. In August 2020, a severe heatwave caused rolling blackouts—the first in over 20 years—affecting nearly 500,000 people. Despite significant solar investments, electricity demand remained high as solar generation declined in the evening, and neighboring states couldn't supply power due to their own needs. Greater energy storage, such as large-scale battery systems, could have mitigated the crisis.

Currently, California relies on lithium-ion batteries, which offer about four hours of power. While battery capacity has increased tenfold to 2.5 gigawatts, it remains insufficient for cities like Los Angeles, which needs 6.5 gigawatts. Additionally, lithium-ion batteries cannot provide long-duration storage to match daytime solar peaks with evening demand.

To fully integrate renewables, longer-duration and diverse storage solutions are essential to reduce reliance on single technologies. Globally, the rapid adoption of renewables underscores the need for advanced, cost-effective, and durable storage systems capable of extended operation and quick response to demand spikes. The energy transition's success hinges on the development of large-scale, efficient storage solutions. [1]

2.2. Solid-State Battery Technology Overview

Batteries comprise an anode, cathode, and electrolyte. During discharge, ions flow from the cathode to the anode, generating electrons to power devices; charging reverses this process.

Advances in battery technology focus on materials improvements. Solid-state batteries (SSBs), which use solid instead of liquid electrolytes, promise faster, safer, and more efficient energy storage. Sodium-based glass electrolytes, for instance, offer triple the energy density of lithium-ion batteries with reduced environmental impact. These lightweight, eco-friendly batteries hold great potential for electric vehicles (EVs), enabling longer ranges and accelerating EV adoption. However, cost-effective, large-scale production remains a major obstacle. [2]

SSB technology faces challenges, including improving ionic conductivity, stabilizing interfaces, and lowering materials costs. Manufacturing struggles with scaling solid electrolytes and adapting current production methods. Adoption is further hindered by infrastructure compatibility, high costs, regulatory barriers, and supply chain issues. Ensuring reliability and providing industry training are essential for widespread implementation. [3]

2.3. Lithium-Ion Battery (LIB) Technology Overview

Solid-state battery technology is a breakthrough for rechargeable batteries, critical for advancing electric vehicles. By replacing liquid electrolytes with stable solids, these batteries enhance safety, enable faster charging, extend ranges up to 1,100 km, and lower costs. [4]

Lithium-ion batteries, essential for electronics and EVs, face safety concerns due to volatile liquid electrolytes. All-solid-state lithium batteries (ASSLBs) address this but require interdisciplinary research to stabilize interfaces and maintain chemical balance during operation. Progress in these areas signals a promising future for safe, high-energy lithium batteries. [5]

2.4. Bismuth-Ion Battery (BIB) Technology Overview

Bismuth, a non-toxic metal, is an eco-friendly alternative to harmful metals, widely used in products like stomach treatments, makeup, and as a lead replacement in paint and ammunition. Known for its brittleness, rainbow-like crystals, and low melting point (271°F/132°C), bismuth is primarily produced by China, which supplies 75% of the global output. Its applications include superconductors, synthetic fuels, cancer treatment, and cleaner electronics. [6]

Bismuth-ion batteries (BIBs) leverage bismuth's Bi+3 state, offering eco-friendliness and strong electrochemical performance compared to lithium-ion and aluminium-ion technologies. While R&D has shown BIB stability, challenges like limited trivalent metals, electrode corrosion, low capacity, and poor cyclic life remain. Innovations in cathode and electrolyte materials could improve their viability for energy storage. Key benefits of BIB all-solid-state batteries include:

- **Enhanced Ionic Conductivity**: Trivalent bismuth ions improve solid-polymer electrolytes, achieving about 8 times greater ionic conductivity.
- **Improved Interfacial Stability**: These ions strengthen interfaces between anode and solid-polymer electrolytes (SPE) and enhance long-term cycling stability at high voltages.
- **Suppression of Lithium Dendrite Growth**: Trivalent bismuth ions alloy with lithium on the anode surface, reducing dendrite formation and increasing safety and battery longevity.
- **High-Voltage Cycling Capability**: Batteries utilize trivalent bismuth ions to cycle stably at high voltages (e.g., 4.4 V) for up to 800 cycles with a capacity retention of 72.4%.

Trivalent bismuth ions in polymer electrolytes improve conductivity, interfacial stability, dendrite suppression, and high-voltage performance, making them promising for durable, high-performance all-solid-state batteries. [7][8]

2.5. Stability, Environmental Impact, and Development Stage of BIBs and LIBs Technologies.

The graph compares Bismuth Ion Batteries (BIBs) and Lithium-Ion Batteries (LIBs) based on three criteria: Stability, Environmental Impact, and Development Stage. Both battery types achieve equal stability with a normalized score of 1.0. However, BIBs have a lower environmental impact rating (0.5) compared to LIBs (0.67). In terms of development stage, BIBs score 0.0, indicating they are in the early development phase, whereas LIBs are fully developed with a score of 1.0. [7] [9] [10] [11]

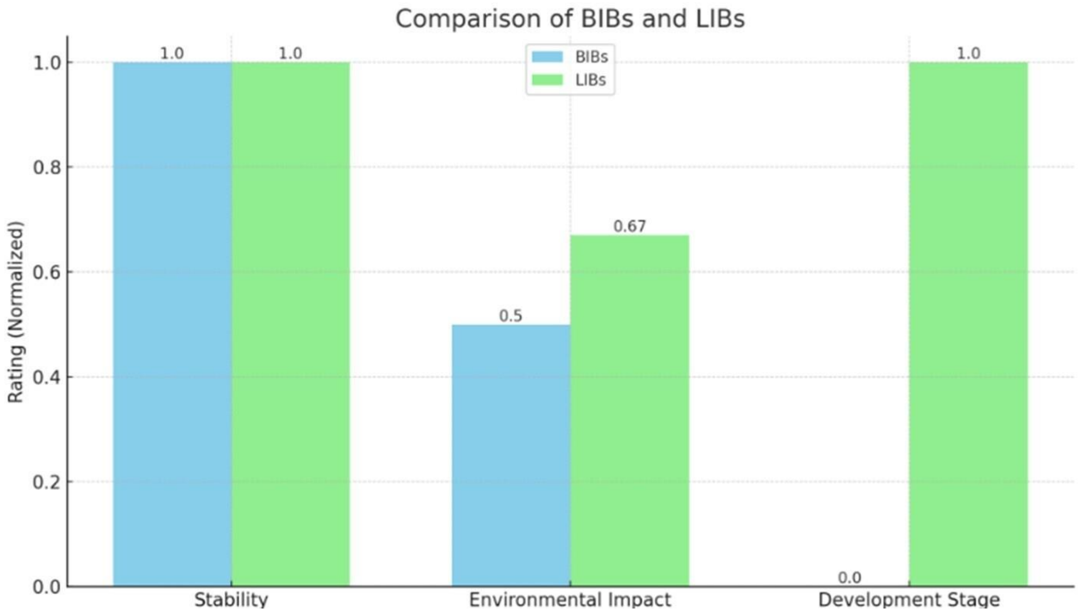


Figure #1: Comparison of Bismuth Ion and Lithium-Ion Batteries in Stability, Environmental Impact, and Development Stage. [7] [9] [10] [11]

2.6. Bismuth-Lithium's Market Trends Comparison (6 months comparison)

From April to October 2024, lithium prices fluctuated significantly, peaking at $15,000/ton in May due to EV demand and supply constraints, then dropping to $9,000/ton by September as supply normalized and alternatives emerged. A slight recovery to $10,533/ton occurred in October.

Bismuth, more stable, saw steady price growth from $460/ton in April to $550/ton in July, driven by pharmaceutical and industrial demand. By October, prices corrected to $499/ton due to demand plateauing and market corrections.

Lithium shows higher volatility, while bismuth remains more stable. [12] [13]

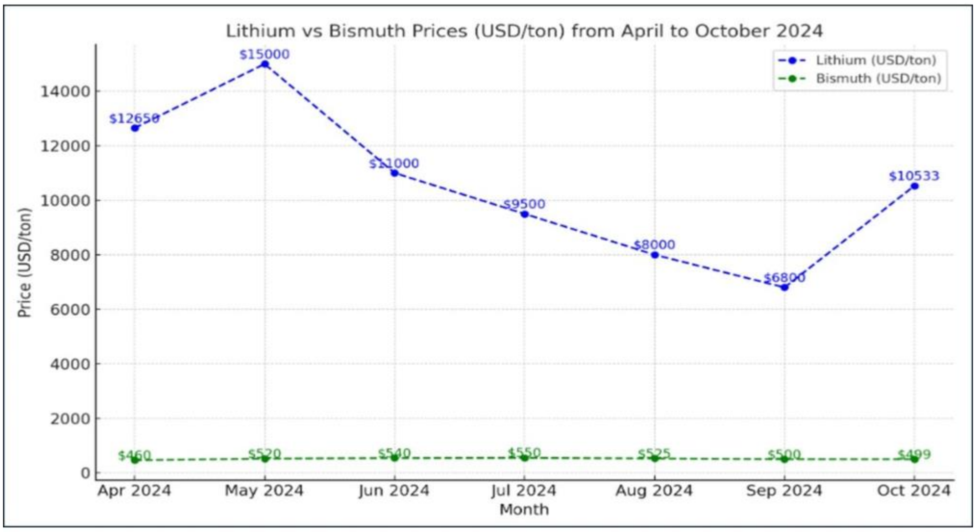


Figure #2. Lithium vs Bismuth Prices (USD/ton) from April to October 2024

2.7. Strategic Business Frameworks

A strategic framework outlines how to create, execute, and evaluate an organization's strategy, aligning team activities with goals. Various planning models can help startups build frameworks, though these are just a few options. [14]

2.7.1. The Business Model

A business model outlines how a company makes money, identifying its customers, value delivery, and financing. The business model canvas summarizes these elements on one page. [15]

2.7.1.1. The Business Model Canvas (BMC)

The Business Model Canvas, by Alex Osterwalder and Yves Pigneur, is a strategic tool for visualizing and evaluating business ideas. It features nine boxes representing key business elements. [15]

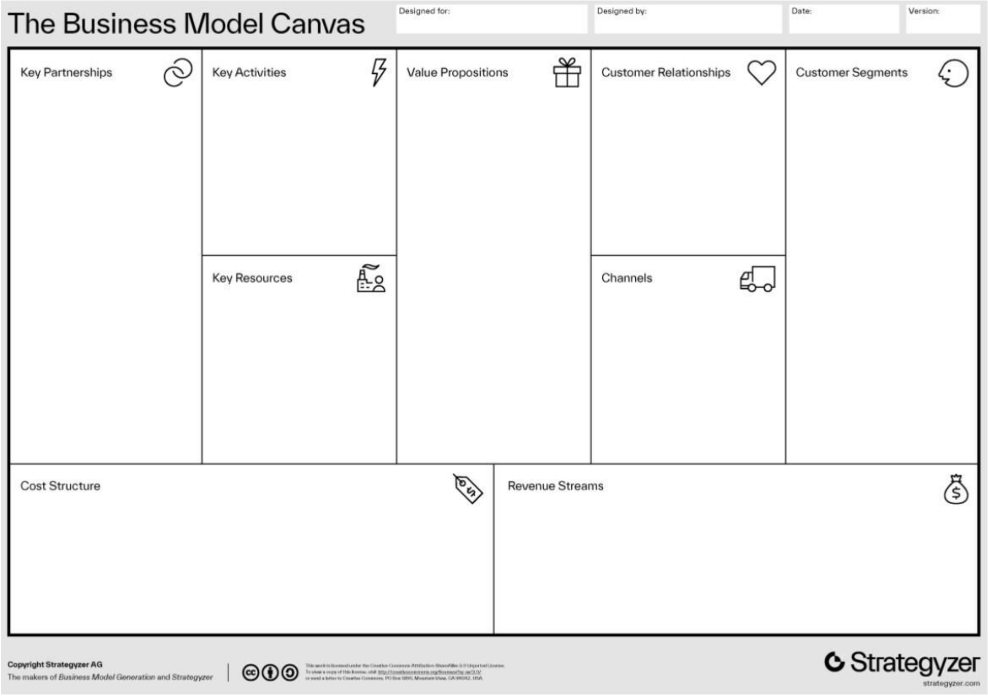


Figure #3. Business Model Canvas. [16]

The canvas's right side addresses external, customer-focused factors, while the left covers internal, business-controlled factors. The centre highlights value propositions exchanged with customers.
The business model canvas comprises nine key elements:

- **Customer Segments**: Defines target groups based on traits like demographics or behaviors, enabling tailored solutions for mass, niche, or multi-sided markets. Personas guide customer focus. [6]

- **Customer Relationships**: Outlines interaction types (e.g., personal assistance, self-service) for acquiring, retaining, and growing customers. [6]

- **Channels**: Details communication and delivery methods, such as owned (websites) or partner-based (retail), for value proposition delivery. [6]

- **Revenue Streams**: Lists revenue models, including transactions, subscriptions, or advertising, for each customer segment. [6]

- **Key Activities**: Covers essential actions like production, problem-solving, and platform management to deliver value and maintain relationships. [6]

- **Key Resources**: Highlights necessary assets—human, financial, intellectual, or physical—to support operations. [6]

- **Key Partners**: Identifies external collaborators like suppliers or alliances to aid activities and reduce risks. [6]

- **Cost Structure**: Summarizes operational costs for value creation, customer relationships, and revenue generation, focusing on cost- or value-driven approaches. [6]

The Business Model Canvas offers a comprehensive framework to assess, improve, and innovate a business model. It is flexible and evolves with changing market dynamics. [15]

2.7.2. The Value Proposition

The value proposition is a company's unique solution to meet customer needs, distinct from competitors' offerings. It can be quantitative (e.g., price, speed) or qualitative (e.g., design, experience). [17]

2.7.2.1. The Value Proposition Canvas

The Value Proposition Canvas, developed by Alex Osterwalder and Yves Pigneur, helps create, analyse, and refine value propositions by understanding customer needs and designing products to address them. [17]

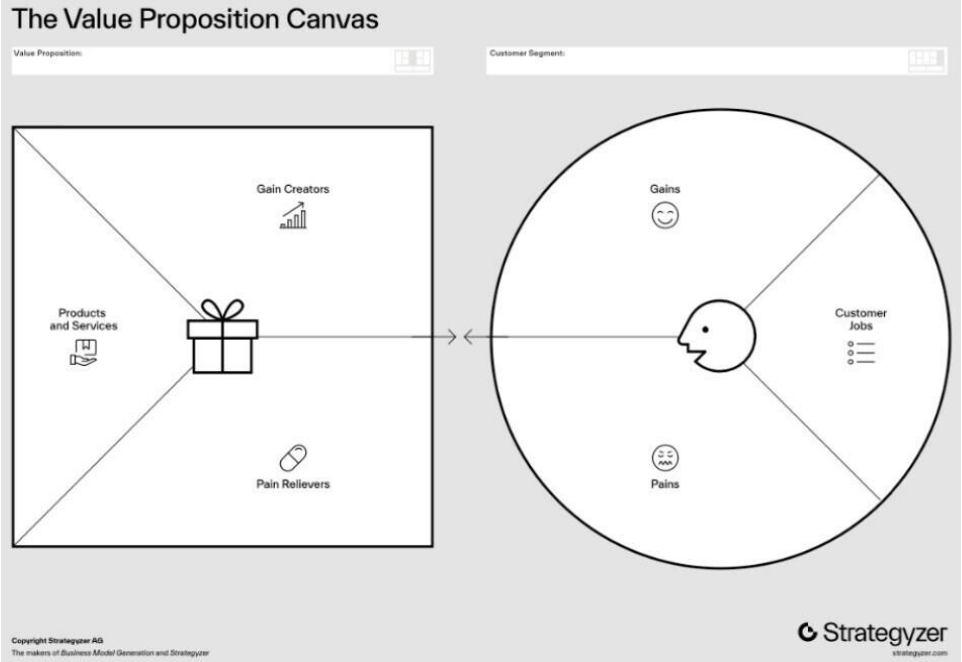


Figure #4. Value Proposition Canvas. [17]

The Value Proposition Canvas consists of key components:

- **Customer Profile**: Defines target customer segments based on demographics and behaviour.
- **Value Map**: Outlines the product’s features and how it fulfils customer needs.
- **Customer Jobs**: Identifies tasks customers want to accomplish.
- **Customer Pains**: Highlights customer challenges and frustrations.
- **Customer Gains**: Specifies desired benefits like emotional, functional, or financial rewards.

This approach helps businesses craft a strong value proposition aligned with customer needs. [17]

2.7.3. Strategy Development

Strategic development establishes mission, vision, and values to guide an organization, identifying issues and creating a competitive edge through operational excellence, product leadership, or customer intimacy. [18]

- **Mission**: Defines the organization's current purpose and targets, focusing on meeting customer needs.
- **Vision**: Describes the future state the organization aims to achieve.
- **Values**: Core principles guiding behaviour and decision-making.
- **Purpose**: Explains the deeper meaning behind the organization's existence beyond profits.
- **Strategy**: Outlines the approach to achieving long-term goals by leveraging strengths.
- **Culture**: Combines values, purpose, and strategy, shaping how work is done and fostering goal alignment.

These elements collectively guide organizational strategy and planning. [18]

2.7.4. Future Visioning & Scenario Planning

Visioning and scenario planning work together in strategic planning. Start by defining a challenge, then refine a shared vision. Use trend analysis to create scenarios, assess risks and opportunities, and prioritize strategies aligned with the vision and challenge. [19]

- **Visioning**: Imagining a desired future to align goals and actions using methods like brainstorming or storytelling.
- **Scenario Planning**: Preparing for opportunities and challenges by analyzing plausible future scenarios through tools like matrices or trend analysis. [19]

2.7.5. The Death Valley Curve

The Death Valley curve describes a startup's phase of operations without revenue, depleting initial equity capital. It's named for the shape of the startup's cash flow burn on a graph. [80]

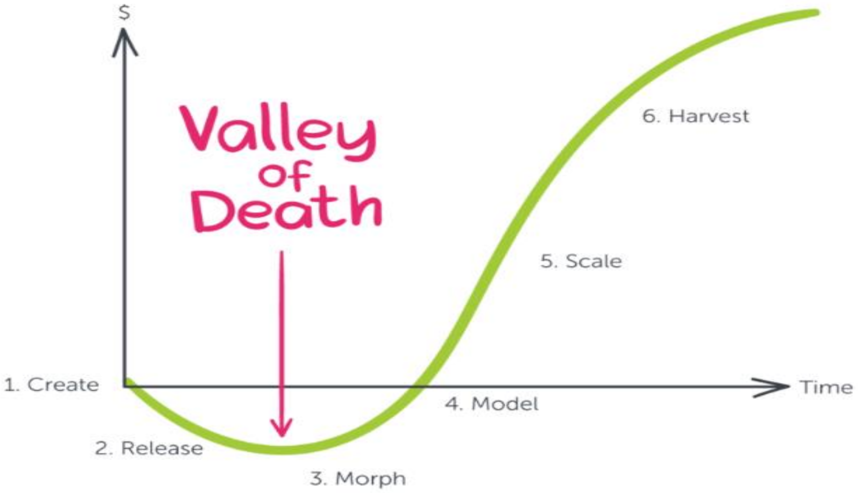


Figure #5. The Death Valley Curve for Entrepreneurs. [81]

2.7.6. **Return of Investment (ROI)**

Return on investment (ROI) measures how much money has been made or lost on an investment after accounting for its cost. It's typically calculated annually for easier comparison but can also be calculated over other periods depending on the context. [82]

$$\text{ROI} = \frac{\text{Current Value of Investment} - \text{Cost of Investment}}{\text{Cost of Investment}}$$

Figure #6. ROI Formula. [82]

3. THE BUSINESS CASE

This business case explores Binergy's challenges and opportunities in the space economy and global solid-state battery market. It outlines the energy demands of the space sector, examines battery fundamentals, identifies challenges, and proposes solutions within a strategic framework for market success.

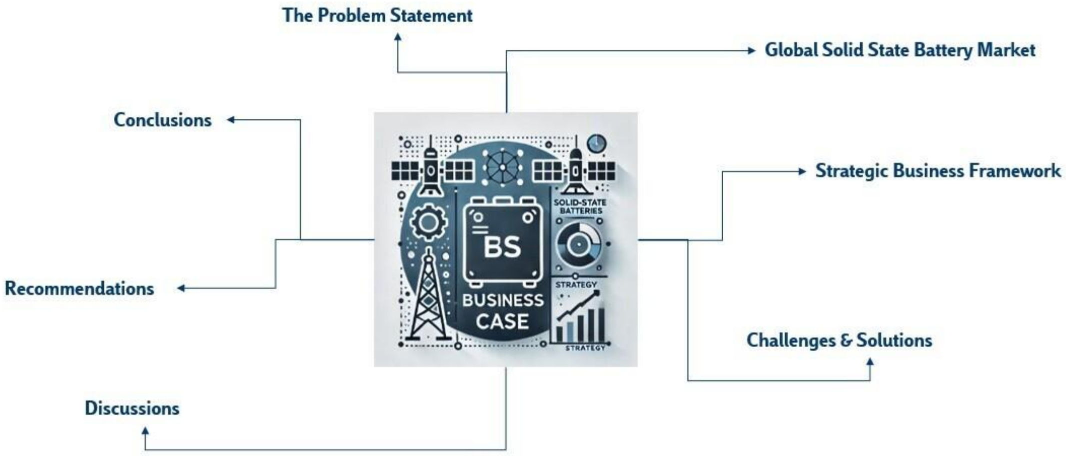
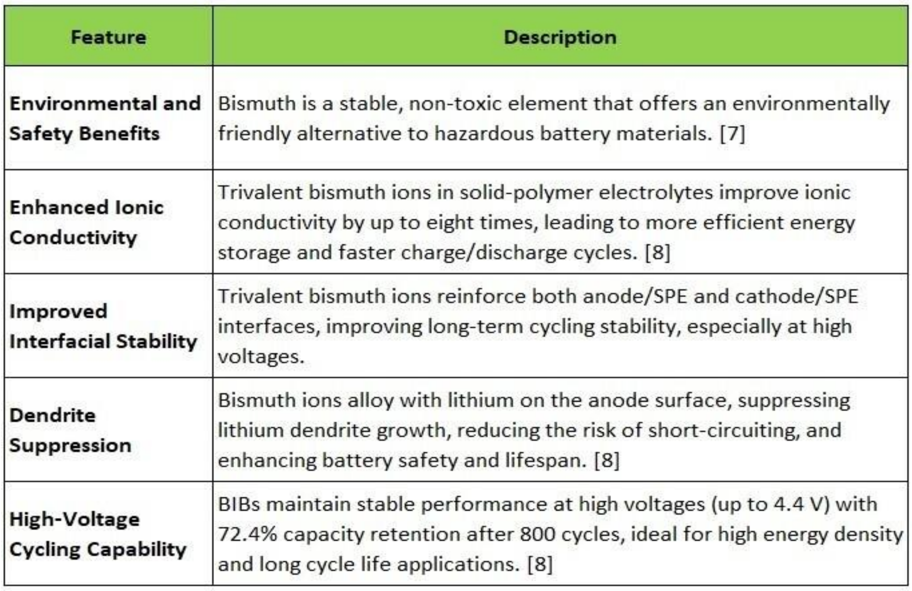


Figure #7. Business Case Framework for Solid-State Batteries.

Binergy is driven to develop Bismuth-ion Batteries (BIBs) to diversify beyond lithium-ion technology. BIBs use bismuth's stable Bi^{3+} state, offering environmental and technical advantages over other trivalent metal ion batteries like aluminium-ion.

Table #1. Key technical and environmental benefits of using bismuth ions in battery technology. [7] [8]



Feature	Description
Environmental and Safety Benefits	Bismuth is a stable, non-toxic element that offers an environmentally friendly alternative to hazardous battery materials. [7]
Enhanced Ionic Conductivity	Trivalent bismuth ions in solid-polymer electrolytes improve ionic conductivity by up to eight times, leading to more efficient energy storage and faster charge/discharge cycles. [8]
Improved Interfacial Stability	Trivalent bismuth ions reinforce both anode/SPE and cathode/SPE interfaces, improving long-term cycling stability, especially at high voltages.
Dendrite Suppression	Bismuth ions alloy with lithium on the anode surface, suppressing lithium dendrite growth, reducing the risk of short-circuiting, and enhancing battery safety and lifespan. [8]
High-Voltage Cycling Capability	BIBs maintain stable performance at high voltages (up to 4.4 V) with 72.4% capacity retention after 800 cycles, ideal for high energy density and long cycle life applications. [8]

Bismuth-ion Batteries (BIBs) offer improved conductivity, stability, and safety, despite challenges like limited metal options and corrosion. Binergy will also face business hurdles, including competition, regulatory compliance, funding, and partnerships.

3.1. The Problem Statement

The shift to renewable energy faces intermittency challenges, and current lithium-ion batteries have limitations in energy density, safety, and long-duration storage. [1]

Solid-State Batteries (SSBs) offer better energy density and safety but face scalability and cost issues. Multivalent batteries like aluminum-ion and bismuth-ion show promise but struggle with corrosion and cycle life. [7][8][20]. Startups must overcome technical, financial, and regulatory hurdles to ensure a stable renewable energy future and prevent inefficiency and grid instability.

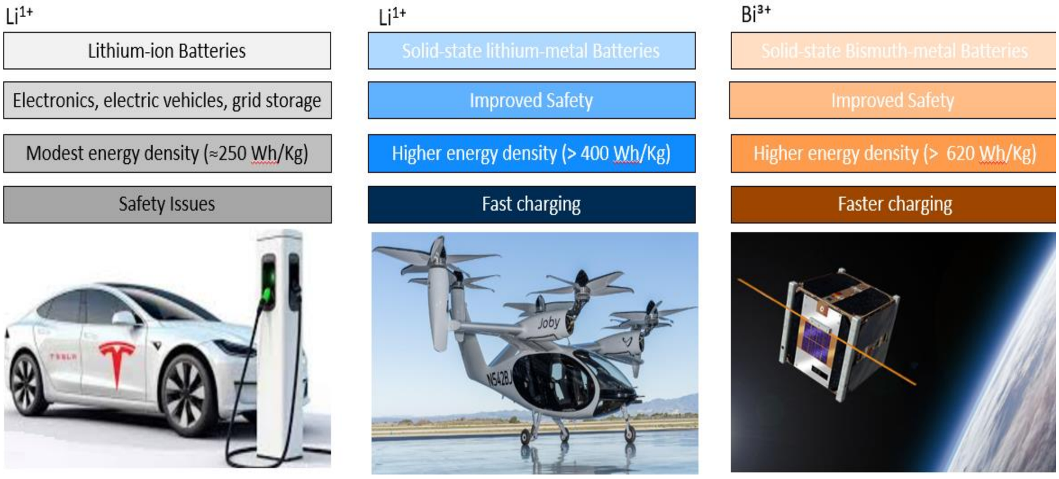


Figure #8. Comparison between technologies, all of them facing a myriad of different challenges. [7]

3.2. Battery Market Overview

The global battery market is growing rapidly, driven by demand in EVs, renewable energy, and space exploration. This growth presents key opportunities for Binergy's Bismuth-ion Battery (BIB) technology. [21][22][23]


Valued at USD 104.3 billion in 2022, with a projected CAGR of 16.1% from 2024 to 2030.

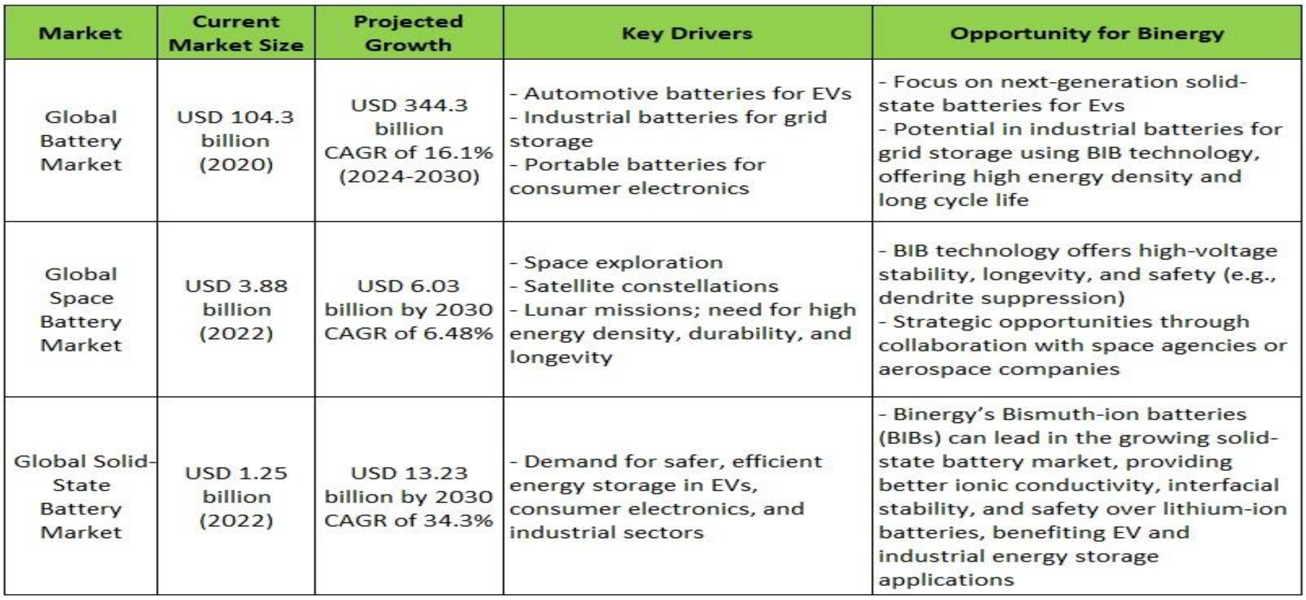
Valued at USD 3.88 billion in 2023, with a projected CAGR of 6.48% from 2023 to 2030.

Valued at USD 1.25 billion in 2022, with a projected CAGR of 34.30% from 2023 to 2030.

Figure #9. Battery Market Overview. [21] [22] [23]

Binergy can capitalize on growth in automotive, industrial, and space sectors by leveraging its Bismuth-ion Battery (BIB) technology to innovate energy storage and gain a competitive edge.

Table #2. Battery Market Summary. [21] [22] [23]



Market	Current Market Size	Projected Growth	Key Drivers	Opportunity for Binergy
Global Battery Market	USD 104.3 billion (2020)	USD 344.3 billion CAGR of 16.1% (2024-2030)	- Automotive batteries for EVs - Industrial batteries for grid storage - Portable batteries for consumer electronics	- Focus on next-generation solid-state batteries for Evs - Potential in industrial batteries for grid storage using BIB technology, offering high energy density and long cycle life
Global Space Battery Market	USD 3.88 billion (2022)	USD 6.03 billion by 2030 CAGR of 6.48%	- Space exploration - Satellite constellations - Lunar missions; need for high energy density, durability, and longevity	- BIB technology offers high-voltage stability, longevity, and safety (e.g., dendrite suppression) - Strategic opportunities through collaboration with space agencies or aerospace companies
Global Solid-State Battery Market	USD 1.25 billion (2022)	USD 13.23 billion by 2030 CAGR of 34.3%	- Demand for safer, efficient energy storage in EVs, consumer electronics, and industrial sectors	- Binergy's Bismuth-ion batteries (BIBs) can lead in the growing solid-state battery market, providing better ionic conductivity, interfacial stability, and safety over lithium-ion batteries, benefiting EV and industrial energy storage applications

3.2.1. Space Solid-State Battery & Non-Space Solid-State Battery Market Estimation

The battery market is evolving with solid-state batteries offering safer, higher-capacity, and longer-lasting solutions for sectors like space exploration, EVs, and industrial storage.

Analysing trends estimates growth in the "Space Solid-State Battery Market" and "Non-Space Solid-State Battery Market," highlighting unique opportunities in each. *Appendix #1 (page 35)* details the growth estimation tools. The global market growth was charted to show contributions from each sector.

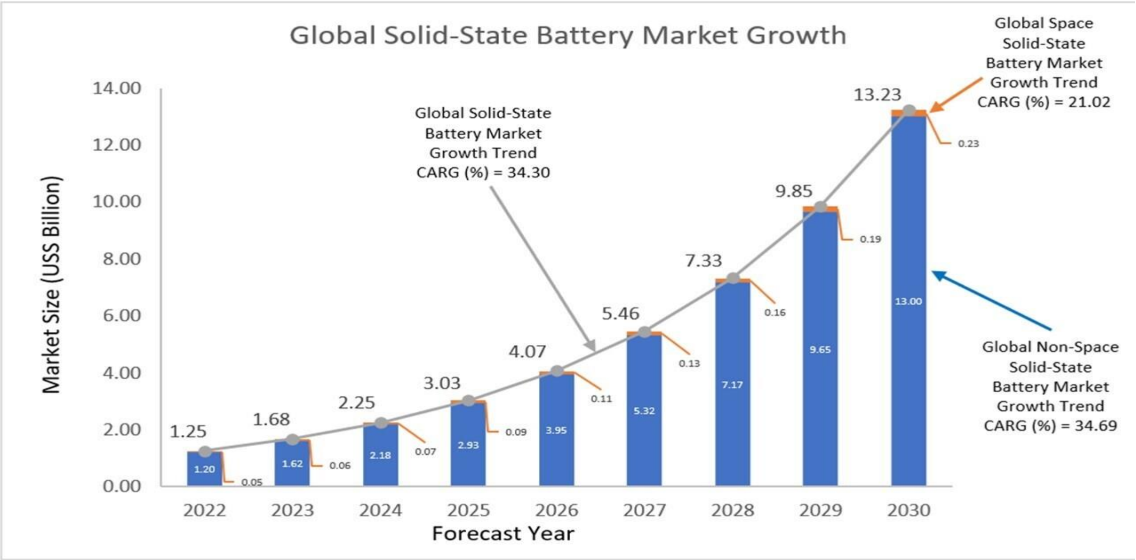
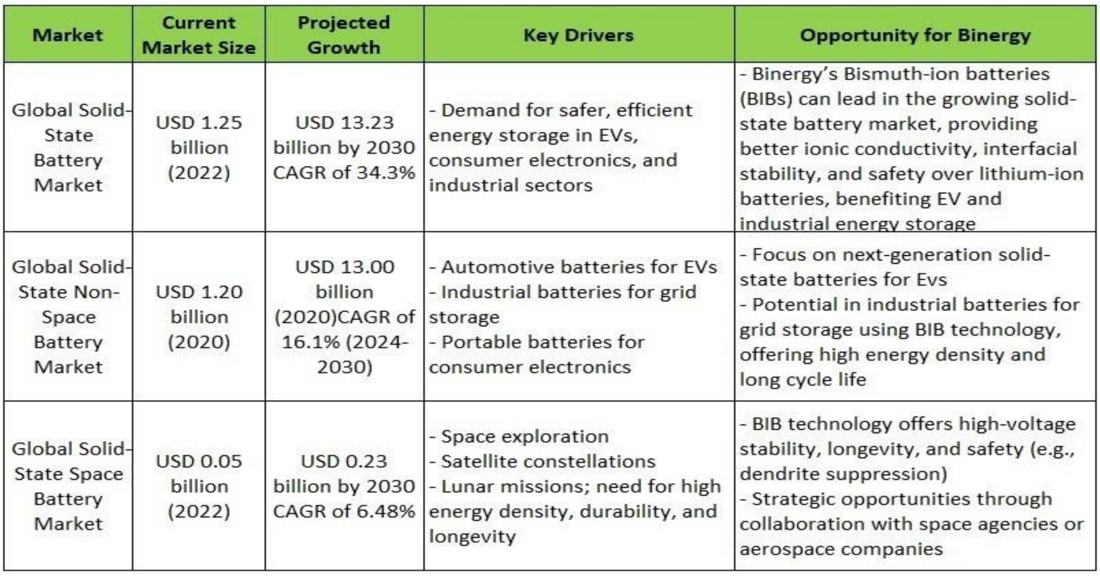


Figure #10. Global Solid-State Battery Market Trend (Estimation). [21] [22] [23] [24]

Figure #9 shows contrasting growth patterns between the Non-Space (Downstream) and Space (Upstream) Solid-State Battery Markets, with the Space market's contribution being minimal. [21][22][23]

Entrepreneurs should engage in both sectors, particularly the broader Non-Space Applications segment, to avoid limiting communication within the space community. [26]

Table #3. Global Solid-State Battery Market Takeaways. [21] [22] [23]



Market	Current Market Size	Projected Growth	Key Drivers	Opportunity for Binergy
Global Solid-State Battery Market	USD 1.25 billion (2022)	USD 13.23 billion by 2030 CAGR of 34.3%	- Demand for safer, efficient energy storage in EVs, consumer electronics, and industrial sectors	- Binergy's Bismuth-ion batteries (BIBs) can lead in the growing solid-state battery market, providing better ionic conductivity, interfacial stability, and safety over lithium-ion batteries, benefiting EV and industrial energy storage
Global Solid-State Non-Space Battery Market	USD 1.20 billion (2020)	USD 13.00 billion (2020)CAGR of 16.1% (2024-2030)	- Automotive batteries for EVs - Industrial batteries for grid storage - Portable batteries for consumer electronics	- Focus on next-generation solid-state batteries for Evs - Potential in industrial batteries for grid storage using BIB technology, offering high energy density and long cycle life
Global Solid-State Space Battery Market	USD 0.05 billion (2022)	USD 0.23 billion by 2030 CAGR of 6.48%	- Space exploration - Satellite constellations - Lunar missions; need for high energy density, durability, and longevity	- BIB technology offers high-voltage stability, longevity, and safety (e.g., dendrite suppression) - Strategic opportunities through collaboration with space agencies or aerospace companies

The comparison between these two markets provides insights into potential startup opportunities:

- ***Non-Space Solid-State Battery Market:*** With a larger size and higher projected 2031 value, this market offers immediate opportunities, broader applications, and a larger customer base, ideal for startups aiming for quick entry and scaling.

- ***Space Solid-State Battery Market:*** Though smaller, its higher growth rate suggests emerging opportunities in space exploration, satellite technology, and aerospace. This niche market may offer high growth potential and specialization opportunities for startups.

3.3. Challenges Faced by Startups & Suggested Solutions

Startups in the solid-state battery market face challenges in technology, commercialization, finance, IP, regulation, workforce, and ESG. Overcoming these is crucial for adopting solid-state batteries in energy storage, ensuring a stable renewable energy future and preventing inefficiencies. [1][32][65]

3.3.1. Technical Issues:

This section provides an in-depth look at key technical aspects of solid-state battery (SSB) development, covering *R&D, integration, and manufacturing* challenges.

The *Appendix #2 (page 37)* summarizes the key challenges and solutions relevant to scaling up solid-state battery technology for commercial use.

Technical challenges can be addressed by improving materials, ensuring stability, and optimizing scalable production. Design improvements enhance energy efficiency, durability, and thermal management. Integration requires standardization, regulatory alignment, diverse sourcing, and real-world testing. [32][33]

3.3.2. Commercialization Hurdles

The *Appendix #3 (page 38)* highlights key challenges in the solid-state battery industry, including cost, cell architecture, supply chain, and collaboration. Solutions include greener production, process optimization, supply diversification, and partnerships for innovation. To stay competitive, solid-state batteries need efficient manufacturing, material innovations, and scaling. Strategies include supply chain investments, partnerships, and R&D for cell architecture. [34][35][36][37][38].

3.3.3. Financial Obstacles:

The solid-state battery industry faces three main challenges: Scale-Up and Technical Validation, Capital Barriers, and Market Entry Risks. Solutions include strategic partnerships, R&D, venture funding, and government support. *See Appendix #4 (page 39)* for details on financial challenges and solutions. [39][40][41]

To tackle high production costs, the industry is improving efficiency and leveraging partnerships, government grants, and collaborations. R&D and process optimization will enhance commercial viability and scalability. [39][40][41]

3.3.4. Intellectual Property Concerns

The solid-state battery industry faces eight key IP challenges: Patent Uncertainty, International Protection Complexities, Trade Secret Protection, Patent Litigation, Patent Clusters, Infringement Risks, Licensing Issues, and Confidentiality. Solutions include diversifying patent portfolios, consulting legal experts, ensuring confidentiality, and conducting patent searches. Strategies also involve licensing, mitigating infringement risks, and navigating patent clusters through collaboration and legal counsel. *See Appendix #5 (page 40)* for additional information.

To mitigate patent risks, companies should conduct patent searches, seek legal advice, and develop tailored strategies. Navigating patent thickets requires collaboration and expertise. Strengthening portfolios, leveraging trade secrets, and forming partnerships are key. Non-disclosure agreements and access controls protect information. Effective licensing, risk management, and PCT use are crucial. Competitiveness relies on diversified portfolios, collaborations, and R&D investment. [42] [43] [44]

3.3.5. Market Barriers

Appendix #6 (page 41) outlines five key market challenges in the solid-state battery industry, along with explanations and proposed solutions. To address these, prioritizing R&D is crucial for improving performance and reducing costs, aiding the shift from lead-acid batteries. Collaboration with space agencies and private companies is vital for developing advanced space batteries. Investment in R&D will address cost and scaling issues, particularly for electric vehicles and renewable energy. Targeting non-space markets offers immediate opportunities, while specialized energy storage solutions can drive growth in the space market. These strategies help navigate challenges and seize opportunities. [20] [21] [22]

3.3.6. Regulatory Requirements

Appendix #7 (page 42) addresses key regulatory, safety, and environmental challenges with suggested solutions to improve compliance and sustainability in the solid-state battery industry.

To address regulatory gaps, companies can implement internal guidelines (e.g., Toyota's ATSG) and align with global initiatives like the Paris Agreement. Environmental assessments, ISO certifications, renewable energy adoption, and compliance with standards (e.g., TCFD, GRI) ensure proper disposal and recycling. Establishing safety standards and governance mitigates explosion and fire risks. Adopting common standards and promoting sustainability aids in navigating regulations and accessing international markets. [45] [46] [47] [48] [49]

3.3.7. Safety Considerations

Solid-state batteries (SSBs) offer key advantages over liquid electrolyte lithium-ion batteries (LE-LIBs) in terms of lifespan, safety, and environmental impact. With non-flammable solid electrolytes, SSBs reduce risks like fires, explosions, and thermal runaway while also improving performance and safety. *Appendix #8 (page 43)* summarizes safety challenges and proposed solutions.

Solid-state batteries (SSBs) outperform lithium-ion batteries (LE-LIBs) by improving safety, performance, and environmental impact. They eliminate flammable liquid electrolytes, reducing fire risks, and use lithium metal anodes to enhance energy density and reduce dendrite formation. With a longer lifespan and fewer volatile components, SSBs are a safer, greener alternative to LE-LIBs. [50]

3.3.8. Sustainability Factors

Appendix #9 (page 44) highlights the need for adopting sustainable practices, advancing technologies like solid-state batteries, and complying with global environmental, social, and governance (ESG) standards to reduce environmental impact and ensure ethical operations.

Industries face pressure to reduce environmental impact and meet sustainability standards. Businesses should prioritize ESG reporting, invest in sustainable R&D (e.g., solid-state batteries), adopt renewable energy, and ensure ethical supply chains. Strong cybersecurity and transparent ESG practices are key for compliance, risk management, and stakeholder trust. [52] ~ [57]

3.3.9. Workforce-Related Matters

Key challenges and proposed solutions to workforce issues in the battery industry are outlined in the *Appendix #10 (page 45)*, based on the initiatives and objectives of the Battery Workforce Initiative (BWI). [61] [62]

The Battery Workforce Initiative (BWI) tackles workforce challenges with standardized training guidelines and a work-based learning model combining on-the-job training and classroom instruction. Collaboration between industry, education, and government is essential. Pilot programs will expand opportunities, focusing on diversity, fair wages, and job security. Data-driven approaches will ensure training meets industry needs, building a skilled, competitive battery manufacturing workforce. [61] [62]

3.3.10. Cost Implications

The solid-state battery industry faces significant costs: R&D for materials and scaling ($10-$50 million annually), sustainability efforts ($1-$5 million), regulatory compliance ($500,000-$2 million), and production ($400,000-$800,000 per MWh). Commercialization requires $5-$15 million, market entry costs $3-$10 million, and managing IP and safety compliance adds $100,000-$500,000 each. Workforce training costs $1-$5 million annually. *Appendix #11* (page 46) highlights the cost landscape of solid-state battery development. To manage costs, organizations should adopt strategic partnerships, efficient funding, and lifecycle cost analysis.

Collaborative R&D, government grants, optimized production, and targeted marketing reduce costs and support market entry. Effective patent management and workforce development ensure sustainable growth. [63] ~ [79]. *Appendix #12 (page 47)* summarizes development costs, scalability-driven price reductions, long-term projections, manufacturer expectations, and factors affecting consumer prices.

3.4. Strategic Frameworks for Binergy Startup: Building a Sustainable Path to Success

Binergy uses six strategic frameworks to launch its renewable energy startup: *"The Business Model"* defines operations, *"Value Proposition"* highlights its unique offering, *"Strategy Development"* focuses on sustainable growth, and *"Future Visioning & Scenario Planning"* ensures adaptability. Addressing the *"Death Valley Curve"* manages early-stage cash flow, while prioritizing *"ROI"* ensures resource efficiency and long-term profitability. [14] [15] [16] [17] [18] [19]

These frameworks align Binergy's activities with its strategic goals, positioning the startup for success.

3.4.1. Binergy's Business Model:

This framework defines how Binergy creates, delivers, and captures value, focusing on revenue generation, target customers, and operational needs. It ensures feasibility, market fit, and competitive advantage in the energy sector. [14]

3.4.1.1. Binergy's Business Model Canvas (BMC):

Strategic management tool that provides a holistic view of how a business operates and creates value. It serves several important purposes such as clarity and communication, strategy development & business planning.[15]. The Binergy's BMC can be seen in *Appendix #13 (page 49)*.

3.4.2. Binergy's Value Proposition:

The value proposition highlights the unique benefits Binergy offers, ensuring it stands out in a competitive market by meeting customer needs and solving problems better than competitors. [15]

3.4.2.1. Binergy's Value Proposition Canvas (VPC):

It is an essential tool for businesses to understand and communicate the value they offer to their customers. It provides customer-centric approach, clear communication and alignment with customer segments. [13]

Three VPCs have been developed, according to Upstream (Space Agencies, Satellite Manufacturers & Space Launchers) and Downstream (EV Manufacturers & Renewable Energy Companies) customers, which are shown in *Appendix #14 (page 50),* Binergy's VPCs for Upstream and Downstream Customers.

3.4.3. Binergy’s Strategy Development:

Strategy development helps Bynergy identify its long-term goals and map out how to achieve them. This framework is crucial for ensuring that all efforts are aligned with the company's objectives. It provides a clear direction on growth, market entry, innovation, and competition, ensuring that Bynergy makes informed, strategic decisions. [16]. *Appendix #15 (page 51)*, shows the main elements for Binergy's Strategy Development, Mission, Vision, Values, Purpose, Strategy and Culture.

Strategy development guides Bynergy's long-term goals and ensures efforts align with objectives. It focuses on growth, market entry, innovation, and competition for informed decisions. See Appendix #18 for key elements: *Mission, Vision, Values, Purpose, Strategy, and Culture*. [16]

3.4.4. Binergy’s Future Visioning and Scenario Planning:

Startups like Bynergy face uncertainty and rapid change, particularly in the energy industry. Future visioning and scenario planning enable the startup to anticipate various future possibilities and prepare for them. This framework allows Bynergy to adapt its strategies as market conditions, technology, and regulations evolve, ensuring long-term resilience and success. [18]. *Appendix #16 (page 54)*, shows an exercise of Visioning & Scenario Planning for the startup Binergy, based on the challenges already known.

3.4.5. Binergy’s Death Valley Curve

It illustrates the period when the startup has begun operations but has not yet generated revenue. During this time, the initial equity capital provided by shareholders is depleted. [80]

Detailed analysis of the Binergy’s Death Valley Curve will be provided in chapter 5, *Post-Project Phase,* together with the *Return of Investment (ROI).*

4. THE PROJECT MANAGEMENT PLAN

A Project Management Plan is a comprehensive document that outlines how a project will be executed, monitored, controlled, and closed. [83] A good project management plan must consider the following domains:

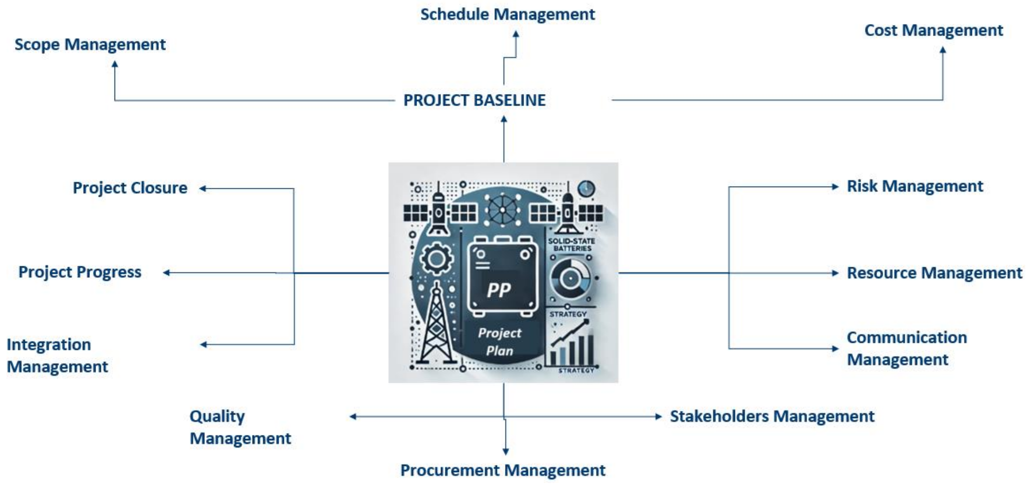


Figure #11. Project Domains. [83]

4.1. Project Baseline

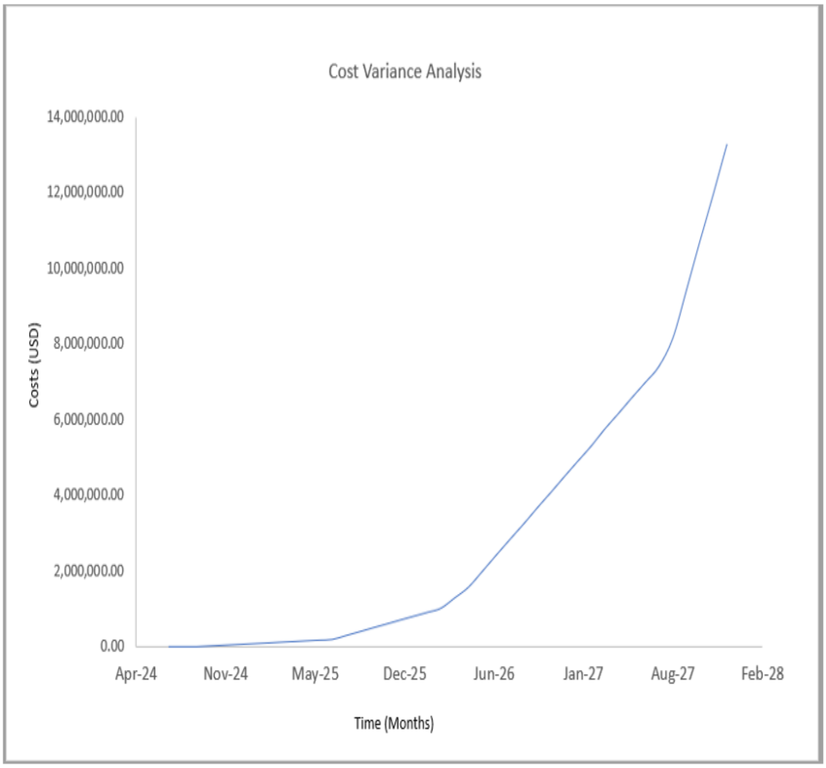
A project baseline is a fixed reference point in project management used to measure and compare actual progress against the original project plan. It serves as a benchmark for assessing performance, helping project managers identify deviations and ensure the project remains within predefined constraints. [84]

Components of a Project Baseline:

- *Scope Baseline:* Defined project objectives and deliverables.
- *Schedule Baseline:* Timeline for project deliverables and milestones.
- *Cost Baseline:* Budgetary limits including resource costs and expenses.

Setting a Project Baseline:

- *Define Project Scope:* Create a scope statement detailing objectives and deliverables.
- *Develop Project Schedule:* Use tools like Gantt charts to outline tasks, deadlines, and resource allocation.
- *Estimate Costs:* Calculate the project budget, considering all expenses and linking it to the project schedule.
- *Seek Stakeholder Approval:* Present the baseline plan to stakeholders for feedback and necessary adjustments prior to project initiation. [84]



- •Scope: Fully functional Bi-Ion Solid-State Battery Production Line.
- •Schedule: 41 month
- •Cost: USD 13,297,689.44

Figure #12. Binergy's Baseline - Cost Variance Analysis for Bi-Ion Solid-State Battery Production Line

This figure represents the cost progression over a 41-month schedule for the development of a fully functional Bi-Ion Solid-State Battery Production Line. Key observations include:

- *Exponential Cost Growth:* Costs rise steeply near the project's end, likely due to intensified resource use, investments, or unforeseen challenges. This may reflect delays, testing complexities, or unexpected issues, highlighting the need for early contingency planning and careful financial monitoring.

- *Total Project Cost:* The final recorded cost is USD 13,297,689.44, emphasizing the substantial investment required for such advanced technological development.

- *Schedule and Scope:* The project is planned for a duration of 41 months, with a focus on delivering a cutting-edge production line for Bi-Ion solid-state batteries, likely due to the high demands of innovation and implementation.

4.1.1. Project Scope

The project scope is the total amount of work that needs to be done to complete a project. Binergy's Project is "Predictive" which means that its Life Cycle follows a structured, planned approach where the scope, time, and cost are defined at the beginning and change very little as the project progresses. In a predictive life cycle, also known as a "waterfall" or "plan-driven" approach, each phase (like planning, design, execution, monitoring, and closure) is typically completed in sequence. [85]. *See Appendix #17 (page 55)* for additional information.

4.1.2. Project Schedule

A project schedule outlines tasks, resources, deadlines, and milestones to ensure timely completion. Used with a work breakdown structure (WBS), it distributes work among team members and requires regular updates for status tracking. Gantt charts [86] have been used to detail tasks, deadlines, and resource allocation. [86]. See *Appendix #18 (page 56).*

4.1.3. Project Costs

Cost management is the process of planning and managing the budget of a business or project. In the case of a project, it helps the project manager estimate what the project will cost and set controls to reduce the chances of the project going over budget. [87]. See *Appendix #19 (page 57)*, which shows a summary of Binergy's Project Costs Management Components & Breakdown. *Appendix #20 (page 58)*, shows a list of all possible sources that Binergy could leverage for its project activities.

4.1.3.1. Earned Value Management (EVM) Key Metrics

Analysing schedule and cost separately do not provide a clear indication of the project's desired trajectory. If we only look at the schedule, it is possible that delays may be the only apparent issue. A project that is late is an issue, but if the project is underbudget, this schedule delay in context could be considered less significant. [88]

EVM is a method that allows us to make this connection between a project's schedule and cost as well as to know if the project is on the right path or not. [88]

Appendix #21 (page 59) summarizes the EVM Technique, Fundamentals and Equations, essential for implementing Earned Value Management.

4.2. Risk Management

Risk analysis and risk management is a process that allows individual risk events and overall risk to be understood and managed proactively, optimising success by minimising threats and maximising opportunities and outcomes. [89]. See Binergy's Risk Management Plan in *Appendix #22 (page 60)*

4.3. Resource Management

Resource management is a series of processes and techniques used to ensure availability of all the necessary resources to complete a project or meet business objectives. It also focuses on making the most efficient use of those resources by eliminating waste for more profits and a high return on investment (ROI). [90]. In Appendix #25 (page x), can be seen information regarding to Binergy's Project Organization, Materials & Equipment.

4.4. Communication Management

Project communication management is a crucial aspect of project management as it ensures all stakeholders are kept informed about the project's progress, issues, and changes, thereby facilitating effective decision making and collaboration. [91]. *Appendix #23 (page 61)* shows the Binergy's Project Communication Matrix.

4.5. Stakeholders Management

A stakeholder is any individual or organization involved in a project or affected by its execution or completion. This includes project sponsors, team members, end-users, and others critical to the project's success. Effective stakeholder management involves identifying these parties and building strong relationships, as their support or opposition can greatly influence project outcomes.[92]. *Appendix #24 (page 62),* shows Binergy's Project Stakeholders Matrix.

4.6. Procurement Management

Procurement is the act of obtaining goods, supplies, and/or services. Therefore, project procurement is obtaining all of the materials and services required for the project. Project procurement management encompasses the processes used for making sure project procurement is successful. [93]

- *Make or Buy Analysis:* It compares the cost-effectiveness of two options for acquiring the Solid-State Cell Production Plant Line Making Machine: on-site assembly versus purchasing a pre-assembled unit. Although assembling the machine was cheaper, the project team opted for the pre-assembled option.

- *Supplier's Selection Criteria:* It provides a concise overview of the critical factors considered when selecting a supplier for materials and equipment, such as the Solid Battery Machine. Each criterion is matched with an evaluation result, highlighting the strengths and capabilities of potential suppliers.

Appendix 25 (page 63) provides a concise overview of the critical factors considered when selecting a supplier for the Solid Battery Machine. Each criterion is matched with an evaluation result, highlighting the strengths and capabilities of the potential supplier.

4.7. Quality Management

Quality Management is the process of continually measuring the quality of all activities and taking corrective action until the team achieves the desired quality [94].

4.7.1. Quality Assurance (QA):

QA ensures that all quality-related activities are performed as defined, providing stakeholders with evidence of compliance. It focuses on meeting quality expectations for products and processes through metrics and audits, assessing customer satisfaction, and identifying corrective actions to achieve project goals. [94]

4.7.2. Quality Control (QC):

QC involves techniques to ensure quality standards by identifying and correcting issues after they arise. It measures project outputs for compliance, identifies risks, and helps maintain budget and schedule through monitoring and adjustments, preventing major rework. [94]

Appendix #26 (page 64) shows the QA and QC actions across different phases of the project. These actions help to ensure that all activities align with Binergy Startup's quality objectives.

4.8. Integration Management

Project integration management is the coordination of all elements of a project. This includes coordinating tasks, resources, stakeholders, and any other project elements, in addition to managing conflicts between different aspects of a project, making trade-offs between competing requests, and evaluating resources. [96]

- *Key Focus Areas:* Schedule, Cost, Scope, Quality, Resources, Risk, Changes, Stakeholders.

- *Seven Key Processes:* Develop Project Charter, Develop Project Management Plan, Direct and Manage Project Work, Manage Project Knowledge, Monitor and Control Project Work, Perform Integrated Change Control, Close Project/Phase

Effective integration management avoids project failure by tracking interdependencies and ensuring aligned progress across areas. Integration is ongoing throughout the project lifecycle. [96]

4.9. Project Progress

The term **project progress** refers to the totality of events, decisions, and developments that take place during the implementation of a project. The various phases, milestones, tasks, and results are recorded and documented. A well-structured project progress allows for the monitoring of the project's progress, early detection of risks, and making adjustments as needed. [96].

Binergy's project has a "Predictive" approach which was already outlined in the "Scope Management". See *Appendix #27 (page 65*) showing the Project Tracking, Control Procedures and Documents.

4.10. Project Closure

The final phase when deliverables are tested against KPIs and the scope, loose ends are tied up, lessons are learned, the handover is complete, and a project is signed off on. [97]

Figure #13. Celebration

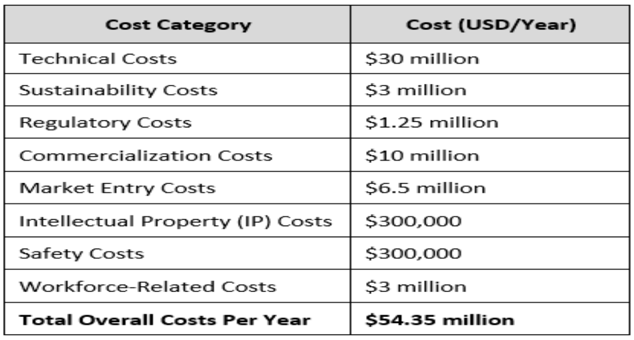
5. THE POST-PROJECT PHASE

The "Post-Project Phase" analysis for Binergy focuses on operational costs, sales strategies, cash flow challenges, and the financial trajectory needed to achieve profitability in the solid-state battery (SSB) market.

5.1. Operational Cost Estimations

Binergy projects annual operational costs at $54.35 million, covering technical, sustainability, regulatory, commercialization, market entry, IP, safety, and workforce-related expenses. These are midpoint estimates from table #26 and serve as a baseline to ensure operational readiness across various cost categories.

Table #4. Midpoints Costs Summary (USD/year)



Cost Category	Cost (USD/Year)
Technical Costs	$30 million
Sustainability Costs	$3 million
Regulatory Costs	$1.25 million
Commercialization Costs	$10 million
Market Entry Costs	$6.5 million
Intellectual Property (IP) Costs	$300,000
Safety Costs	$300,000
Workforce-Related Costs	$3 million
Total Overall Costs Per Year	**$54.35 million**

See *Appendix #28 (page 66)*, for a better understanding of regular Operational Costs.

Operational costs are estimated, assuming Binergy completes each project stage efficiently. The estimate considers personnel, methods, regulations, funding, materials, infrastructure, and partnerships. High technical costs dominate, reflecting project complexity, while commercialization and market entry highlight significant upfront investments for SSB market penetration.

5.2. Sales Strategy

Binergy aims to become a key player in the solid-state battery (SSB) market by initially focusing on downstream non-space applications, such as electric vehicles (EVs), consumer electronics, and other commercial uses, which make up the majority of the market. The company’s approach leverages specific strategies to address commercialization, safety, market entry, regulatory compliance, IP protection, workforce development, technical advancements, sustainability, and bismuth’s cost competitiveness over lithium.

As a mere estimation, Binergy's sales goal is expected to reach the following market share milestones:

- By the end of 2028: 0.50 % of the market size achieved = USD 36.70 million
- By the end of 2029: 1.0 % of the market size achieved = USD 98.50 million
- By the end of 2030: 1.5 % of the market size achieved = USD 198.45 million

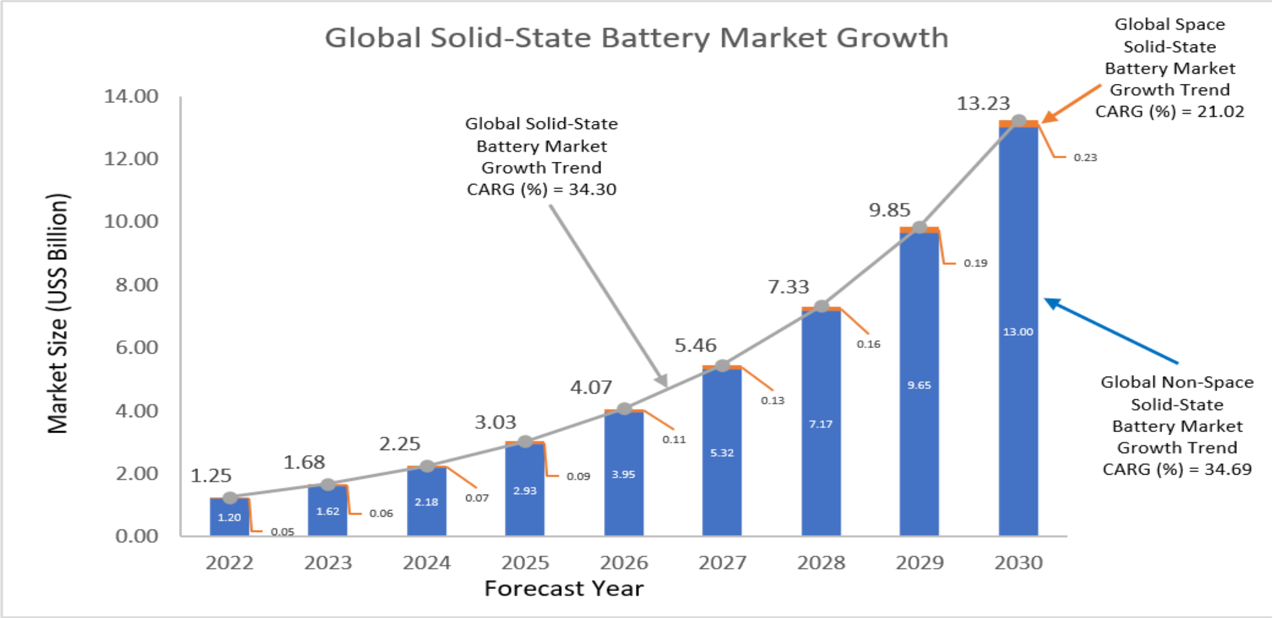


Figure #14. Global Solid-State Battery Market Growth.

Calculation Example: By the end of 2028: 0.5% of the market size achieved = (7.33 billion x 0.5)/100 = 0.03665 billion = USD 36.70 million in accumulated sales.

Binergy's phased approach in setting specific market share goals aligns with gradual scaling, positioning the company for sustainable growth. Achieving these milestones is essential for Binergy's roadmap to profitability.

5.3. Binergy's Death Valley Curve & ROI Analysis

The "Death Valley Baseline" shows Binergy's starting point to track progress. Its sales strategy targets 0.5% of the global solid-state battery market by 2028, 1% by 2029, and 1.5% by 2030, outlining a strong ROI trajectory. However, like many startups, Binergy must first overcome the "Death Valley" phase, where early costs exceed profits.

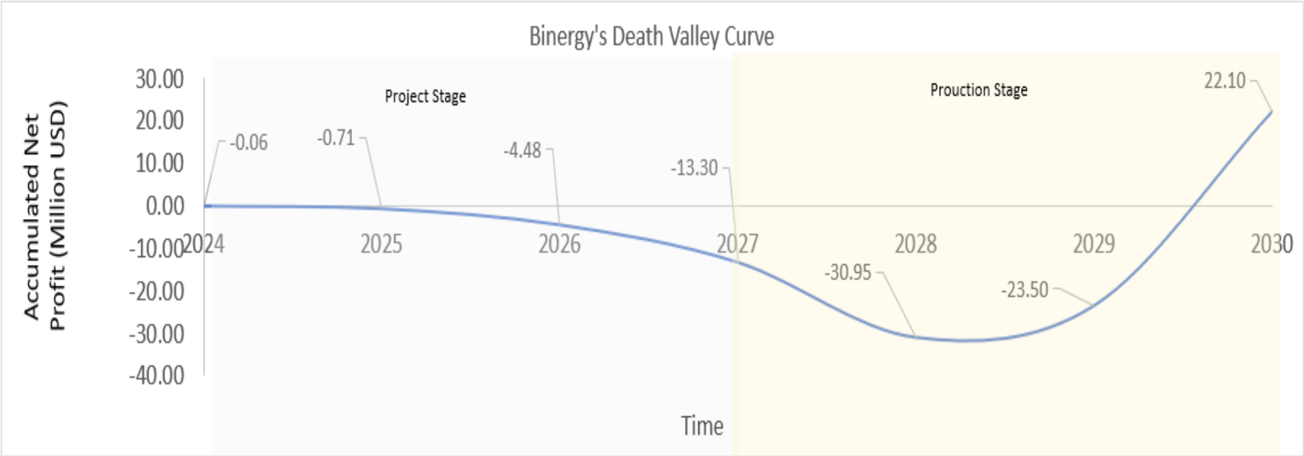


Figure #15. Binergy's Death Valley Curve

5.3.1. Key Phases of the Curve:

- *Cost Accumulation (Descent into the Valley):* Binergy faces high costs with no revenue, focusing on R&D, IP management, manufacturing trials, and market prep. It must manage burn rate, strategically allocate resources, and develop an MVP to test market fit.

- *Survival Phase (Depth of the Valley):* From 2028 to mid-2030, Binergy's cash reserves are low with negative ROI. It must secure additional funding, demonstrate progress through milestones, and survive until breakeven.

- *Break-Even Phase (Climbing Out of the Valley):* By mid-2030, revenues equal costs and ROI improves. Binergy focuses on optimizing operations, reducing costs, and scaling market presence.

- *Growth and Profitability (Out of the Valley):* From 2032 onward, ROI increases (0.67 in 2032, 1.35 in 2033, 2.64 in 2035), signalling profitability. Binergy scales operations, expands market share, and invests in R&D, sustainability, and education for long-term impact.

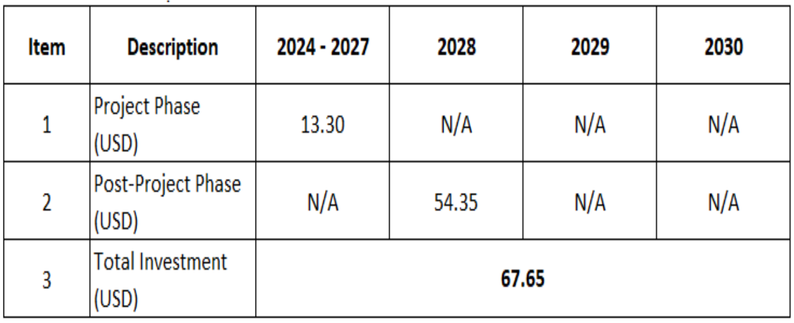
- *Investor Considerations:*
  - Short-Term Risks: Negative ROI until 2030 may deter short-term investors.
  - Long-Term Appeal: Post-2032 ROI growth and market expansion are attractive.
  - Resilience and Vision: Strategic reinvestment ensures profitability and alignment with global priorities.

See Appendix #29. (page 67), outlining the relationship between Binergy's Death Valey Curve, Costs, Sales and Net Profits and ROI.

5.4. Investment Summary

Total investment is **67.65 million USD**, split between project and post-project phases (2024-2028). This funding is critical for sustaining operations through the Death Valley period.

Table #5. Global SSB Market Share Goals

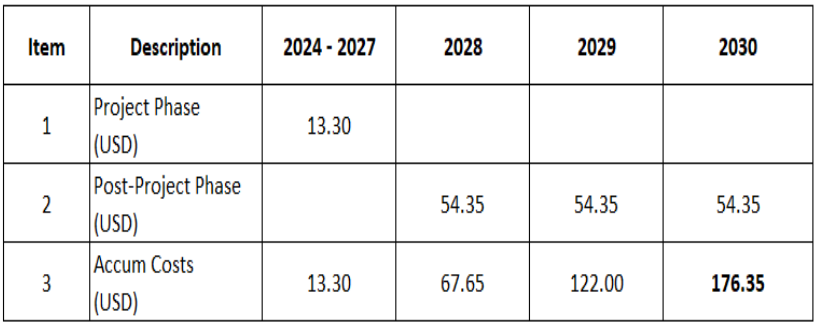


Item	Description	2024 - 2027	2028	2029	2030
1	Project Phase (USD)	13.30	N/A	N/A	N/A
2	Post-Project Phase (USD)	N/A	54.35	N/A	N/A
3	Total Investment (USD)	**67.65**			

5.5. Cost Summary

Costs accumulate to **176.35 million USD** by 2030, peaking in 2029 to support scaling. Effective cost management here is essential for the project's transition to profitability.

Table #6. Cost Summary

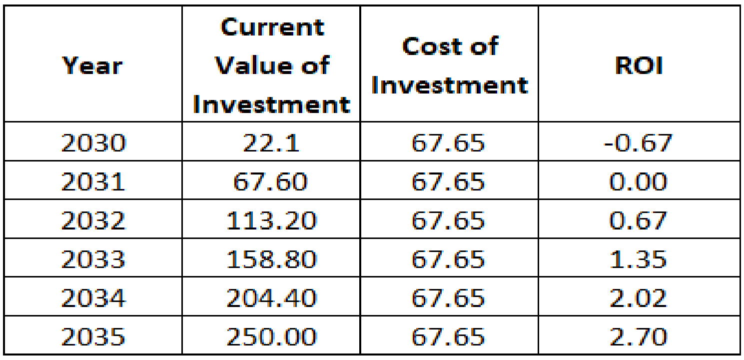


Item	Description	2024 - 2027	2028	2029	2030
1	Project Phase (USD)	13.30			
2	Post-Project Phase (USD)		54.35	54.35	54.35
3	Accum Costs (USD)	13.30	67.65	122.00	**176.35**

5.6. Net Profit & ROI

The forecast for the investment from 2030 to 2035 shows its value rising from $22.1M to $250M, while the cost remains constant at $67.65M. Net profit increases from -$0.67M to $2.7M, and ROI steadily improves, turning positive in 2031 and reaching 2.70 by 2035, signalling strong returns after the "Death Valley" period.

Table #7. Net Profit & ROI



Year	Current Value of Investment	Cost of Investment	ROI
2030	22.1	67.65	-0.67
2031	67.60	67.65	0.00
2032	113.20	67.65	0.67
2033	158.80	67.65	1.35
2034	204.40	67.65	2.02
2035	250.00	67.65	2.70

Binergy’s post-project plan reflects a well-thought-out approach to establishing itself in the competitive SSB market. Key factors, such as initial heavy investment, the “Death Valley” cash flow challenge, and long-term ROI projections, show the potential for high returns if milestones are met. The outlined cost structure and sales targets underscore the importance of disciplined financial management, efficient operations, and effective market penetration.

6. DISCUSSIONS

6.1. Technical and Financial Challenges in Scaling Bismuth-Ion Technology

Scaling BIBs faces challenges in materials complexity, stability, and high initial costs, affecting early profitability. Continuous R&D and partnerships are essential to reduce production costs and enhance scalability.

6.2. Importance of the Non-Space Market for Early Revenue

Non-space markets like EVs and consumer electronics are critical for early revenues due to their size and accessibility. Diversifying applications accelerates commercialization and positions Binergy for future entry into the space sector.

6.3. Navigating 'Death Valley' and Financial Management

The "Death Valley" phase underscores the need for strong financial management. Securing funding, careful budgeting, and phased growth plans are vital for Binergy to sustain operations and achieve profitability by 2029.

6.4. ESG and Regulatory Alignment for Market Positioning

Aligning with ESG standards enhances Binergy's market position and readiness for stricter regulations, appealing to environmentally conscious investors and facilitating smoother market entry.

6.5. Technological Advances and Industry Risks

Emerging technologies like advanced lithium-ion and hydrogen fuel cells pose risks to BIBs. Binergy must stay agile, innovate, and adapt to maintain competitiveness through continuous monitoring and collaboration.

6.6. Ecosystem Collaboration for Innovation and Growth

Partnerships across space and renewable industries can drive innovation, share costs, and validate products, fostering knowledge exchange and strengthening Binergy's position in key markets.

7. RECOMMENDATIONS

7.1. Strengthen Strategic Partnerships

To mitigate the technical and commercialization hurdles, Binergy should continue forming alliances with research institutions, government entities, and industry leaders in the space and renewable energy sectors. These collaborations can drive innovation, enable technology sharing, and help secure grants or other funding support.

7.2. Focus on Workforce Development

Given the specialized skills required in the SSB market, Binergy should invest in workforce development initiatives. Establishing partnerships with educational institutions to create training programs would address industry skill gaps, support technology adoption, and build a resilient, skilled workforce.

7.3. Enhance Market Entry Strategies for Non-Space Applications

Targeting downstream non-space applications, such as EVs and consumer electronics, can provide Binergy with immediate revenue streams. This will enable faster market entry and diversification, reducing the company’s reliance solely on the space economy's nascent SSB demand.

7.4. Refine ESG and Regulatory Compliance Strategies

With growing environmental, social, and governance (ESG) expectations, Binergy should continue focusing on sustainability initiatives that align with international standards. This includes adopting circular economy practices, implementing rigorous ESG reporting, and strengthening recycling initiatives to minimize environmental impact.

7.5. Optimize Financial Management for ‘Death Valley’ Period

To ensure survival through the critical cash-flow challenges during initial operations, Binergy should implement a detailed cash management plan and consider diversified funding sources. A phased market entry with measurable milestones and scenario-based financial planning can support stable growth and reduce risk.

8. CONCLUSIONS

- Current lithium-ion batteries face limitations such as low energy density and high production costs.
- Global renewable energy systems suffer from grid instability, risking blackouts, as renewable sources are intermittent.
- Binergy faces key challenges in technology, commercialization, finance, and safety. These can be addressed through investment, a strong market strategy, key partnerships, and ESG compliance.
- Binergy's Solid BIBs leverage non-toxic materials, superior cycling capabilities, and enhanced safety standards to address these challenges.
- These batteries aim to serve high-demand applications like electric vehicles (EVs) and renewable energy systems, with a target to capture 1.5% of the global market by 2030, equivalent to achieving $22.10 Million in revenues.
- The global solid-state battery market is projected to grow from $1.25 billion in 2022 to $13.23 billion by 2030 (CAGR of 34.30%), underscoring the urgency for innovative solutions.
- The non-space solid-state battery market (the dominant segment) will expand from $1.2 billion in 2022 to $13 billion by 2030.
- The space segment, smaller but critical for innovation, is set to grow at a steady CAGR of 21.02% during the same period.
- This booming market offers Binergy a dual advantage: niche innovation and mainstream scalability.
- A total project budget of $13.30 million (2024–2027) ensures milestones like manufacturing trials and commercialization.
- Full-scale production by 2028 will require $54.35 million, totalling a funding need of $67.65 million.
- Phased development from Preliminary R&D ($189,044) to Manufacturing Trials ($6.25 million) ensures a strategic, efficient path to market readiness.
- Binergy's Death Valley phase will require resilience through 2028–2030, with breakeven achieved by mid-2030.
- ROI then accelerates, reaching 0.67 by 2032, 1.35 by 2033, and 2.64 by 2035, making it a compelling long-term investment.
- Binergy is not just another startup, it is a catalyst for the sustainable energy revolution. For investors, it represents a rare blend of groundbreaking innovation, long-term profitability, and meaningful impact.
- As the world embraces renewable energy, Binergy is poised to lead with innovative solutions. With a $13 billion non-space market by 2030 and a 1.5% market share goal, the potential is clear. Together, we can turn challenges into opportunities and create a sustainable, profitable future.

9. REFERENCES

1. https://www.youtube.com/watch?v=trA5s2iGj2A&t=711s

2. https://www.maketecheasier.com/solid-state-batteries/

3. https://www.mdpi.com/2313-0105/10/1/29#:~:text=Concerns%20include%20the%20flammability%20of,performance%20and%20lifespan%20%5B11%5D.

4. https://www.youtube.com/watch?v=R00pxgb_jbA&t=47s

5. https://www.sciencedirect.com/topics/engineering/all-solid-state-lithium-batteries

6. https://www.youtube.com/watch?v=39F5ZgY54tQ

7. https://www.sciencedirect.com/science/article/abs/pii/S2405829719310220?via%3Dihub

8. https://www.sciencedirect.com/science/article/abs/pii/S1385894724010015

9. https://ui.adsabs.harvard.edu/abs/2020EneSM..25..100X/abstract

10. https://www.mdpi.com/1996-1944/17/1/21

11. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10780295/

12. https://procurementtactics.com/lithium-prices/

13. https://procurementtactics.com/bismuth-prices/

14. https://quantive.com/resources/articles/top-strategic-frameworks

15. https://creately.com/guides/business-model-canvas-explained/

16. https://www.strategyzer.com/library/the-business-model-canvas

17. https://businessdesigntools.com/the-tools/value-proposition-canvas/#:~:text=The%20Value%20Proposition%20Canvas%20is%20a%20strategic%20tool,products%20or%20services%20that% 20effectively%20address%20those%20needs.

18. https://onstrategyhq.com/resources/developing-your-strategy/

19. https://www.linkedin.com/advice/3/how-do-you-use-visioning-scenario-planning

20. https://www.youtube.com/watch?v=NPaOJceBkJs&t=637s

21. https://www.grandviewresearch.com/industry-analysis/battery-market

22. https://www.maximizemarketresearch.com/market-report/global-space-battery-market/31284/

23. https://www.databridgemarketresearch.com/reports/global-solid-state-battery-market#:~:text=Solid%20State%20Battery%20Market%20Analysis%20and%20Size&text=The%20global%20solid%20state%20battery,period%20of%202024%20to%202031.

24. https://www.cuemath.com/commercial-math/proportion/

25. https://www.oecd-ilibrary.org/science-and-technology/oecd-handbook-on-measuring-the-space-economy-2nd-edition_8bfef437-en;jsessionid=KWLuI7GoTL3IA8lQfor7qQ6hRUD-vvLIqlOBKRj6.ip-10-240-5-56

26. https://elearningunodc.org/login/index.php

27. https://satsearch.co/products/redwirespace-assb-all-solid-state-battery-pack#:~:text=The%20Redwire%20All%20Solid-State,cell%20with%20mission%20safety%20assurance

28. https://www.quantumscape.com/technology/

29. https://nebula.esa.int/content/high-energy-density-solid-state-batteries-based-li-metal-anode

30. https://www.nasa.gov/aeronautics/nasas-solid-state-battery-research-exceeds-initial-goals-draws-interest/

31. https://www2.deloitte.com/us/en/insights/industry/aerospace-defense/future-of-space-economy.html

32. https://www.mdpi.com/2571-8800/7/3/12#:~:text=Designing%20solid%20electrolyte%20materials%20with,requires%20iterative%20experimentation%20and%20optimization

33. https://eepower.com/news/largest-us-solid-state-battery-facility-to-address-scalability-challenges/#

34. https://waveep.com/factorial-and-lg-chem-sign-mou-to-develop-solid-state-batteries/#:~:text=(Factorial)%2C%20an%20industry%20leader,of%20solid-state%20battery%20materials

35. https://futurebatterylab.com/costs-of-solid-state-batteries-expensive-premium-solution-or-affordable-all-rounder/

36. https://publications.anl.gov/anlpubs/2020/03/158938.pdf

37. https://medium.com/batterybits/solid-state-batteries-is-there-a-viable-path-to-commercialization-30f36a7685d7

38. https://www.eiu.com/n/complexities-of-battery-supply-chain-may-slow-ev-adoption/

39. https://www.notebookcheck.net/EV-battery-prices-are-falling-as-true-solid-state-cell-costs-are-projected-to-match-batteries-with-5-liquid-electrolyte.859561.0.html

40. https://www.sae.org/news/2023/11/solid-state-battery-status

41. https://publications.anl.gov/anlpubs/2020/03/158938.pdf

42. https://www.researchgate.net/publication/377262008_An_Industrial_Perspective_and_Intellectual_Property_Landscape_on_Solid-State_Battery_Technology_with_a_Focus_on_Solid-State_Electrolyte_Chemistries

43. https://www.powerelectronicsnews.com/newcomers-to-the-solid-state-li-ion-battery-patent-landscape/#:~:text=Its%20patent%20on%20solid-state%20batteries%20is%20related%20to%20a%20solid-state

44. https://www.wipo.int/wipo_magazine/en/2006/05/article_0010.html

45. https://astra.grandviewresearch.com/solid-state-battery-industry-esg-outlook

46. https://global.toyota/en/sustainability/esg/information-security/

47. https://unfccc.int/process-and-meetings/the-paris-agreement

48. https://www.youtube.com/watch?v=WiGD0OgK2ug

49. https://www.youtube.com/watch?v=OVC-szbc2HE

50. https://www.mdpi.com/2313-0105/10/1/29#:~:text=Concerns%20include%20the%20flammability%20of,performance%20and%20lifespan%20%5B11%5D.

51. https://www.youtube.com/watch?v=VWMfeseybt4

52. https://www.youtube.com/watch?v=AkbGz3CYvqE&t=12s

53. https://www.youtube.com/watch?v=bdsj70EfcIg

54. https://ourworldindata.org/grapher/lithium-production?time=latest

55. https://www.youtube.com/watch?v=JcJ8me22NVs

56. https://astra.grandviewresearch.com/solid-state-battery-industry-esg-outlook

57. https://www.youtube.com/watch?v=9dnN82DsQ2k

58. https://www.techtarget.com/sustainability/definition/ESG-score#:~:text=An%20ESG%20score%20is%20a,around%20the%20topic%20has%20grown.

59. https://www.nationalgrid.com/stories/energy-explained/what-are-scope-1-2-3-carbon-emissions

60. https://astra.grandviewresearch.com/solid-state-battery-industry-esg-outlook

61. https://www.emergingtechbrew.com/stories/2024/03/01/US-battery-industry-workforce-center-for-automotive-research-UAW

62. https://netl.doe.gov/bwi

63. https://ir.quantumscape.com/resources/events-and-presentations/default.aspx

64. https://about.bnef.com/blog/lithium-ion-battery-pack-prices-hit-record-low-of-139-kwh/

65. https://www.quantumscape.com/technology

66. https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/the-race-to-decarbonize-electric-vehicle-batteries

67. https://www2.deloitte.com/us/en/pages/operations/articles/ev-battery-supply-chain.html

68. https://www.deloitte.com/uk/en/Industries/energy/perspectives/global-energy-storage-renewable-energy-storage.html

69. https://about.bnef.com/blog/lithium-ion-battery-pack-prices-hit-record-low-of-139-kwh/

70. https://www.eia.gov/electricity/workshop/batterystorage/pdf/Alex_Mey_EIA.PDF

71. https://www.eia.gov/analysis/studies/electricity/batterystorage/pdf/battery_storage_2021.pdf

72. https://www.pnnl.gov/ESGC-cost-performance

73. https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/battery-2030-resilient-sustainable-and-circular

74. https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/capturing-the-battery-value-chain-opportunity

75. https://www.wipo.int/web-publications/world-intellectual-property-report-2024/assets/60090/944_WIPR_2024_WEB.pdf

76. https://www.wipo.int/edocs/pubdocs/en/wipo-pub-944-2024-en-world-intellectual-property-report-2024.pdf

77. https://www.nasa.gov/wp-content/uploads/2021/04/sabers_cas_fact_sheet_508.pdf

78. https://www2.deloitte.com/us/en/pages/operations/articles/ev-battery-supply-chain.html

79. https://about.bnef.com/

80. https://www.investopedia.com/terms/d/death-valley-curve.asp#:~:text=The%20death%20valley%20curve%20describes,when%20plotted%20on%20a%20graph.

81. https://www.linkedin.com/pulse/what-death-valley-curve-martyn-eeles/

82. https://www.investopedia.com/terms/r/returnoninvestment.asp

83. https://www.teamwork.com/project-management-guide/project-management-plan/

84. https://www.wrike.com/project-management-guide/faq/what-is-a-baseline-in-project-management-project-baseline/

85. https://www.projectmanager.com/blog/project-scope

86. https://www.wrike.com/project-management-guide/faq/what-is-a-project-schedule-in-project-management/

87. https://www.projectmanager.com/training/basics-project-cost-management

88. https://www.migso-pcubed.com/blog/cost-management/earned-value-management/

89. https://www.apm.org.uk/resources/what-is-project-management/what-is-risk-management/

90. https://www.coursera.org/articles/resource-management

91. https://www.wrike.com/project-management-guide/faq/what-is-project-communication-management/

92. https://projectmanagement.ie/blog/what-is-stakeholder-management/

93. https://www.wrike.com/project-management-guide/faq/what-is-project-procurement-management/

94. https://business.adobe.com/blog/basics/quality-management#:~:text=Project%20quality%20management%20is%20the,Establish%20standards%20to%20aim%20for

95. https://www.wrike.com/project-management-guide/faq/what-is-project-integration-management/

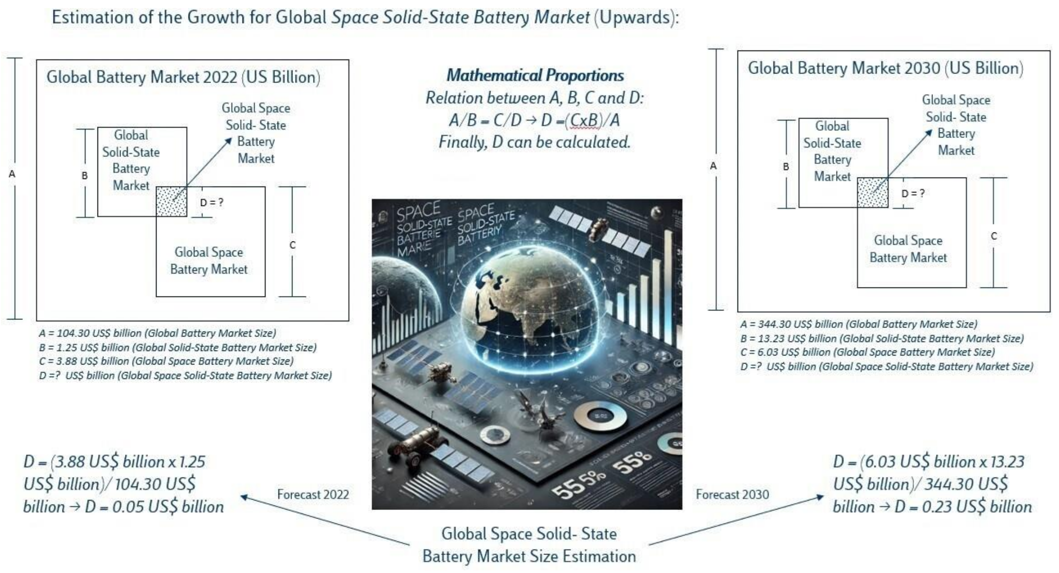
96. https://www.awork.com/glossary/project-progress

97. https://clickup.com/blog/project-closure/#:~:text=Project%20closure%20is%20an%20integral,project%20is%20signed%20off%20on.

10. APPENDICES

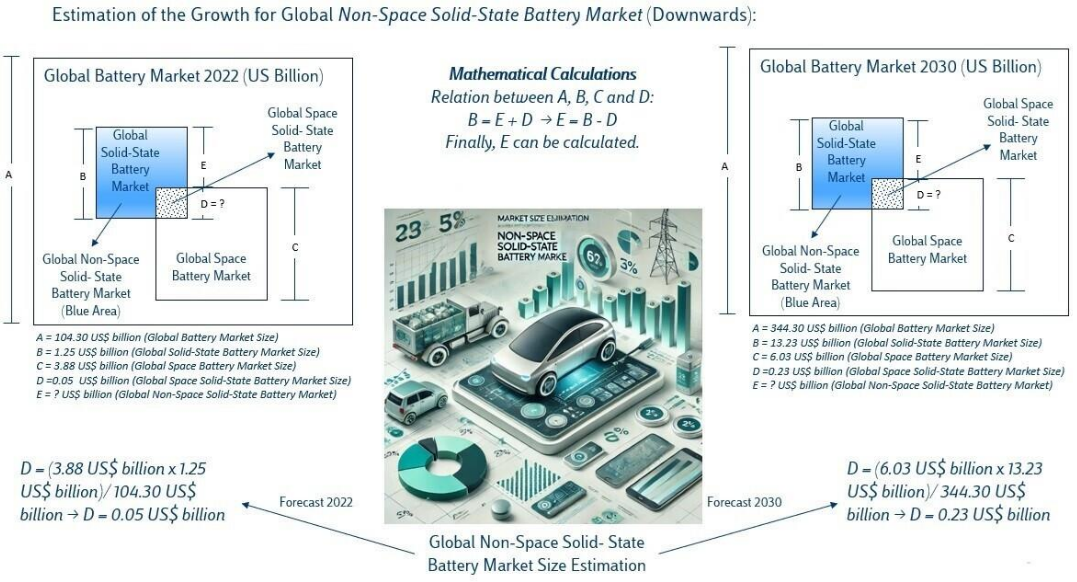
Appendix #1. Estimation of the Growth for Space and Non-Space Solid Battery Markets.

The size estimation of The Space Solid-State Battery Market (Upstream) has been carried out through Proportions, considering the known sizes of The Global Battery Market, The Global Space Battery Market, and The Global Solid-State Battery Market.



Figure# 14. Calculations for the Space SSB Market. [21] [22] [23] [24]

Proportion delineates a mathematical relationship between two quantities. In its essence, if two sets of numbers exhibit parallel increases or decreases, they are deemed directly proportional. [24]



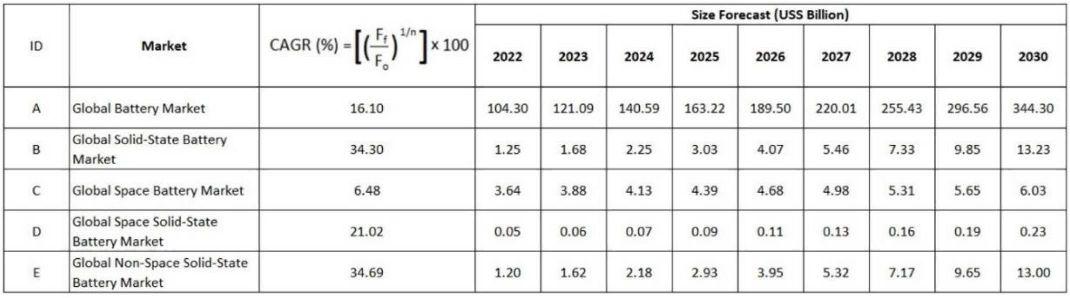
Figure# 15. Calculations for the Space SSB Market. [21] [22] [23] [24]

The size estimation of The Non-Space Solid-State Battery (Downstream) was estimated by subtracting the values known from The Global Solid-State Battery Market and The Space Solid-State Battery (Upstream).

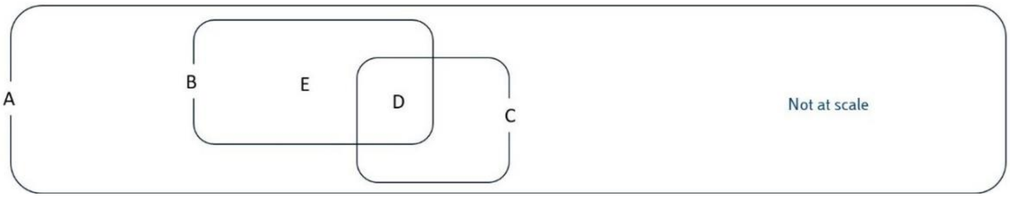
While this principle may not precisely mirror the dynamics of the markets under examination, it serves as a plausible assumption for the progression of this study.

Following, all additional values were calculated and market data was summarized in the following table:

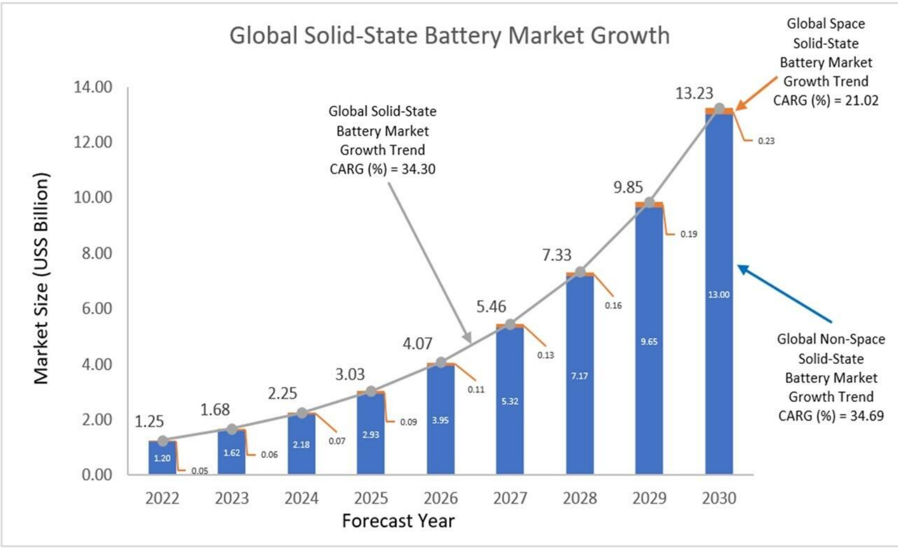
Table #14. Compilation of SSB Market data according to its classification. [21] [22] [23] [24]



ID	Market	CAGR (%) = $\left[\left(\frac{F_f}{F_o}\right)^{1/n}\right] \times 100$	Size Forecast (US$ Billion)								
			2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
A	Global Battery Market	16.10	104.30	121.09	140.59	163.22	189.50	220.01	255.43	296.56	344.30
B	Global Solid-State Battery Market	34.30	1.25	1.68	2.25	3.03	4.07	5.46	7.33	9.85	13.23
C	Global Space Battery Market	6.48	3.64	3.88	4.13	4.39	4.68	4.98	5.31	5.65	6.03
D	Global Space Solid-State Battery Market	21.02	0.05	0.06	0.07	0.09	0.11	0.13	0.16	0.19	0.23
E	Global Non-Space Solid-State Battery Market	34.69	1.20	1.62	2.18	2.93	3.95	5.32	7.17	9.65	13.00



Finally, the Global Solid-State Battery Market Growth was systematically charted to illustrate the contributions of each market under examination.



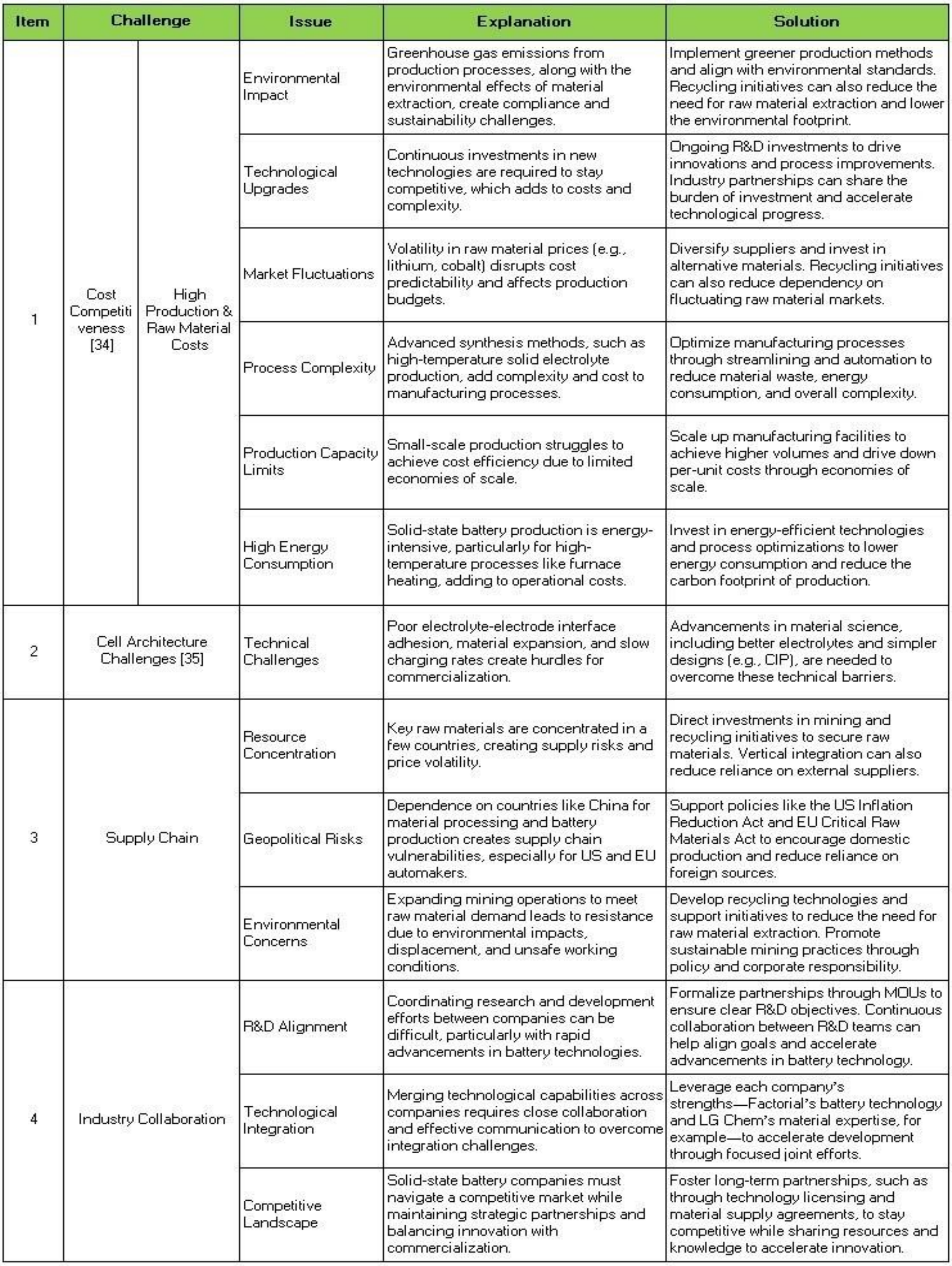
Figure# 16. Global Solid-State Battery Market Trend (Estimation). [21] [22] [23] [24]

The figure# 11 depicts the contrasting growth patterns between the Non-Space Solid-State Battery Market (Downstream) and the Space Solid-State Battery Market (Upstream). Notably, the contribution of the Space Solid-State Battery Market is deemed insignificant. [21] [22] [23]

Appendix # 2. Technical Challenges and Solutions for SSB manufacturing. [32] [33]

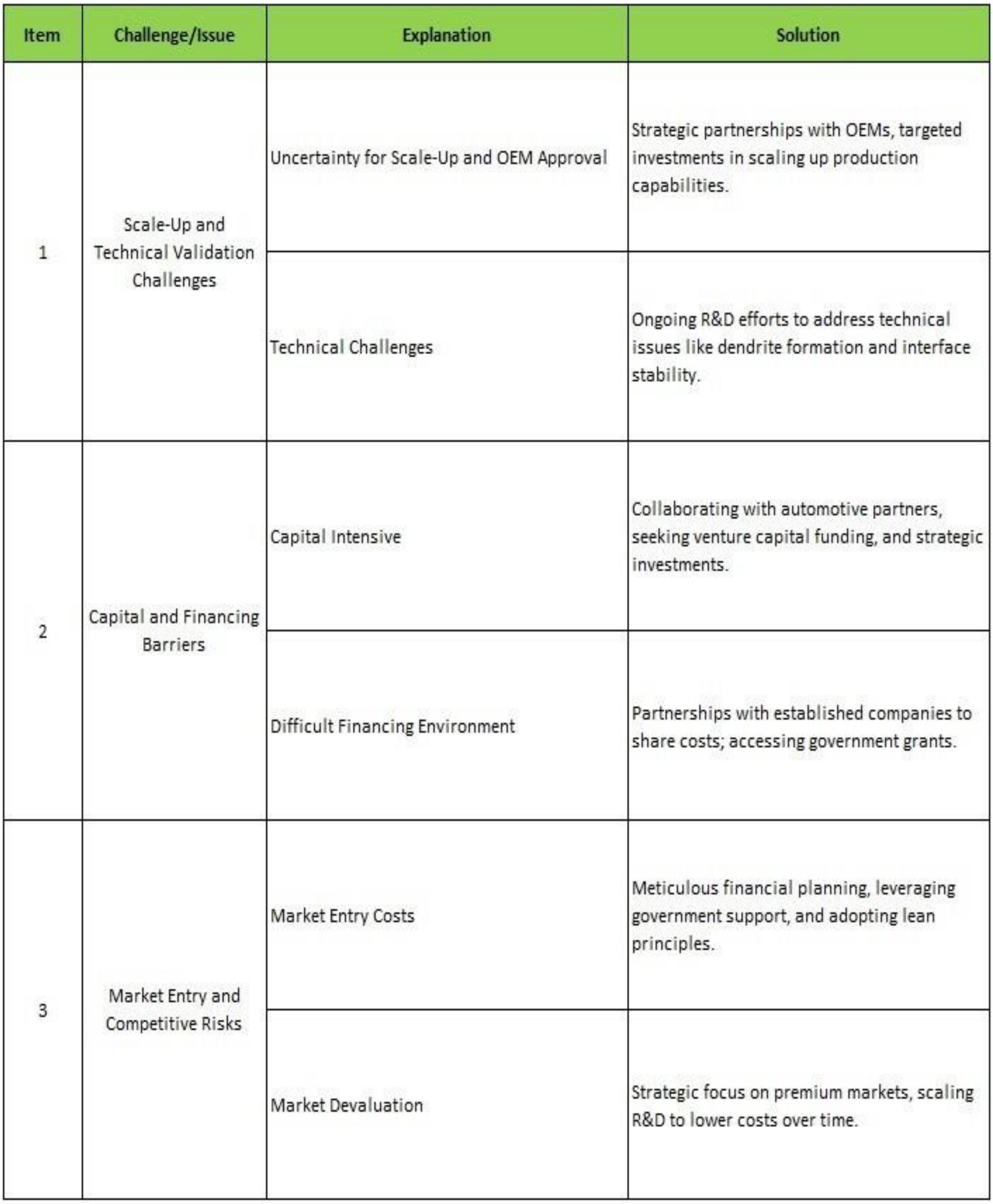
Item	Challenges	Issue	Explanation	Solution
1	Manufacturing	Scalability	Scaling from lab tests to mass production is difficult due to the high cost and limited availability of materials like solid electrolytes. High-temperature processing adds complexity and cost to production.	Factorial Energy is investing $50 million in a Massachusetts facility with a 200 MWh assembly line, providing the infrastructure for high-volume production, lowering costs and enhancing viability.
		Material Compatibility	Solid electrolytes must be compatible with both the anode and cathode. Incompatibility can lead to mechanical stresses, layer separation, or cracking, compromising safety and performance.	Factorial co-located its new plant near its R&D facility, enabling close collaboration between research and production teams to quickly resolve material compatibility issues through rapid iteration.
2	Integration	Lack of Established Economy of Scale	Unlike lithium-ion batteries, solid-state batteries lack a large-scale manufacturing infrastructure. Retrofitting or building new production lines is expensive and time-consuming.	Factorial's FEST (Factorial Electrolyte System Technology) is compatible with existing lithium-ion battery manufacturing equipment, reducing transition costs by allowing automakers to adopt SSB technology.
		High Transition Costs for the Industry	Transitioning to solid-state technology requires new infrastructure, which is costly and complex. The lack of standardized production models adds to the challenge.	Factorial's large-scale plant could serve as a model for scaling solid-state production, driving the shift to more efficient technologies and lowering costs for the entire industry.
3	R&D	Adhesion and Interface Stability	Strong adhesion and stability at the electrolyte-electrode interfaces are critical for battery performance and longevity.	Specialized manufacturing techniques are needed to enhance compatibility and adhesion at these interfaces, ensuring stable and high-performing batteries.
		Thermal Management	Proper thermal management is necessary to prevent overheating and safety risks, as exothermic reactions between battery components can lead to thermal runaway.	Innovative engineering solutions and advanced materials are required to integrate effective thermal management systems that mitigate safety risks.
		Energy Density	Achieving high energy densities in solid-state batteries requires the use of lithium metal anodes, which face challenges in integration.	Continued R&D is crucial for developing solid electrolytes with high ionic conductivity to enable effective use of lithium metal anodes.

Appendix #3. The commercialization challenges and proposed solutions for SSB technology. [34] [35] [36] [37] [38]



Item	Challenge		Issue	Explanation	Solution
1	Cost Competitiveness [34]	High Production & Raw Material Costs	Environmental Impact	Greenhouse gas emissions from production processes, along with the environmental effects of material extraction, create compliance and sustainability challenges.	Implement greener production methods and align with environmental standards. Recycling initiatives can also reduce the need for raw material extraction and lower the environmental footprint.
			Technological Upgrades	Continuous investments in new technologies are required to stay competitive, which adds to costs and complexity.	Ongoing R&D investments to drive innovations and process improvements. Industry partnerships can share the burden of investment and accelerate technological progress.
			Market Fluctuations	Volatility in raw material prices (e.g., lithium, cobalt) disrupts cost predictability and affects production budgets.	Diversify suppliers and invest in alternative materials. Recycling initiatives can also reduce dependency on fluctuating raw material markets.
			Process Complexity	Advanced synthesis methods, such as high-temperature solid electrolyte production, add complexity and cost to manufacturing processes.	Optimize manufacturing processes through streamlining and automation to reduce material waste, energy consumption, and overall complexity.
			Production Capacity Limits	Small-scale production struggles to achieve cost efficiency due to limited economies of scale.	Scale up manufacturing facilities to achieve higher volumes and drive down per-unit costs through economies of scale.
			High Energy Consumption	Solid-state battery production is energy-intensive, particularly for high-temperature processes like furnace heating, adding to operational costs.	Invest in energy-efficient technologies and process optimizations to lower energy consumption and reduce the carbon footprint of production.
2	Cell Architecture Challenges [35]		Technical Challenges	Poor electrolyte-electrode interface adhesion, material expansion, and slow charging rates create hurdles for commercialization.	Advancements in material science, including better electrolytes and simpler designs (e.g., CIP), are needed to overcome these technical barriers.
3	Supply Chain		Resource Concentration	Key raw materials are concentrated in a few countries, creating supply risks and price volatility.	Direct investments in mining and recycling initiatives to secure raw materials. Vertical integration can also reduce reliance on external suppliers.
			Geopolitical Risks	Dependence on countries like China for material processing and battery production creates supply chain vulnerabilities, especially for US and EU automakers.	Support policies like the US Inflation Reduction Act and EU Critical Raw Materials Act to encourage domestic production and reduce reliance on foreign sources.
			Environmental Concerns	Expanding mining operations to meet raw material demand leads to resistance due to environmental impacts, displacement, and unsafe working conditions.	Develop recycling technologies and support initiatives to reduce the need for raw material extraction. Promote sustainable mining practices through policy and corporate responsibility.
4	Industry Collaboration		R&D Alignment	Coordinating research and development efforts between companies can be difficult, particularly with rapid advancements in battery technologies.	Formalize partnerships through MOUs to ensure clear R&D objectives. Continuous collaboration between R&D teams can help align goals and accelerate advancements in battery technology.
			Technological Integration	Merging technological capabilities across companies requires close collaboration and effective communication to overcome integration challenges.	Leverage each company's strengths—Factorial's battery technology and LG Chem's material expertise, for example—to accelerate development through focused joint efforts.
			Competitive Landscape	Solid-state battery companies must navigate a competitive market while maintaining strategic partnerships and balancing innovation with commercialization.	Foster long-term partnerships, such as through technology licensing and material supply agreements, to stay competitive while sharing resources and knowledge to accelerate innovation.

Appendix #4. The financial challenges and proposed solutions for SSB technology. [39] [40] [41]

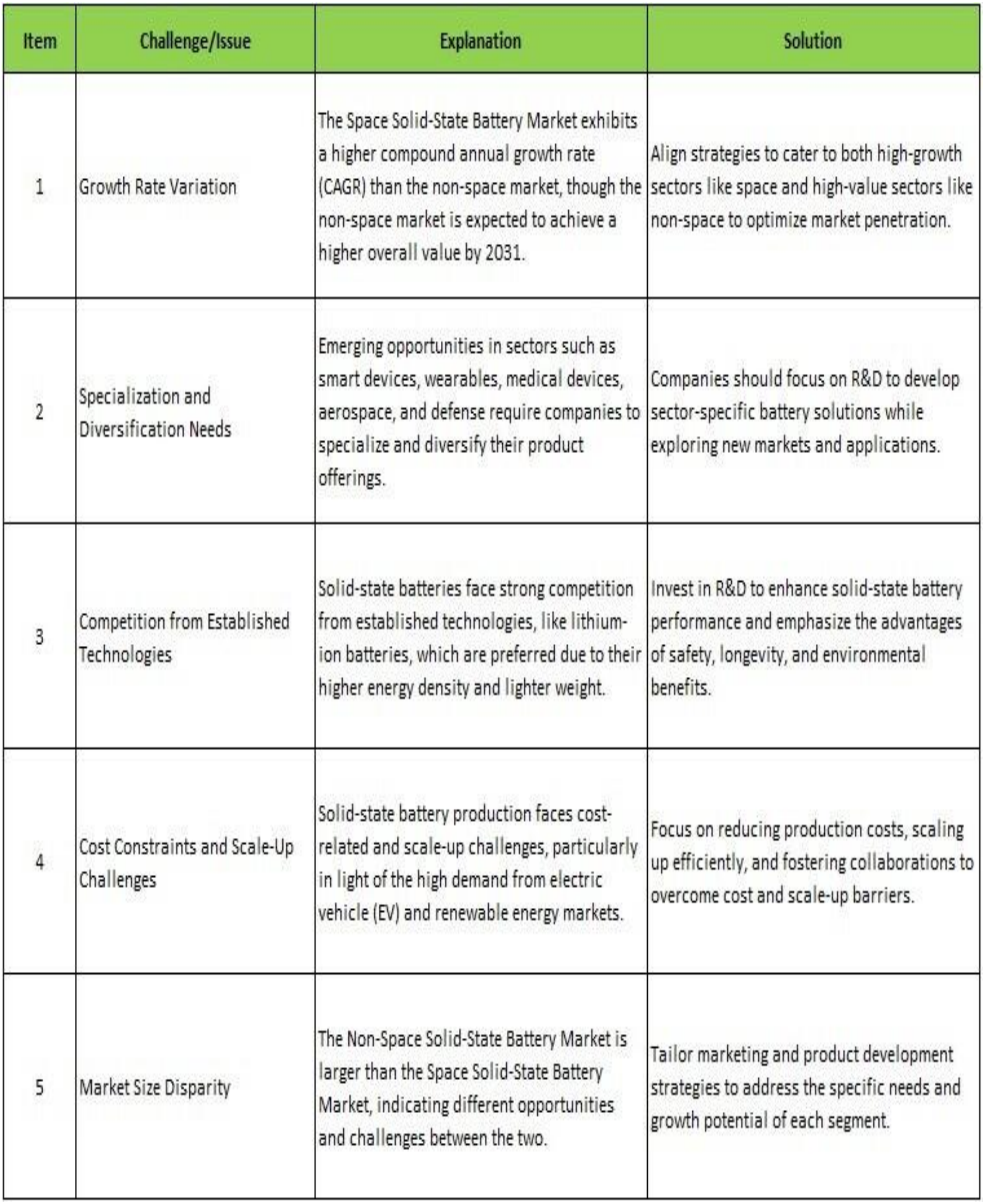


Item	Challenge/Issue	Explanation	Solution
1	Scale-Up and Technical Validation Challenges	Uncertainty for Scale-Up and OEM Approval	Strategic partnerships with OEMs, targeted investments in scaling up production capabilities.
		Technical Challenges	Ongoing R&D efforts to address technical issues like dendrite formation and interface stability.
2	Capital and Financing Barriers	Capital Intensive	Collaborating with automotive partners, seeking venture capital funding, and strategic investments.
		Difficult Financing Environment	Partnerships with established companies to share costs; accessing government grants.
3	Market Entry and Competitive Risks	Market Entry Costs	Meticulous financial planning, leveraging government support, and adopting lean principles.
		Market Devaluation	Strategic focus on premium markets, scaling R&D to lower costs over time.

Appendix #5. IP-related challenges and solutions in the SSB sector. [42] [43] [44]

Item	Challenge/Issue	Explanation	Solution
1	Evolving Patent Landscape Uncertainty	The patent landscape for solid-state battery technology is rapidly changing, creating uncertainty for companies entering the market.	Diversify patent portfolios, collaborate with established entities, and invest in ongoing R&D to stay competitive.
2	International Patent Protection Complexities	Solid-state battery technology faces complex international patent protection challenges due to varying legal frameworks across jurisdictions.	Engage legal experts and utilize mechanisms like the Patent Cooperation Treaty (PCT) to simplify and strengthen global IP protections.
3	Trade Secret Protection	Ensuring confidentiality of proprietary technology is critical, requiring strong trade secret protection to prevent unauthorized access or theft.	Implement robust non-disclosure agreements (NDAs), strict access controls, and regular security updates to protect sensitive information.
4	Patent Litigation	Patent disputes can arise from infringement claims, leading to costly legal battles for all involved parties.	Focus on risk management, seek settlements or licensing agreements where possible, and adhere to legal frameworks to resolve disputes.
5	Patent Infringement Risks	Companies face risks of infringing on existing patents due to the dense patent landscape in the solid-state battery sector.	Conduct comprehensive patent searches, consult with legal experts, and develop tailored patent strategies to avoid infringement risks.
6	Patent Thickets	Dense clusters of patents within the solid-state battery space create navigation challenges for innovators.	Conduct thorough patent searches, collaborate with others, and seek legal counsel to navigate patent thickets effectively.
7	Limited Patent Protection	Limited patent protection can leave companies vulnerable to competition and enforcement challenges in the solid-state battery market.	Strengthen patent portfolios, use trade secrets strategically, and forge partnerships to mitigate the risks of limited patent protection.
8	Patent Licensing and Collaboration Hurdles	Negotiating patent licensing and collaborations in solid-state battery technology can be complex and costly.	Form strategic partnerships, understand IP landscape thoroughly, and develop clear licensing agreements to enable smoother collaboration.

Appendix #6. Challenges related to SSB Market growth and competition. [20] [21] [22]

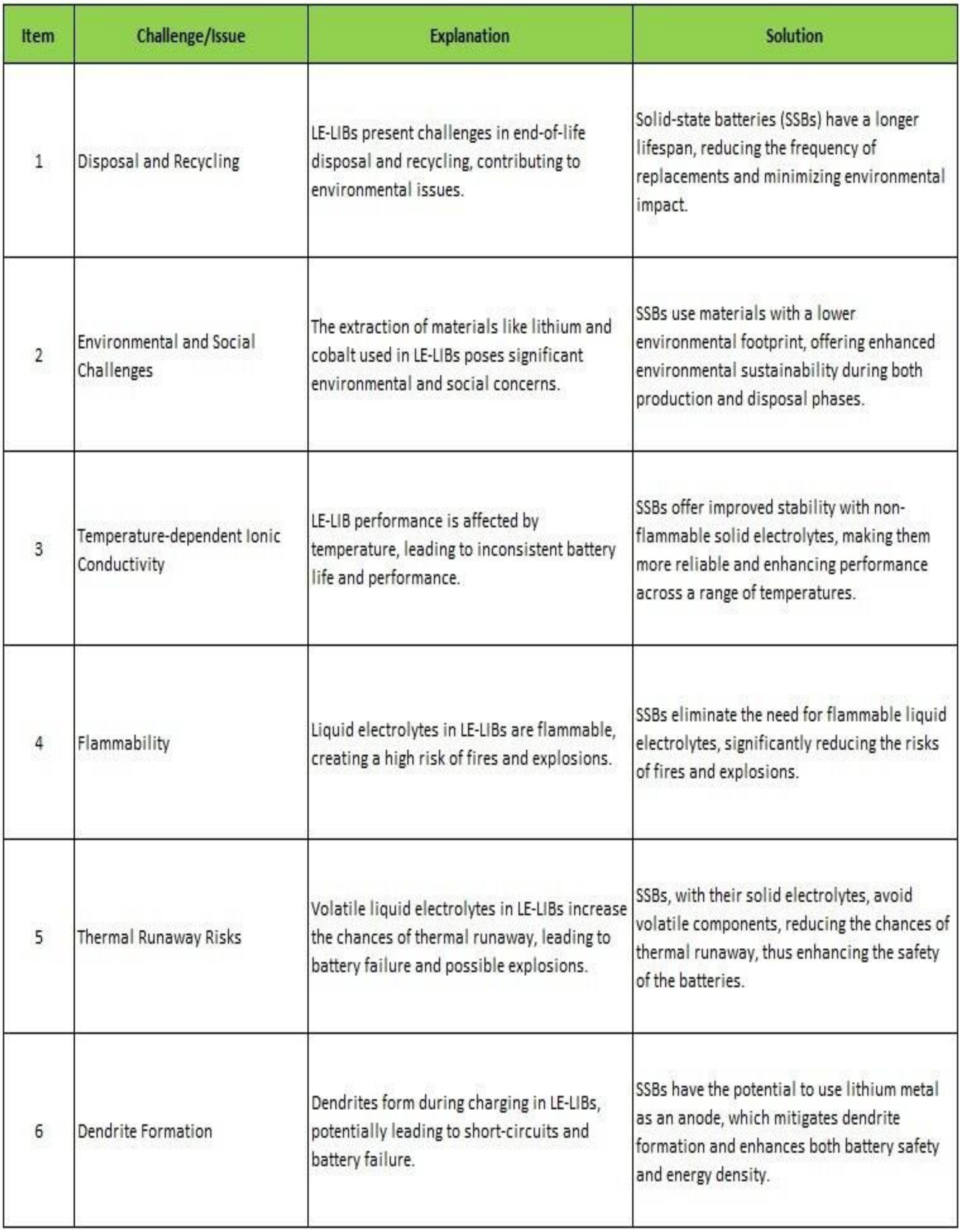


Item	Challenge/Issue	Explanation	Solution
1	Growth Rate Variation	The Space Solid-State Battery Market exhibits a higher compound annual growth rate (CAGR) than the non-space market, though the non-space market is expected to achieve a higher overall value by 2031.	Align strategies to cater to both high-growth sectors like space and high-value sectors like non-space to optimize market penetration.
2	Specialization and Diversification Needs	Emerging opportunities in sectors such as smart devices, wearables, medical devices, aerospace, and defense require companies to specialize and diversify their product offerings.	Companies should focus on R&D to develop sector-specific battery solutions while exploring new markets and applications.
3	Competition from Established Technologies	Solid-state batteries face strong competition from established technologies, like lithium-ion batteries, which are preferred due to their higher energy density and lighter weight.	Invest in R&D to enhance solid-state battery performance and emphasize the advantages of safety, longevity, and environmental benefits.
4	Cost Constraints and Scale-Up Challenges	Solid-state battery production faces cost-related and scale-up challenges, particularly in light of the high demand from electric vehicle (EV) and renewable energy markets.	Focus on reducing production costs, scaling up efficiently, and fostering collaborations to overcome cost and scale-up barriers.
5	Market Size Disparity	The Non-Space Solid-State Battery Market is larger than the Space Solid-State Battery Market, indicating different opportunities and challenges between the two.	Tailor marketing and product development strategies to address the specific needs and growth potential of each segment.

Appendix #7. Challenges and solutions for SSB industry regarding to regulation and safety concerns.[45] [46] [47] [48] [49]

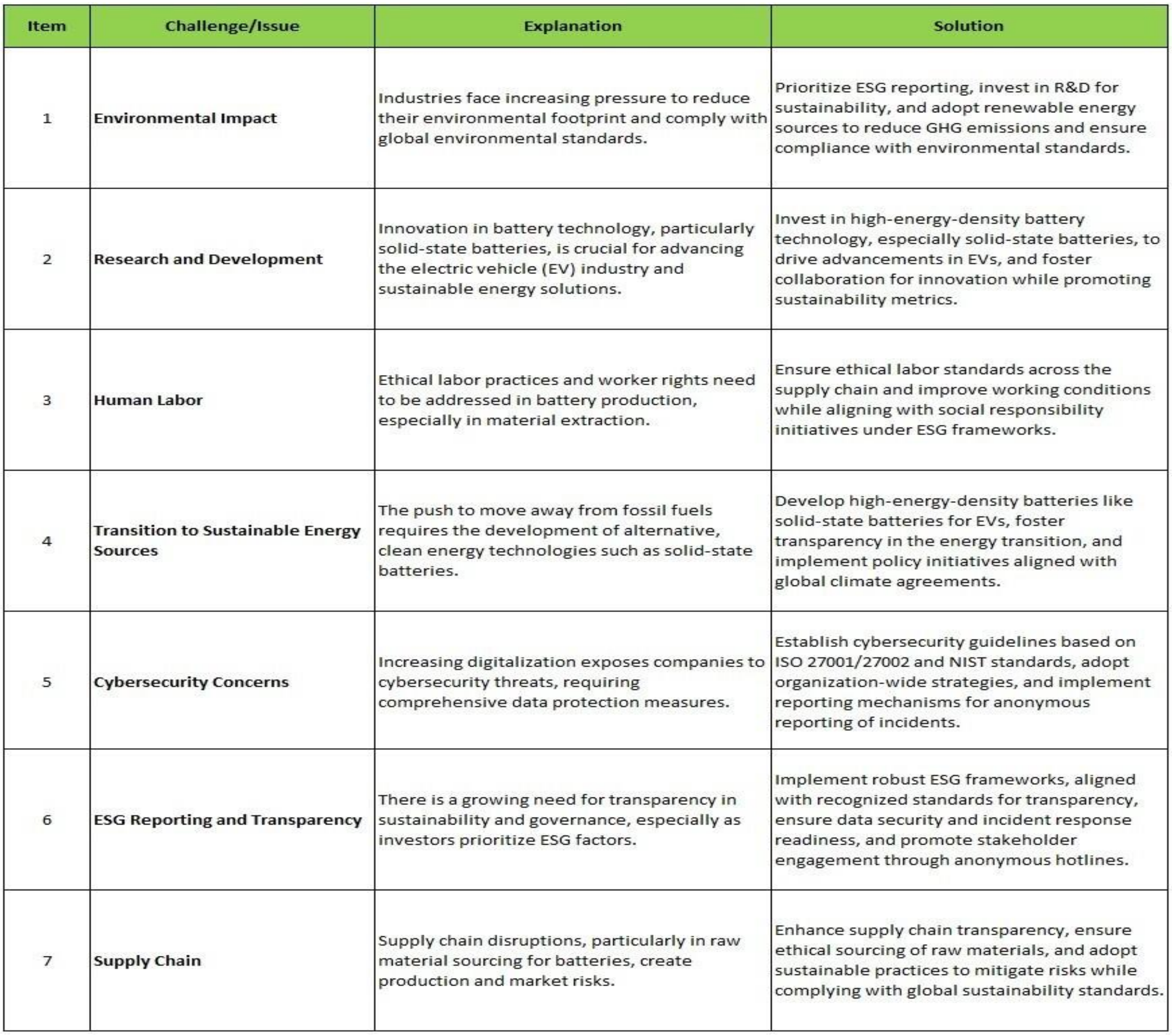
Item	Challenge/Issue	Explanation	Solution
1	International Harmonization	The existence of diverse regulatory frameworks globally hinders market access and innovation for companies in the solid-state battery sector.	Organizations can adopt common standards, promote sustainable practices, and establish robust governance structures to facilitate navigation through international regulatory harmonization challenges.
2	Safety Standards and Protocols	The risk of explosions and fires associated with solid-state batteries necessitates stringent safety standards and protocols.	Companies should adopt comprehensive security guidelines, implement anonymous reporting mechanisms, and strengthen governance structures to ensure safety and mitigate risks effectively.
3	Lack of Specific Regulations	The industry faces significant regulatory gaps, creating uncertainty in compliance with standards and guidelines for solid-state battery technologies.	Companies can adopt internal guidelines such as Toyota's ATSG and align with global initiatives like the Paris Agreement to ensure compliance, foster innovation, and maintain transparency despite gaps.
4	Environmental Impact Assessment	Strong regulatory frameworks are needed to assess the environmental impact of solid-state batteries, particularly in terms of disposal and recycling processes.	Organizations can implement environmental assessments, adopt ISO certifications, use renewable energy, establish robust governance, and align with international standards like TCFD (Task Force on Climate-Related Financial Disclosures) and GRI (Global Reporting Initiative).

Appendix #8. Safety challenges of traditional liquid electrolyte lithium-ion batteries (LE-LIBs) and how solid-state batteries (SSBs) address these challenges. [50] [51]



Item	Challenge/Issue	Explanation	Solution
1	Disposal and Recycling	LE-LIBs present challenges in end-of-life disposal and recycling, contributing to environmental issues.	Solid-state batteries (SSBs) have a longer lifespan, reducing the frequency of replacements and minimizing environmental impact.
2	Environmental and Social Challenges	The extraction of materials like lithium and cobalt used in LE-LIBs poses significant environmental and social concerns.	SSBs use materials with a lower environmental footprint, offering enhanced environmental sustainability during both production and disposal phases.
3	Temperature-dependent Ionic Conductivity	LE-LIB performance is affected by temperature, leading to inconsistent battery life and performance.	SSBs offer improved stability with non-flammable solid electrolytes, making them more reliable and enhancing performance across a range of temperatures.
4	Flammability	Liquid electrolytes in LE-LIBs are flammable, creating a high risk of fires and explosions.	SSBs eliminate the need for flammable liquid electrolytes, significantly reducing the risks of fires and explosions.
5	Thermal Runaway Risks	Volatile liquid electrolytes in LE-LIBs increase the chances of thermal runaway, leading to battery failure and possible explosions.	SSBs, with their solid electrolytes, avoid volatile components, reducing the chances of thermal runaway, thus enhancing the safety of the batteries.
6	Dendrite Formation	Dendrites form during charging in LE-LIBs, potentially leading to short-circuits and battery failure.	SSBs have the potential to use lithium metal as an anode, which mitigates dendrite formation and enhances both battery safety and energy density.

Appendix #9. Information related to the sustainability challenges and their solutions. [52] ~ [57]

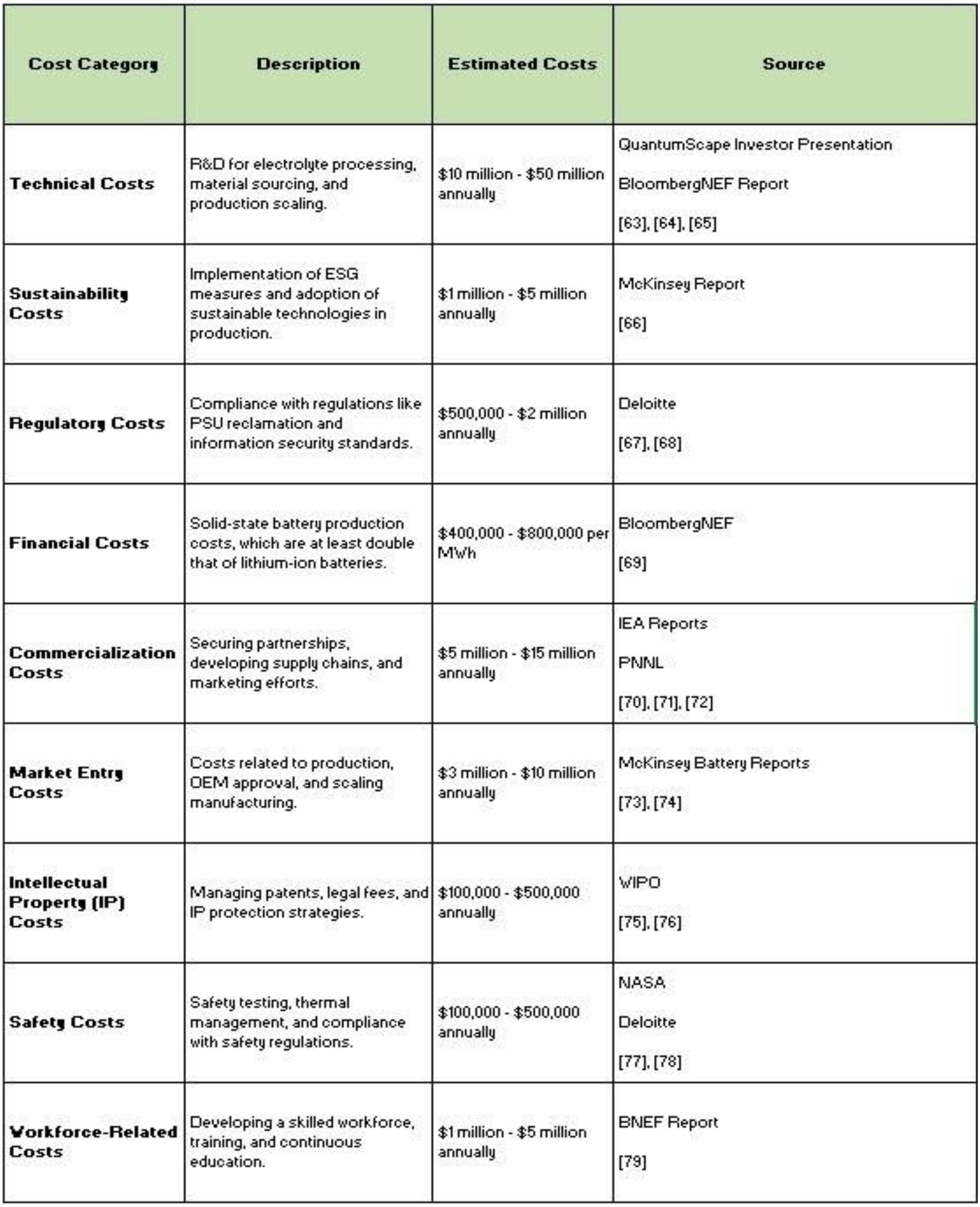


Item	Challenge/Issue	Explanation	Solution
1	**Environmental Impact**	Industries face increasing pressure to reduce their environmental footprint and comply with global environmental standards.	Prioritize ESG reporting, invest in R&D for sustainability, and adopt renewable energy sources to reduce GHG emissions and ensure compliance with environmental standards.
2	**Research and Development**	Innovation in battery technology, particularly solid-state batteries, is crucial for advancing the electric vehicle (EV) industry and sustainable energy solutions.	Invest in high-energy-density battery technology, especially solid-state batteries, to drive advancements in EVs, and foster collaboration for innovation while promoting sustainability metrics.
3	**Human Labor**	Ethical labor practices and worker rights need to be addressed in battery production, especially in material extraction.	Ensure ethical labor standards across the supply chain and improve working conditions while aligning with social responsibility initiatives under ESG frameworks.
4	**Transition to Sustainable Energy Sources**	The push to move away from fossil fuels requires the development of alternative, clean energy technologies such as solid-state batteries.	Develop high-energy-density batteries like solid-state batteries for EVs, foster transparency in the energy transition, and implement policy initiatives aligned with global climate agreements.
5	**Cybersecurity Concerns**	Increasing digitalization exposes companies to cybersecurity threats, requiring comprehensive data protection measures.	Establish cybersecurity guidelines based on ISO 27001/27002 and NIST standards, adopt organization-wide strategies, and implement reporting mechanisms for anonymous reporting of incidents.
6	**ESG Reporting and Transparency**	There is a growing need for transparency in sustainability and governance, especially as investors prioritize ESG factors.	Implement robust ESG frameworks, aligned with recognized standards for transparency, ensure data security and incident response readiness, and promote stakeholder engagement through anonymous hotlines.
7	**Supply Chain**	Supply chain disruptions, particularly in raw material sourcing for batteries, create production and market risks.	Enhance supply chain transparency, ensure ethical sourcing of raw materials, and adopt sustainable practices to mitigate risks while complying with global sustainability standards.

Appendix #10. Key challenges and proposed solutions to workforce issues in the battery industry. [61] [62]

Item	Challenge/Issue	Explanation	Solution
1	Educational Misalignment	Existing educational programs are not aligned with the evolving needs of the battery industry, leading to inadequately prepared workers.	Align educational programs with industry needs through reskilling and upskilling initiatives, ensuring workers are prepared for the battery industry's evolving demands.
2	Lack of Standardized Training Programs	There are no nationally accepted frameworks for training, leading to inconsistent skill levels among workers across regions.	Develop and implement nationally accepted training guidelines, such as those promoted by the Battery Workforce Initiative (BWI), to standardize workforce preparation across the country.
3	Recruitment and Retention	Attracting new workers and retaining them is difficult, especially with the rapid growth of the battery industry.	Implement work-based learning models, provide career pathways, and enhance worker retention by addressing industry needs and ensuring inclusivity in workforce development strategies.
4	Diversity, Equity, and Inclusion (DEI)	Ensuring equitable access to job opportunities and increasing workforce diversity in the battery sector poses challenges.	Apply DEI principles in recruitment and workforce development, ensuring inclusive job opportunities that attract a more diverse workforce, with initiatives like those supported by the BWI.
5	Labor Concerns	The shift to electric vehicles may lead to the displacement of traditional powertrain jobs, raising concerns about job security and fair wages.	Support union efforts, such as those of the United Auto Workers (UAW), to protect worker rights, advocate for fair wages, and promote union representation in nonunionized battery plants.
6	Skill Gap	The rapid expansion of the battery industry has created a surge in demand for skilled workers, leading to gaps in areas like safety, electrochemistry, and manufacturing.	BWI's initiatives focus on bridging the skill gap by developing standardized training programs and ensuring alignment between educational programs and industry needs, helping to train skilled workers.
7	Massive Increase in Battery Demand	The demand for lithium-ion batteries is expected to grow sixfold by 2030, creating urgent workforce challenges.	Rapidly scale the workforce through training initiatives, work-based learning models, and collaboration with industry leaders to ensure a steady pipeline of skilled workers to meet demand.
8	Evolving Industry Trends	Continuous advancements in battery technology require workers to adapt quickly to new skills.	Implement adaptive and ongoing training programs to ensure the workforce stays current with new technologies and production methods, ensuring they remain competitive in the evolving industry.
9	Shortage of Skilled Workers	Many companies report difficulty in finding skilled workers, particularly for critical roles like engineers and technicians.	Support initiatives like BWI that develop standardized training and reskilling programs to address workforce shortages and fill critical roles in the battery industry.
10	Global Competition	The U.S. battery workforce must rapidly develop to remain competitive with international competitors.	Focus on workforce development, investing in education and collaboration, and addressing skill gaps to ensure the U.S. can compete globally in the advanced manufacturing and battery sectors.

Appendix #11. Cost Landscape of Solid-State Battery Development. [63] ~ [79]



Cost Category	Description	Estimated Costs	Source
Technical Costs	R&D for electrolyte processing, material sourcing, and production scaling.	$10 million - $50 million annually	QuantumScape Investor Presentation BloombergNEF Report [63], [64], [65]
Sustainability Costs	Implementation of ESG measures and adoption of sustainable technologies in production.	$1 million - $5 million annually	McKinsey Report [66]
Regulatory Costs	Compliance with regulations like PSU reclamation and information security standards.	$500,000 - $2 million annually	Deloitte [67], [68]
Financial Costs	Solid-state battery production costs, which are at least double that of lithium-ion batteries.	$400,000 - $800,000 per MWh	BloombergNEF [69]
Commercialization Costs	Securing partnerships, developing supply chains, and marketing efforts.	$5 million - $15 million annually	IEA Reports PNNL [70], [71], [72]
Market Entry Costs	Costs related to production, OEM approval, and scaling manufacturing.	$3 million - $10 million annually	McKinsey Battery Reports [73], [74]
Intellectual Property (IP) Costs	Managing patents, legal fees, and IP protection strategies.	$100,000 - $500,000 annually	WIPO [75], [76]
Safety Costs	Safety testing, thermal management, and compliance with safety regulations.	$100,000 - $500,000 annually	NASA Deloitte [77], [78]
Workforce-Related Costs	Developing a skilled workforce, training, and continuous education.	$1 million - $5 million annually	BNEF Report [79]

Appendix #12. Cost Analysis and Future Projections for Solid-State Battery Manufacturing

The following table provides an overview of the costs associated with solid-state battery development, highlighting key factors such as initial production costs, potential price reductions through scaling, long-term projections, manufacturer expectations, and market comparisons with lithium-ion batteries. It also covers the factors influencing final consumer prices. [63] ~ [79]

Table #15. Overview of the costs associated with solid-state battery development. [63] ~ [79]

Item	Cost Category	Description	Cost Estimates	Notes	Sources
1	Production Cost	Initial costs associated with manufacturing solid-state batteries.	$400 - $800 per kWh by 2026	Higher than current lithium-ion batteries ($101 per kWh in 2021)	QuantumScape - Events and Presentations [63]
2	Scaling Effects	Cost reductions expected as production scales up and processes are optimized.	Lithium-ion prices fell from $469 to $101 per kWh (2013-2021)	Economies of scale are critical for reducing costs.	BNEF Blog - Lithium-ion Battery Pack Prices [64]
3	Long-Term Projections	Future costs will depend on manufacturing complexity and materials used.	$75 - $128 per kWh for lithium metal anodes	Combining components could lower costs; early development stages remain.	McKinsey - Decarbonize EV Batteries [66]
4	Manufacturer Expectations	Forecasts from manufacturers regarding the expected production costs.	Nissan: $75 per kWh by 2028; potentially $65 thereafter	Manufacturer claims can vary; need careful consideration.	QuantumScape - Technology [65]
5	Consumer Price	The final cost consumers pay, including additional expenses such as distribution and profit margins.	Higher than production costs	Final price depends on various factors beyond production costs.	Deloitte - EV Battery Supply Chain [67]
6	Market Comparison	Comparison of solid-state battery costs with conventional lithium-ion systems.	$100 per kWh (estimates for solid-state)	Conventional systems around $120 per kWh according to Schnell et al.	BNEF - Lithium-ion Battery Pack Prices [69]
7	Factors Influencing Consumer Price	Additional costs incurred in bringing the product to market.	Varies widely	Includes marketing, distribution, taxes, and retailer margins.	PNNL - Energy Storage Costs [72]

To effectively manage the costs of solid-state battery development, organizations should take a holistic approach that integrates partnerships, funding strategies, and process improvements.

Collaborating on research initiatives and leveraging government grants can reduce technical and sustainability costs.

Streamlining regulatory compliance through internal policies and expert consultants, along with optimizing production processes and sourcing materials, will help lower manufacturing expenses.

Strategic partnerships and targeted marketing can support market entry, while early prototype development allows for valuable feedback from OEMs.

Managing intellectual property and investing in workforce development through educational collaborations will ensure a skilled workforce, creating a framework for long-term success in this competitive field.

Cost Comparison between LiBs and SSBs

This graph compares the costs of Li-ion batteries (LIB) and solid-state batteries (SSB) in terms of $/kWh.

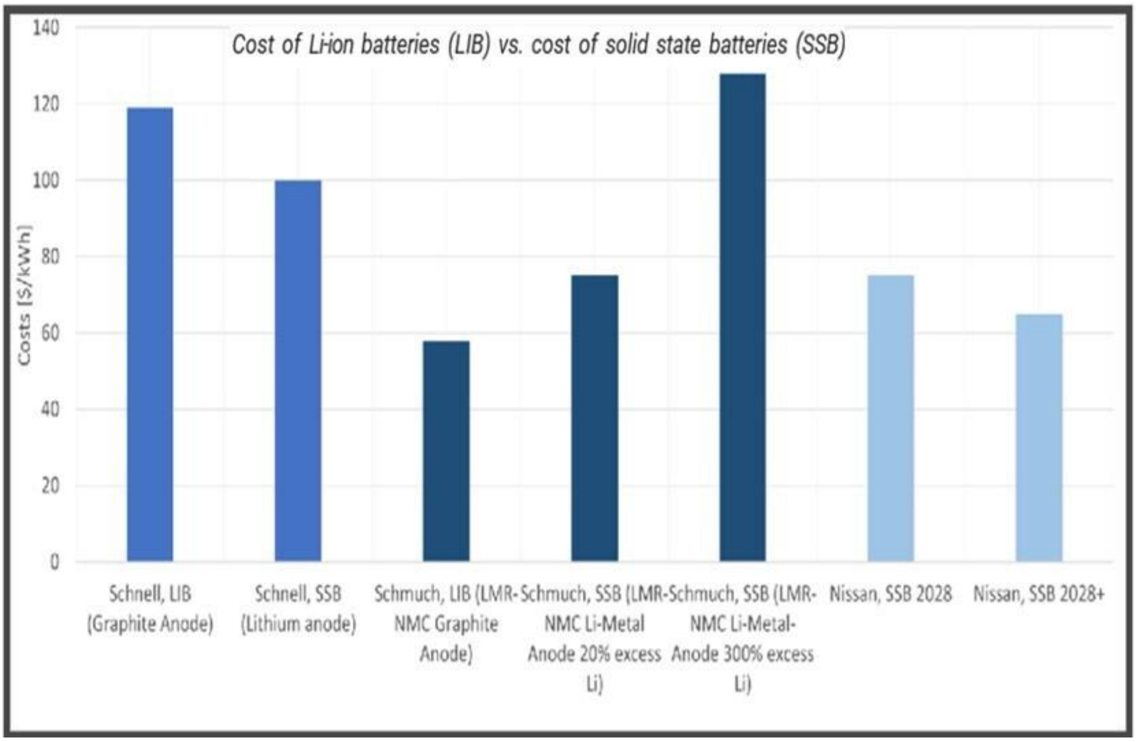


Figure #27. Li-ion batteries (LIB) and solid-state batteries (SSB) comparison in terms of $/kWh

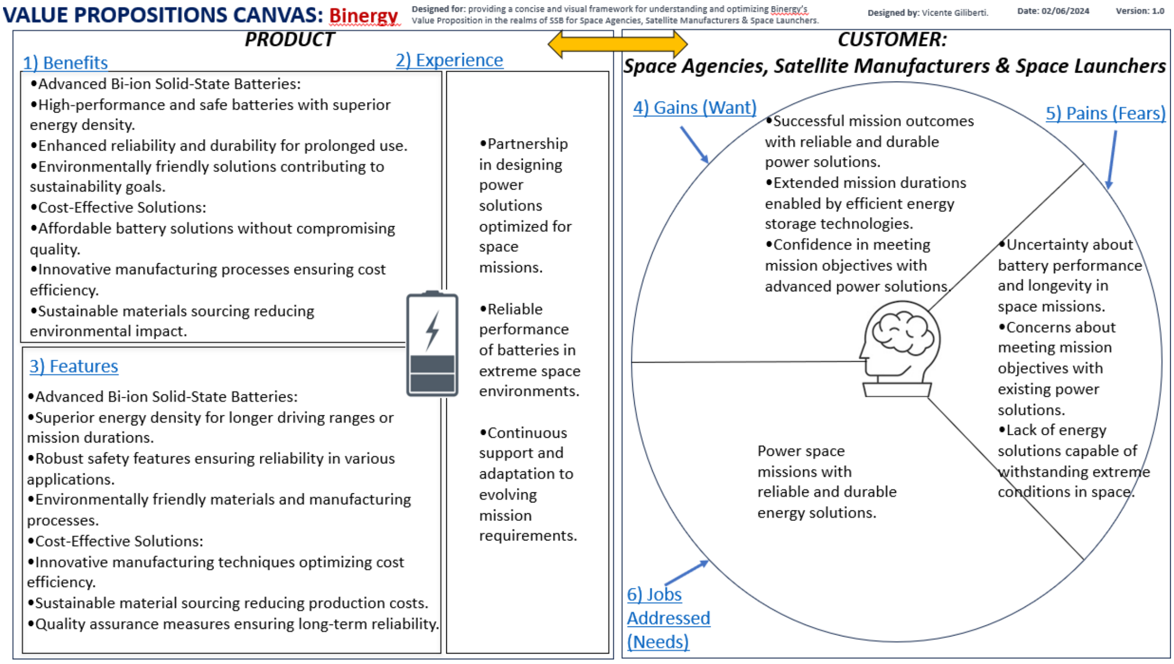
- **Cost Comparison:** Solid-state batteries (SSB) are trending towards lower costs compared to traditional Li-ion batteries (LIB), with future projections suggesting competitiveness.
- **Configuration Impact:** Battery configurations significantly affect costs; for instance, Schnell's LIB is costlier than Schmuch's LIB with an LMR-NMC anode.
- **Future Projections:** Nissan's projections indicate that solid-state battery costs could drop to around $60/kWh, enhancing their market competitiveness.

While solid-state batteries are promising for long-term cost reductions, some configurations, particularly those with excess lithium, may currently be more expensive. Future projections, especially from Nissan, show a trend towards lower costs, making solid-state batteries a viable alternative in the coming years. [80]

Appendix #13. Binergy's VPCs for Upstream and Downstream Customers

It is an essential tool for businesses to understand and communicate the value they offer to their customers. It provides customer-centric approach, clear communication and alignment with customer segments. [13]

Three VPCs have been developed, according to Upstream (Space Agencies, Satellite Manufacturers & Space Launchers) and Downstream (EV Manufacturers & Renewable Energy Companies) customers, which are shown as follows:



VALUE PROPOSITIONS CANVAS: Binergy **Designed for:** providing a concise and visual framework for understanding and optimizing Binergy's Value Proposition in the realms of SSB for Space Agencies, Satellite Manufacturers & Space Launchers. **Designed by:** Vicente Giliberti. **Date:** 02/06/2024 **Version:** 1.0

PRODUCT

1) Benefits

- Advanced Bi-ion Solid-State Batteries:
- High-performance and safe batteries with superior energy density.
- Enhanced reliability and durability for prolonged use.
- Environmentally friendly solutions contributing to sustainability goals.
- Cost-Effective Solutions:
- Affordable battery solutions without compromising quality.
- Innovative manufacturing processes ensuring cost efficiency.
- Sustainable materials sourcing reducing environmental impact.

2) Experience

- Partnership in designing power solutions optimized for space missions.
- Reliable performance of batteries in extreme space environments.
- Continuous support and adaptation to evolving mission requirements.

3) Features

- Advanced Bi-ion Solid-State Batteries:
- Superior energy density for longer driving ranges or mission durations.
- Robust safety features ensuring reliability in various applications.
- Environmentally friendly materials and manufacturing processes.
- Cost-Effective Solutions:
- Innovative manufacturing techniques optimizing cost efficiency.
- Sustainable material sourcing reducing production costs.
- Quality assurance measures ensuring long-term reliability.

CUSTOMER:

Space Agencies, Satellite Manufacturers & Space Launchers

4) Gains (Want)

- Successful mission outcomes with reliable and durable power solutions.
- Extended mission durations enabled by efficient energy storage technologies.
- Confidence in meeting mission objectives with advanced power solutions.

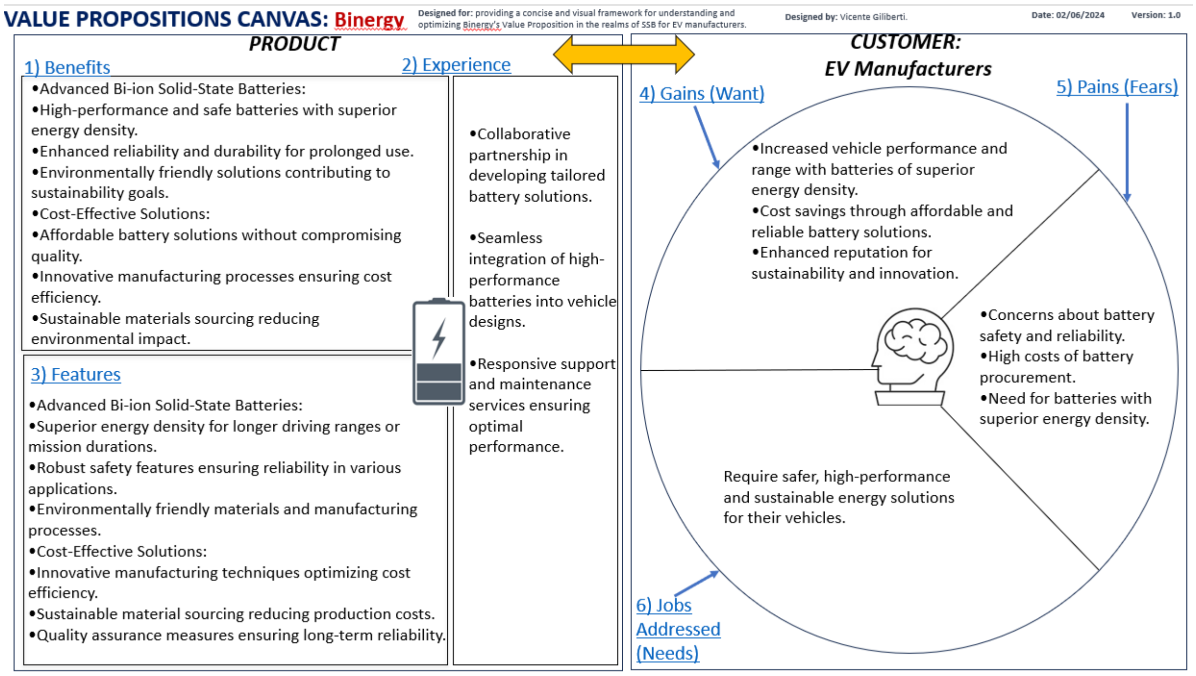
5) Pains (Fears)

- Uncertainty about battery performance and longevity in space missions.
- Concerns about meeting mission objectives with existing power solutions.
- Lack of energy solutions capable of withstanding extreme conditions in space.

6) Jobs Addressed (Needs)

Power space missions with reliable and durable energy solutions.

Figure #29. The "Value Proposition Canvas" from Binergy Startup to Upstream Customer.



VALUE PROPOSITIONS CANVAS: Binergy **Designed for:** providing a concise and visual framework for understanding and optimizing Binergy's Value Proposition in the realms of SSB for EV manufacturers. **Designed by:** Vicente Giliberti. **Date:** 02/06/2024 **Version:** 1.0

PRODUCT

1) Benefits

- Advanced Bi-ion Solid-State Batteries:
- High-performance and safe batteries with superior energy density.
- Enhanced reliability and durability for prolonged use.
- Environmentally friendly solutions contributing to sustainability goals.
- Cost-Effective Solutions:
- Affordable battery solutions without compromising quality.
- Innovative manufacturing processes ensuring cost efficiency.
- Sustainable materials sourcing reducing environmental impact.

2) Experience

- Collaborative partnership in developing tailored battery solutions.
- Seamless integration of high-performance batteries into vehicle designs.
- Responsive support and maintenance services ensuring optimal performance.

3) Features

- Advanced Bi-ion Solid-State Batteries:
- Superior energy density for longer driving ranges or mission durations.
- Robust safety features ensuring reliability in various applications.
- Environmentally friendly materials and manufacturing processes.
- Cost-Effective Solutions:
- Innovative manufacturing techniques optimizing cost efficiency.
- Sustainable material sourcing reducing production costs.
- Quality assurance measures ensuring long-term reliability.

CUSTOMER:

EV Manufacturers

4) Gains (Want)

- Increased vehicle performance and range with batteries of superior energy density.
- Cost savings through affordable and reliable battery solutions.
- Enhanced reputation for sustainability and innovation.

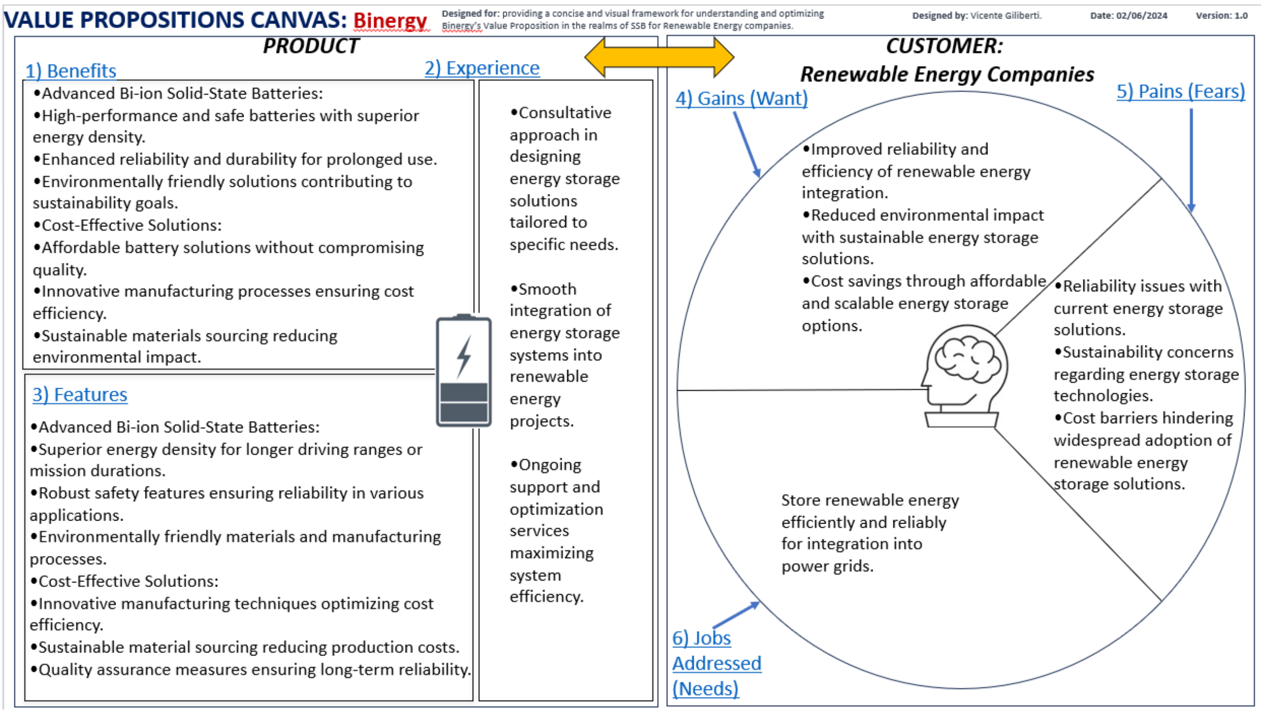
5) Pains (Fears)

- Concerns about battery safety and reliability.
- High costs of battery procurement.
- Need for batteries with superior energy density.

6) Jobs Addressed (Needs)

Require safer, high-performance and sustainable energy solutions for their vehicles.

Figure #30. The "Value Proposition Canvas" from Binergy Startup to Downstream Customer (EV Manufacturer).



VALUE PROPOSITIONS CANVAS: Binergy

Designed for: providing a concise and visual framework for understanding and optimizing Binergy's Value Proposition in the realms of SSB for Renewable Energy companies.

Designed by: Vicente Giliberti. **Date:** 02/06/2024 **Version:** 1.0

PRODUCT

1) Benefits

- Advanced Bi-ion Solid-State Batteries:
- High-performance and safe batteries with superior energy density.
- Enhanced reliability and durability for prolonged use.
- Environmentally friendly solutions contributing to sustainability goals.
- Cost-Effective Solutions:
- Affordable battery solutions without compromising quality.
- Innovative manufacturing processes ensuring cost efficiency.
- Sustainable materials sourcing reducing environmental impact.

2) Experience

- Consultative approach in designing energy storage solutions tailored to specific needs.
- Smooth integration of energy storage systems into renewable energy projects.
- Ongoing support and optimization services maximizing system efficiency.

3) Features

- Advanced Bi-ion Solid-State Batteries:
- Superior energy density for longer driving ranges or mission durations.
- Robust safety features ensuring reliability in various applications.
- Environmentally friendly materials and manufacturing processes.
- Cost-Effective Solutions:
- Innovative manufacturing techniques optimizing cost efficiency.
- Sustainable material sourcing reducing production costs.
- Quality assurance measures ensuring long-term reliability.

CUSTOMER:

Renewable Energy Companies

4) Gains (Want)

- Improved reliability and efficiency of renewable energy integration.
- Reduced environmental impact with sustainable energy storage solutions.
- Cost savings through affordable and scalable energy storage options.

5) Pains (Fears)

- Reliability issues with current energy storage solutions.
- Sustainability concerns regarding energy storage technologies.
- Cost barriers hindering widespread adoption of renewable energy storage solutions.

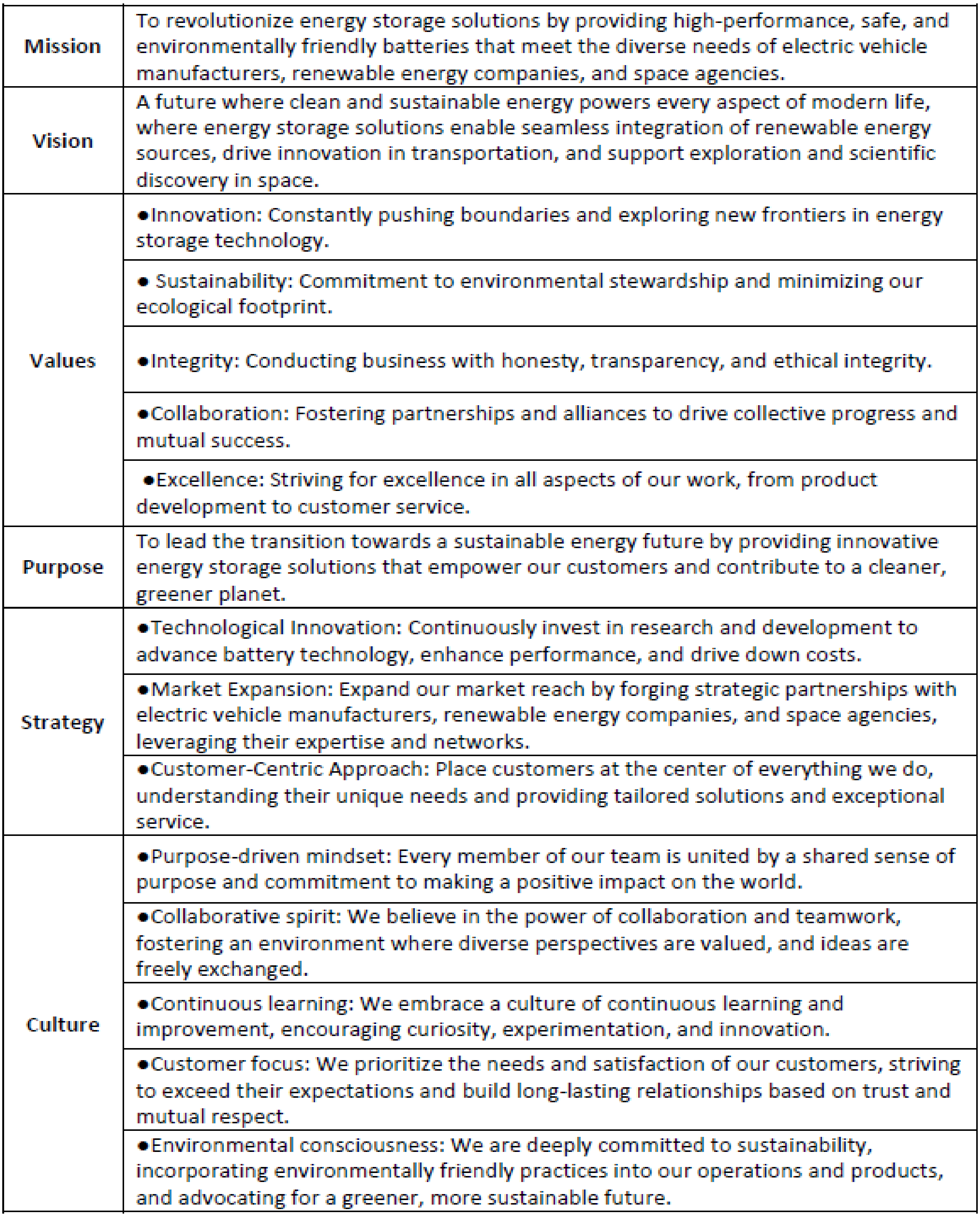
6) Jobs Addressed (Needs)

Store renewable energy efficiently and reliably for integration into power grids.

Figure #31. The "Value Proposition Canvas" from Binergy Startup to Downstream Customer (Renewable Energy Companies).

Appendix #14. Elements for Strategic Development

Table #16. Strategy Development Elements. Mission, Vision, Values. [16]



Mission	To revolutionize energy storage solutions by providing high-performance, safe, and environmentally friendly batteries that meet the diverse needs of electric vehicle manufacturers, renewable energy companies, and space agencies.
Vision	A future where clean and sustainable energy powers every aspect of modern life, where energy storage solutions enable seamless integration of renewable energy sources, drive innovation in transportation, and support exploration and scientific discovery in space.
Values	●Innovation: Constantly pushing boundaries and exploring new frontiers in energy storage technology.
	● Sustainability: Commitment to environmental stewardship and minimizing our ecological footprint.
	●Integrity: Conducting business with honesty, transparency, and ethical integrity.
	●Collaboration: Fostering partnerships and alliances to drive collective progress and mutual success.
	●Excellence: Striving for excellence in all aspects of our work, from product development to customer service.
Purpose	To lead the transition towards a sustainable energy future by providing innovative energy storage solutions that empower our customers and contribute to a cleaner, greener planet.
Strategy	●Technological Innovation: Continuously invest in research and development to advance battery technology, enhance performance, and drive down costs.
	●Market Expansion: Expand our market reach by forging strategic partnerships with electric vehicle manufacturers, renewable energy companies, and space agencies, leveraging their expertise and networks.
	●Customer-Centric Approach: Place customers at the center of everything we do, understanding their unique needs and providing tailored solutions and exceptional service.
Culture	●Purpose-driven mindset: Every member of our team is united by a shared sense of purpose and commitment to making a positive impact on the world.
	●Collaborative spirit: We believe in the power of collaboration and teamwork, fostering an environment where diverse perspectives are valued, and ideas are freely exchanged.
	●Continuous learning: We embrace a culture of continuous learning and improvement, encouraging curiosity, experimentation, and innovation.
	●Customer focus: We prioritize the needs and satisfaction of our customers, striving to exceed their expectations and build long-lasting relationships based on trust and mutual respect.
	●Environmental consciousness: We are deeply committed to sustainability, incorporating environmentally friendly practices into our operations and products, and advocating for a greener, more sustainable future.

Appendix #15. Exercise of Future Visioning & Scenario Planning

Combine visioning and scenario planning iteratively for large group strategic planning. Start with a specific future challenge. Facilitate a visioning session to gather ideas and refine the main themes. Develop and compare scenarios based on key factors and uncertainties, exploring implications and opportunities. Prioritize actions to achieve the vision and navigate scenarios. Review outcomes to ensure alignment with the vision and initial challenge. [18]

Following is an exercise of Visioning & Scenario Planning for the startup Binergy, based on the challenges already known.

Step 1: Define Critical Uncertainties through visioning session:

Figure #32. Critical Uncertainties listed after visioning session applying brainstorming.

Step 2: Eliminate Duplicates and/or Cluster-like factors: through brainstorming and make changes as required:

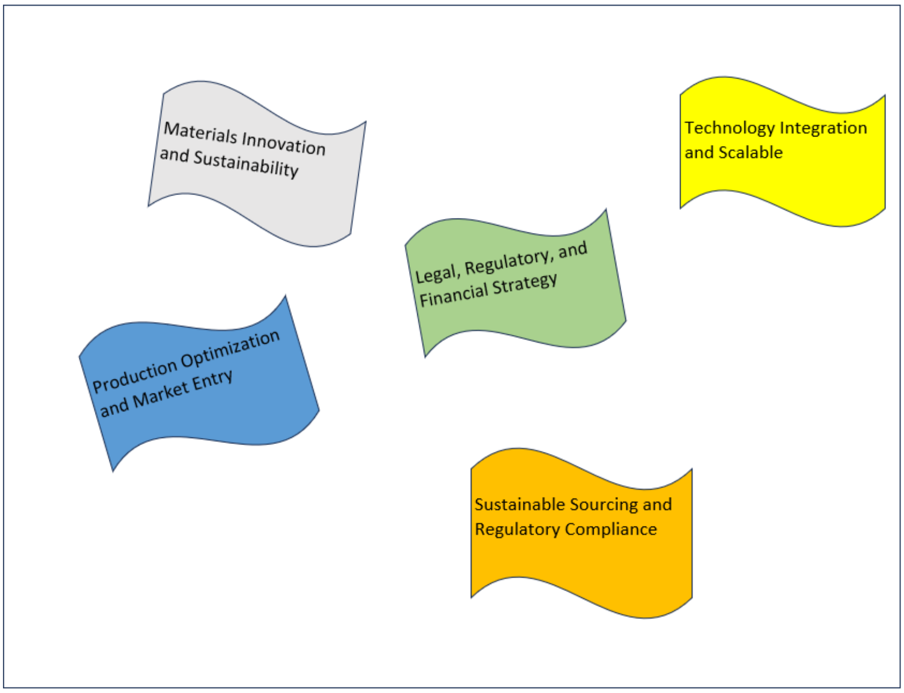


Figure #33. Critical Uncertainties changes after Cluster-like factors elimination through brainstorming activities.

Step 3: Build -Up Impact-Importance Diagram and Set Scenarios:

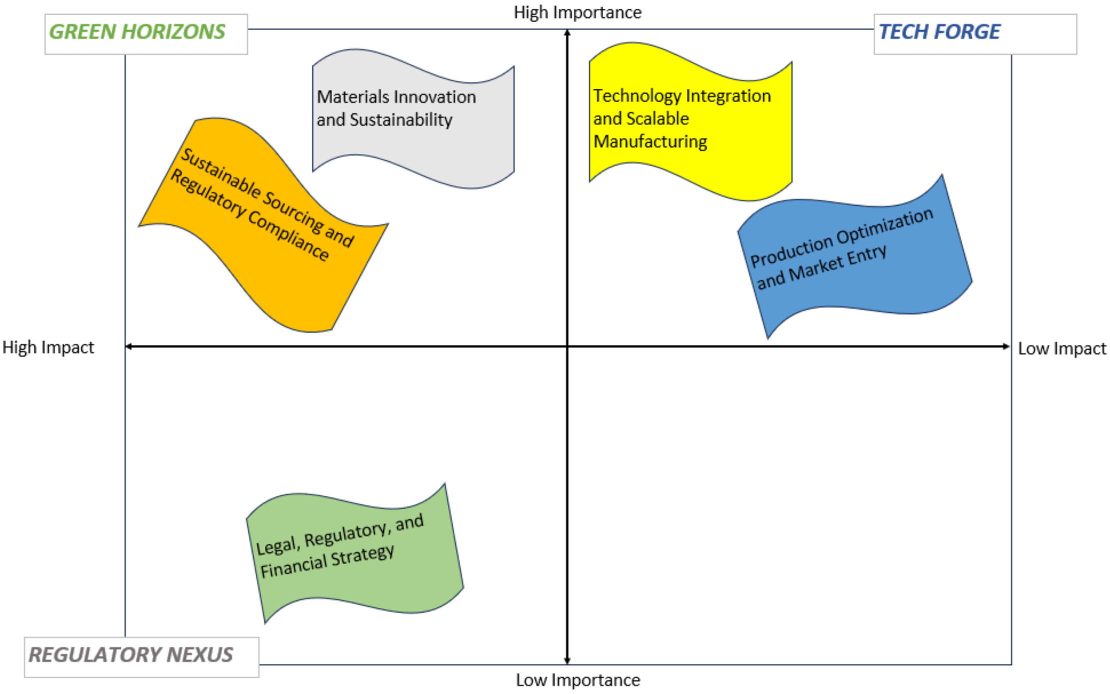


Figure #34. Scenarios Definition: "Green Horizons"

Scenarios definition allow stakeholders to prioritize efforts based on the combined impact and importance of each uncertainty. The uncertainties with high impact and importance require immediate attention and resources, while those with high impact but low importance may need to be addressed in the long term or with fewer resources.

Step 4: Looking for "robust" strategies:

A "robust" strategy is defined as one that aligns with multiple explored scenarios. Seven strategies meeting this criterion have been unanimously agreed upon, as follows:

- *Cross-sector Collaboration:* Establish partnerships and collaborations with other organizations, academia, and governmental bodies to leverage resources, share knowledge, and navigate uncertainties together. This strategy can help in addressing challenges related to materials innovation, technology integration, regulatory compliance, and financial strategy.

- *Continuous Innovation:* Foster a culture of innovation within the organization to continually develop and adapt technologies, processes, and products/services to meet evolving market demands and regulatory requirements. This strategy is relevant across scenarios as it supports sustainability, scalability, and compliance efforts.

- *Supply Chain Transparency:* Implement robust supply chain management practices to ensure sustainable sourcing, ethical manufacturing, and compliance with regulations. Transparency in the supply chain helps mitigate risks associated with materials sourcing, production optimization, and regulatory compliance.

- *Diversification:* Diversify product/service offerings, markets, and revenue streams to spread risks and capitalize on emerging opportunities. This strategy can help mitigate uncertainties related to market entry, regulatory changes, and financial fluctuations.

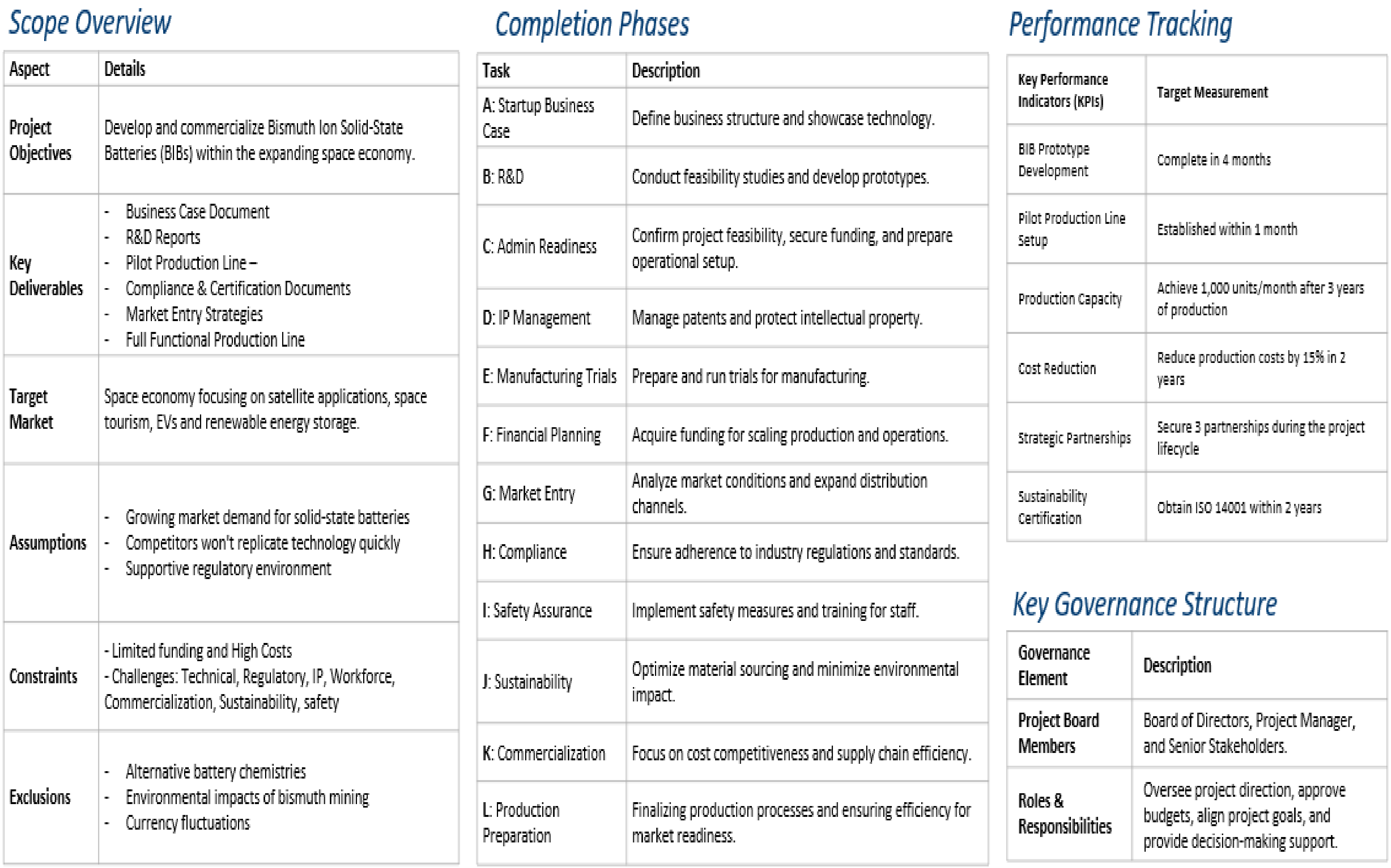
- *Data-driven Decision-making:* Invest in data analytics and decision support systems to gather insights, monitor performance, and adapt strategies in real-time. Data-driven decision-making enhances agility and resilience across all scenarios by enabling proactive risk management and strategic planning.

- *Stakeholder Engagement:* Engage with stakeholders including customers, investors, regulators, and communities to understand their needs, expectations, and concerns. Building strong relationships with stakeholders fosters trust, enhances reputation, and facilitates smoother navigation of uncertainties.

- *Compliance Management:* Develop robust compliance management systems to ensure adherence to legal, regulatory, and financial requirements. This includes staying updated on changing regulations, conducting regular audits, and implementing internal controls to mitigate compliance risks.

By adopting these robust strategies, organizations can better navigate the uncertainties presented in the Green Horizons, TechForge, and Regulatory Nexus scenarios while positioning themselves for sustainable growth and success.

See Appendix #16. Binergy's Project Scope Summary



Scope Overview

Aspect	Details
Project Objectives	Develop and commercialize Bismuth Ion Solid-State Batteries (BIBs) within the expanding space economy.
Key Deliverables	- Business Case Document - R&D Reports - Pilot Production Line – - Compliance & Certification Documents - Market Entry Strategies - Full Functional Production Line
Target Market	Space economy focusing on satellite applications, space tourism, EVs and renewable energy storage.
Assumptions	- Growing market demand for solid-state batteries - Competitors won't replicate technology quickly - Supportive regulatory environment
Constraints	- Limited funding and High Costs - Challenges: Technical, Regulatory, IP, Workforce, Commercialization, Sustainability, safety
Exclusions	- Alternative battery chemistries - Environmental impacts of bismuth mining - Currency fluctuations

Completion Phases

Task	Description
A: Startup Business Case	Define business structure and showcase technology.
B: R&D	Conduct feasibility studies and develop prototypes.
C: Admin Readiness	Confirm project feasibility, secure funding, and prepare operational setup.
D: IP Management	Manage patents and protect intellectual property.
E: Manufacturing Trials	Prepare and run trials for manufacturing.
F: Financial Planning	Acquire funding for scaling production and operations.
G: Market Entry	Analyze market conditions and expand distribution channels.
H: Compliance	Ensure adherence to industry regulations and standards.
I: Safety Assurance	Implement safety measures and training for staff.
J: Sustainability	Optimize material sourcing and minimize environmental impact.
K: Commercialization	Focus on cost competitiveness and supply chain efficiency.
L: Production Preparation	Finalizing production processes and ensuring efficiency for market readiness.

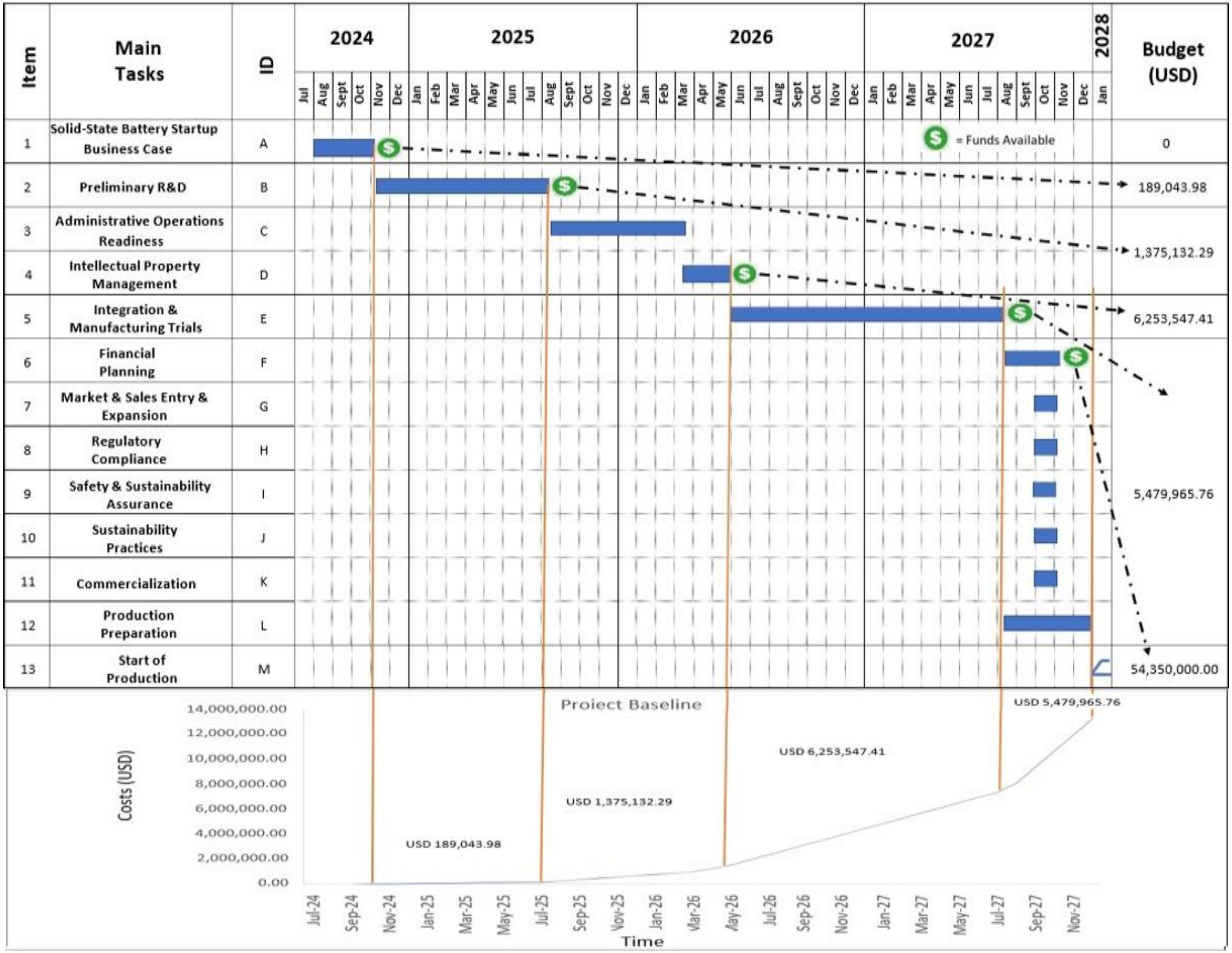
Performance Tracking

Key Performance Indicators (KPIs)	Target Measurement
BIB Prototype Development	Complete in 4 months
Pilot Production Line Setup	Established within 1 month
Production Capacity	Achieve 1,000 units/month after 3 years of production
Cost Reduction	Reduce production costs by 15% in 2 years
Strategic Partnerships	Secure 3 partnerships during the project lifecycle
Sustainability Certification	Obtain ISO 14001 within 2 years

Key Governance Structure

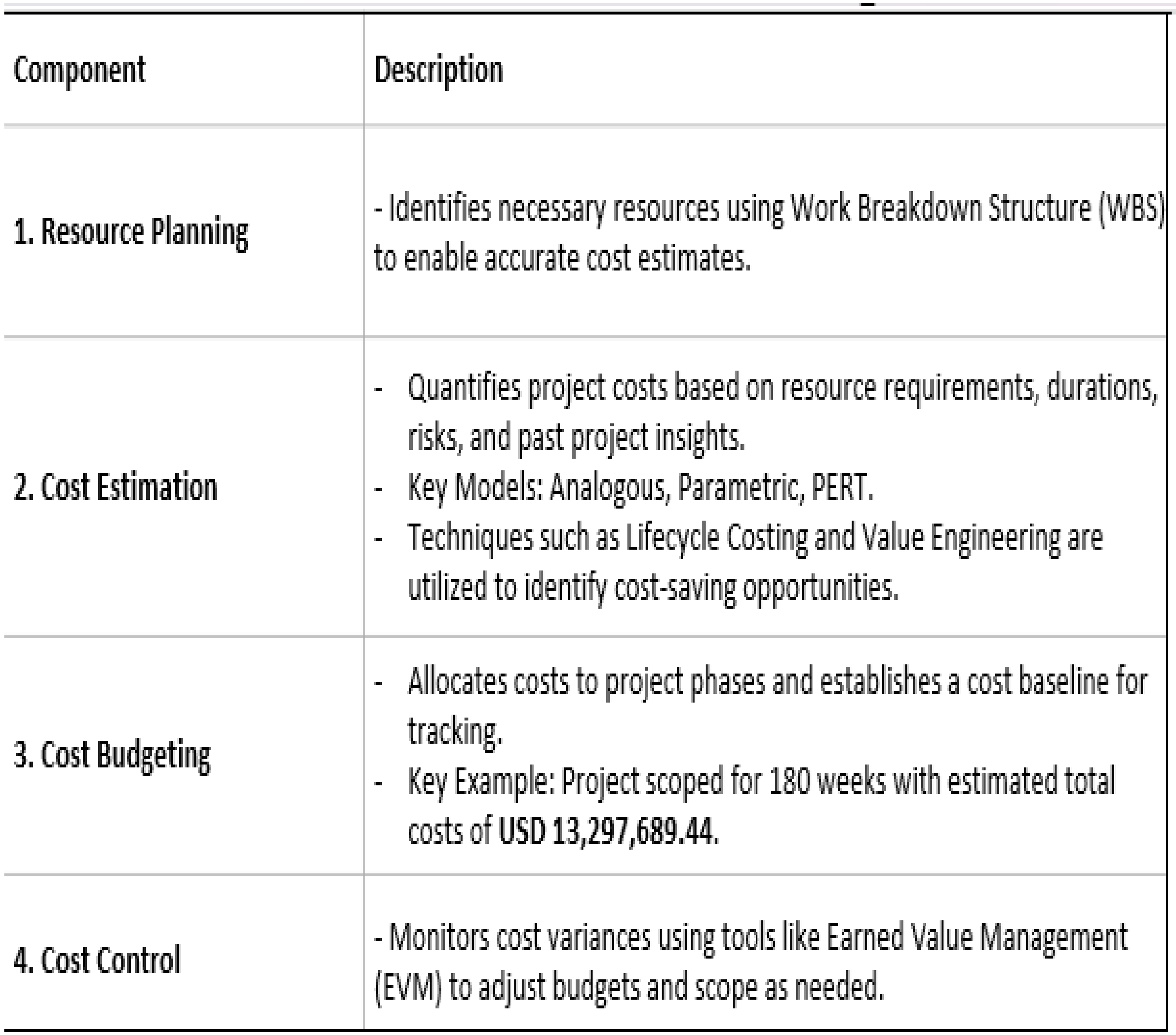
Governance Element	Description
Project Board Members	Board of Directors, Project Manager, and Senior Stakeholders.
Roles & Responsibilities	Oversee project direction, approve budgets, align project goals, and provide decision-making support.

Appendix #17. Binergy’s Gantt Chart & Costs Summary



Item	Main Tasks	ID	Budget (USD)
1	Solid-State Battery Startup Business Case	A	0
2	Preliminary R&D	B	189,043.98
3	Administrative Operations Readiness	C	1,375,132.29
4	Intellectual Property Management	D	
5	Integration & Manufacturing Trials	E	6,253,547.41
6	Financial Planning	F	5,479,965.76
7	Market & Sales Entry & Expansion	G	
8	Regulatory Compliance	H	
9	Safety & Sustainability Assurance	I	
10	Sustainability Practices	J	
11	Commercialization	K	
12	Production Preparation	L	
13	Start of Production	M	54,350,000.00

Appendix #18. Summary of Binergy's Project Costs Management Components & Breakdown



Component	Description
1. Resource Planning	- Identifies necessary resources using Work Breakdown Structure (WBS) to enable accurate cost estimates.
2. Cost Estimation	- Quantifies project costs based on resource requirements, durations, risks, and past project insights. - Key Models: Analogous, Parametric, PERT. - Techniques such as Lifecycle Costing and Value Engineering are utilized to identify cost-saving opportunities.
3. Cost Budgeting	- Allocates costs to project phases and establishes a cost baseline for tracking. - Key Example: Project scoped for 180 weeks with estimated total costs of **USD 13,297,689.44**.
4. Cost Control	- Monitors cost variances using tools like Earned Value Management (EVM) to adjust budgets and scope as needed.

Cost Classification	Total (USD)
Preliminary R&D	3,689,044.94
Administrative Operations Readiness	1,119,594.22
Intellectual Property Management	6,035,419.99
Integration & Manufacturing Trials	373,385.44
Financial Planning	705,833.92
Market & Sales Entry & Expansion	429,072.46
Other Categories	1,469,930.88
Total Estimated Cost	**13,297,689.44**

Appendix #19. Sources of Funds

Type of investment	Description	Key points
Venture Capital (VC) Funding	Venture capital involves investment from private firms or funds in exchange for equity in a startup. In the space industry, VC funding is often sought by early-stage companies with promising technologies or innovative solutions.	VC investors provide not just capital but often bring industry expertise and mentorship.
		Startups typically go through multiple funding rounds as they progress from seed to series A, B, and beyond.
Angel Investors	Angel investors are individuals who invest their personal funds in startups, usually during the early stages of development. Angels play a crucial role in providing initial capital and mentorship to space entrepreneurs.	Angel investors may be more flexible than traditional venture capital and can act quickly on investment decisions.
		They often contribute industry experience and personal networks to support startups.
Government Grants and Contracts	Governments worldwide offer grants and contracts to stimulate space innovation and development. Organizations like NASA provide funding for research, development, and specific projects that align with space exploration goals.	Grants may be competitive and often require alignment with government space initiatives.
		Government contracts involve startups providing specific products or services to governmental space agencies.
Corporate Partnerships	Collaborating with established aerospace or technology companies through partnerships is a strategic way for startups to access resources, funding, and market opportunities.	Corporate partnerships can provide funding, access to established networks, and opportunities for joint development.
		Partnerships may involve collaboration on research projects, technology transfer, or joint ventures.
Space Accelerators and Incubators	Space-focused accelerators and incubators provide startups with funding, mentorship, and resources to accelerate their growth. They often run structured programs with demo days for startups to showcase their progress.	Accelerators offer a supportive environment for startups, fostering innovation and collaboration.
		Access to mentorship, industry connections, and potential follow-on funding are common benefits.
Space Competitions and Prizes	Competitions, like the past Google Lunar XPRIZE or the SpaceX Hyperloop Pod Competition, offer cash prizes for achieving specific space-related goals. These competitions attract innovative teams from around the world.	Prizes serve as incentives for breakthroughs in space technology.
		Competitions often garner significant media attention, raising the profile of participating startups.
Space-specific Funding Platforms	Platforms like Space Angels connect investors with space startups seeking funding. These platforms specialize in the space sector, providing a targeted approach for both investors and startups.	Space-specific platforms understand the unique challenges and opportunities within the space industry.
		They often offer a network of space-focused investors and industry experts.
International Funding Opportunities	Collaborating with international space agencies, organizations, or investors provides startups with access to a global ecosystem. This may involve participating in international programs, joint ventures, or securing funding from entities outside the startup's home country.	Global collaboration can bring diverse perspectives, resources, and market access.
		Startups should be aware of regulatory and cultural differences when seeking international funding.
Strategic Alliances with Research Institutions	Forming strategic alliances with research institutions or universities can lead to collaborative projects and funding opportunities. Research partnerships often involve joint projects and knowledge exchange.	Alliances can provide access to cutting-edge research, facilities, and expertise.
		Funding may come in the form of grants, joint research initiatives, or technology transfer agreements.
Debt financing	Debt financing involves taking on debt, typically in the form of loans or bonds, to fund business operations, investments, or other financial needs.	The borrower can make productive use of the assets in their business.
		Different types of assets can be used as collateral e.g. equipment, robotics, automation, intellectual property or future revenue streams.
		Unlike equity financing, debt financing does not dilute ownership or control of the company, allowing shareholders to retain full ownership of the business.

Appendix #20. EVM Technique, Fundamentals and Equations.

- **Planned Value (PV)**: Budget for scheduled work.
- **Earned Value (EV)**: Value of work performed.
- **Actual Cost (AC)**: Cost incurred for the work performed.

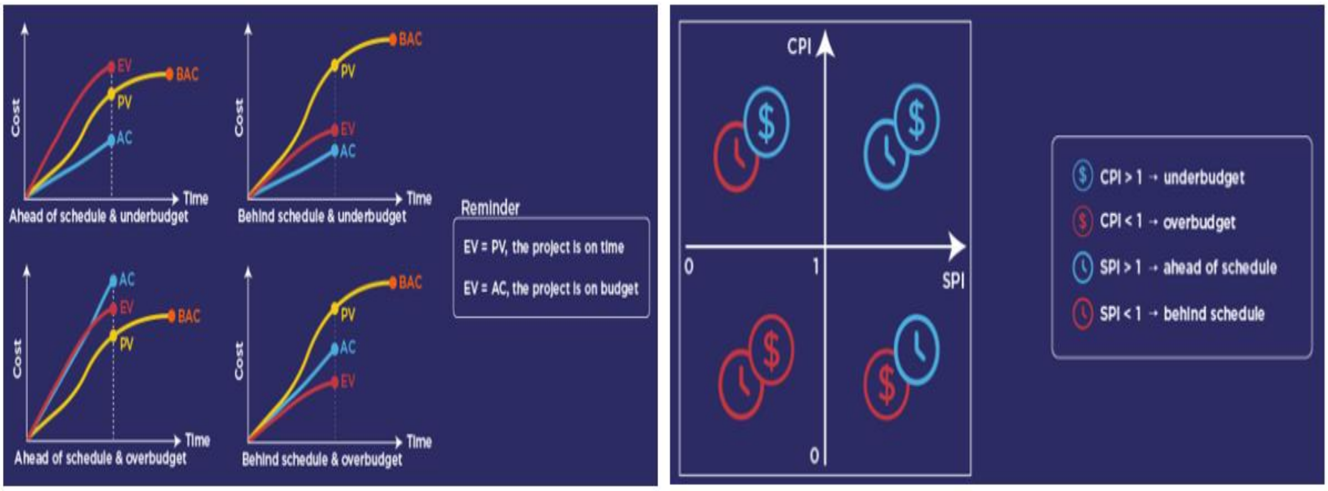


Figure #20. Earned Value Analysis

Schedule Variance (SV): SV = EV – PV

If **SV > 0**: Project is ahead of schedule.

If **SV = 0**: Project is on schedule.

If **SV < 0**: Project is behind schedule.

Cost Variance (CV): CV = EV – AC

If **CV > 0**: Project is under budget.

If **CV = 0**: Project is on budget.

If **CV < 0**: Project is over budget.

Schedule Performance Index (SPI): SPI = EV / PV

If **SPI > 1.00**: Project is ahead of schedule.

- If **SPI = 1.00**: Project is on schedule.
- If **SPI < 1.00**: Project is behind schedule.

Cost Performance Index (CPI): CPI = EV / AC

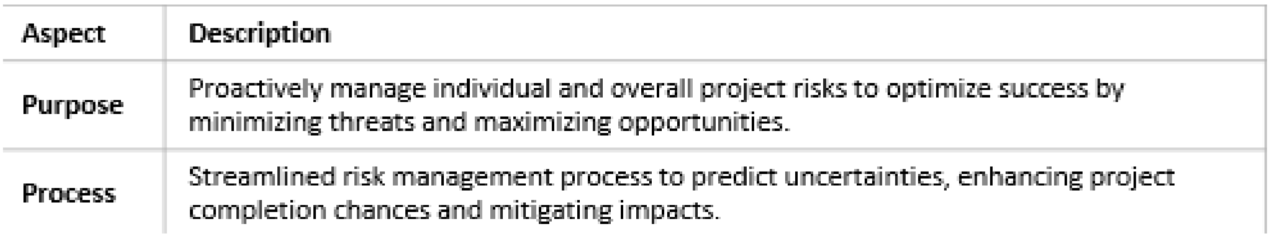
If **CPI > 1.00**: Project is under budget.

If **CPI = 1.00**: Project is on budget.

If **CPI < 1.00**: Project is over budget.

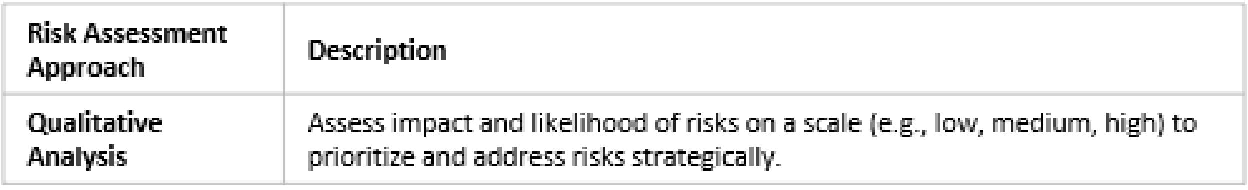
Appendix #21. Binergy's Risk Management Plan Summary.

Overview of Risk Management:



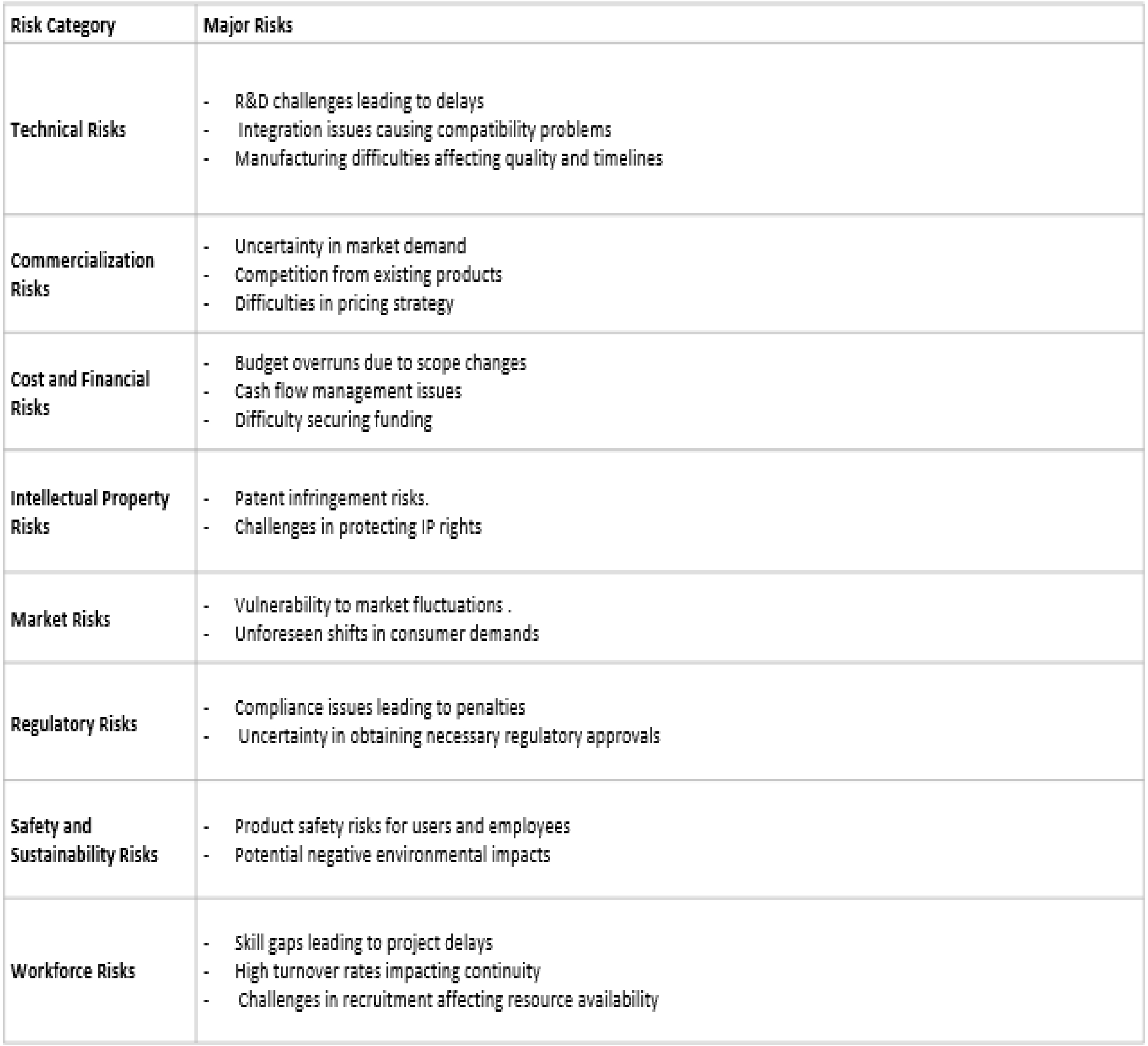
Aspect	Description
Purpose	Proactively manage individual and overall project risks to optimize success by minimizing threats and maximizing opportunities.
Process	Streamlined risk management process to predict uncertainties, enhancing project completion chances and mitigating impacts.

Risk Assessment Approach:



Risk Assessment Approach	Description
Qualitative Analysis	Assess impact and likelihood of risks on a scale (e.g., low, medium, high) to prioritize and address risks strategically.

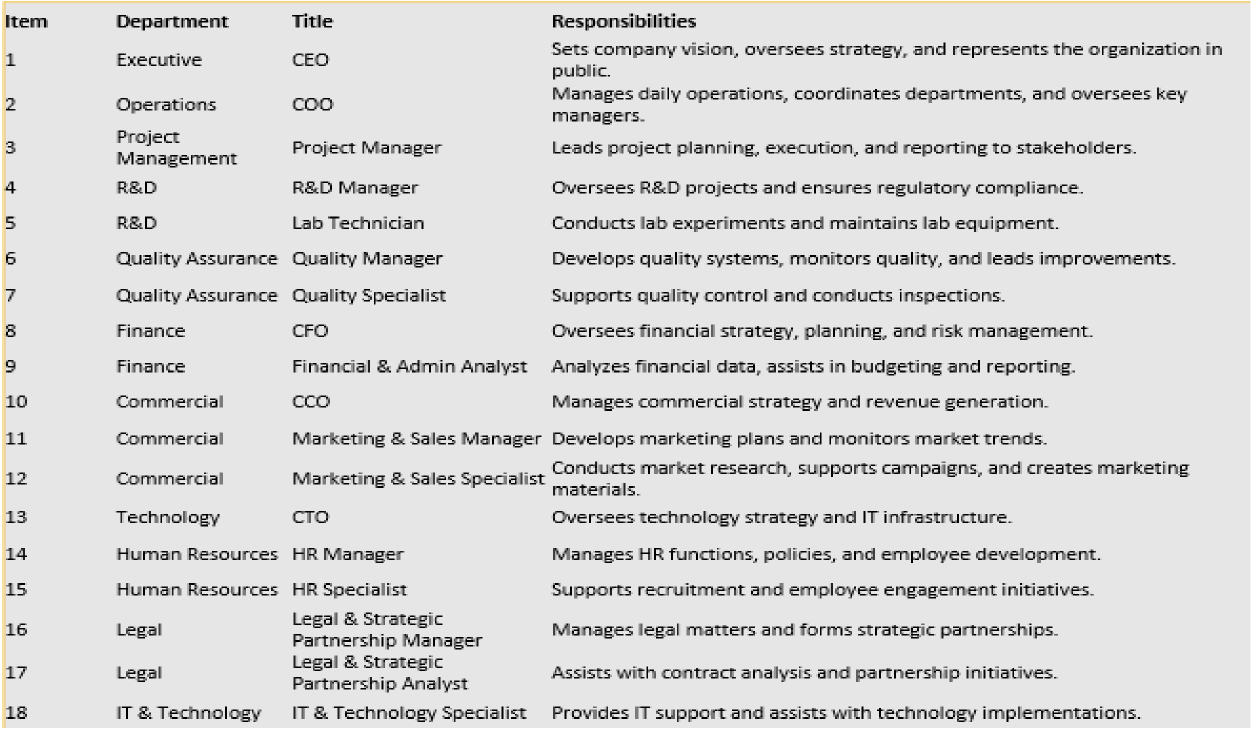
Key Risk Categories & Examples:



Risk Category	Major Risks
Technical Risks	- R&D challenges leading to delays - Integration issues causing compatibility problems - Manufacturing difficulties affecting quality and timelines
Commercialization Risks	- Uncertainty in market demand - Competition from existing products - Difficulties in pricing strategy
Cost and Financial Risks	- Budget overruns due to scope changes - Cash flow management issues - Difficulty securing funding
Intellectual Property Risks	- Patent infringement risks. - Challenges in protecting IP rights
Market Risks	- Vulnerability to market fluctuations . - Unforeseen shifts in consumer demands
Regulatory Risks	- Compliance issues leading to penalties - Uncertainty in obtaining necessary regulatory approvals
Safety and Sustainability Risks	- Product safety risks for users and employees - Potential negative environmental impacts
Workforce Risks	- Skill gaps leading to project delays - High turnover rates impacting continuity - Challenges in recruitment affecting resource availability

Appendix #22. Binergy's Project Organization, Materials & Equipment

Binergy's Project Organization:



Item	Department	Title	Responsibilities
1	Executive	CEO	Sets company vision, oversees strategy, and represents the organization in public.
2	Operations	COO	Manages daily operations, coordinates departments, and oversees key managers.
3	Project Management	Project Manager	Leads project planning, execution, and reporting to stakeholders.
4	R&D	R&D Manager	Oversees R&D projects and ensures regulatory compliance.
5	R&D	Lab Technician	Conducts lab experiments and maintains lab equipment.
6	Quality Assurance	Quality Manager	Develops quality systems, monitors quality, and leads improvements.
7	Quality Assurance	Quality Specialist	Supports quality control and conducts inspections.
8	Finance	CFO	Oversees financial strategy, planning, and risk management.
9	Finance	Financial & Admin Analyst	Analyzes financial data, assists in budgeting and reporting.
10	Commercial	CCO	Manages commercial strategy and revenue generation.
11	Commercial	Marketing & Sales Manager	Develops marketing plans and monitors market trends.
12	Commercial	Marketing & Sales Specialist	Conducts market research, supports campaigns, and creates marketing materials.
13	Technology	CTO	Oversees technology strategy and IT infrastructure.
14	Human Resources	HR Manager	Manages HR functions, policies, and employee development.
15	Human Resources	HR Specialist	Supports recruitment and employee engagement initiatives.
16	Legal	Legal & Strategic Partnership Manager	Manages legal matters and forms strategic partnerships.
17	Legal	Legal & Strategic Partnership Analyst	Assists with contract analysis and partnership initiatives.
18	IT & Technology	IT & Technology Specialist	Provides IT support and assists with technology implementations.

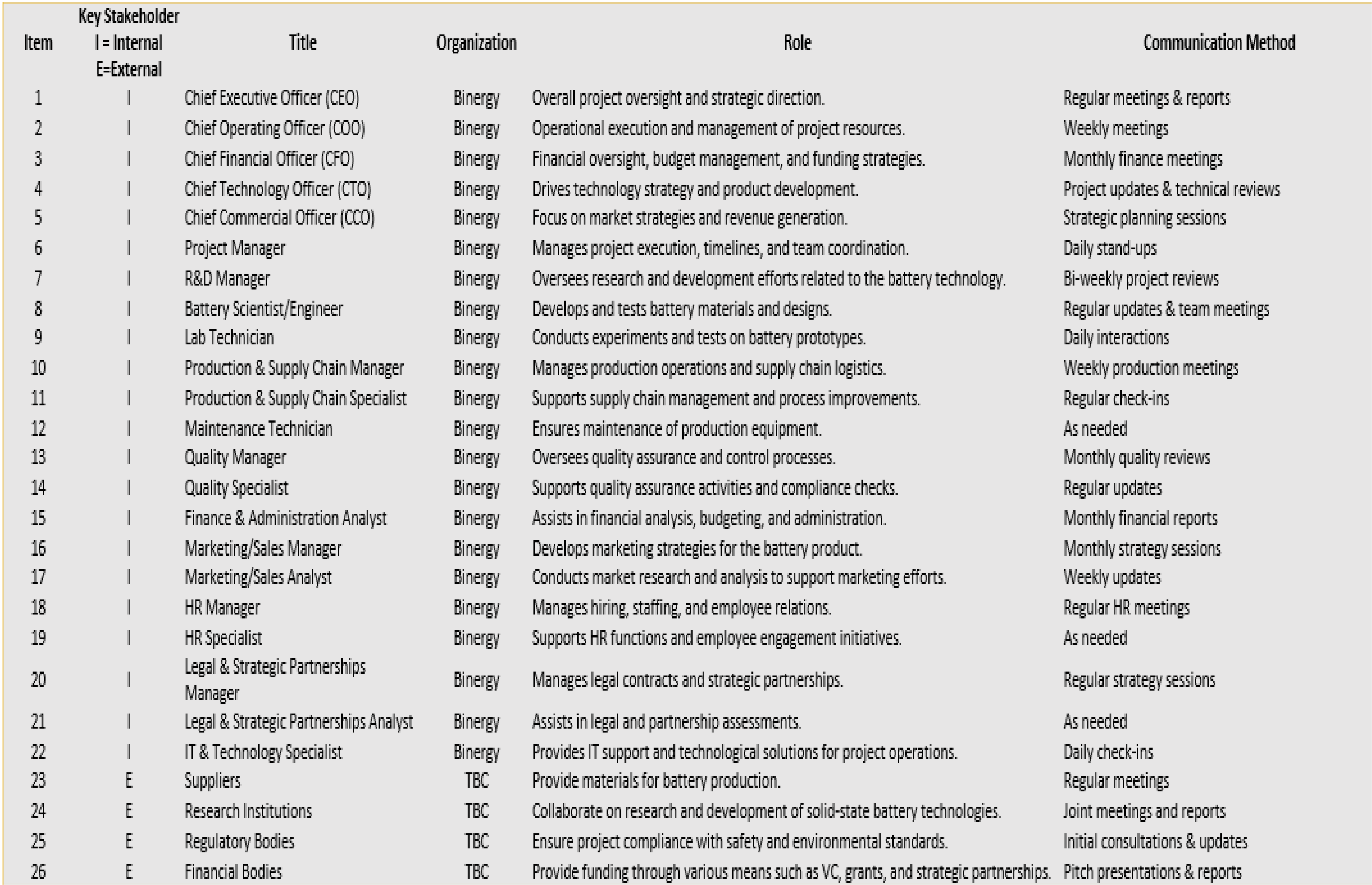
Binergy's Project Materials & Equipment:

Item No.	Classification	Description
1	Production Material & Equipment	Includes battery production line machinery and quality control systems.
2	Warehouse & Storage Equipment	Storage solutions and climate-controlled units for inventory management.
3	Safety Material & Equipment	PPE, safety systems, and monitoring equipment for workplace safety.
4	Medical Consumables & Devices	First aid kits, AEDs, and sanitation products for health and safety.
5	Laboratory Supplies & Equipment	Analytical tools and testing equipment for battery research and quality checks.
6	General Services & Miscellaneous	Maintenance supplies for facility management, including HVAC and electrical components.
7	Miscellaneous Tools	Maintenance and assembly tools, along with office equipment for administrative tasks.
8	Office Supplies	Daily operational supplies like writing materials and organizational tools.
9	Office Furniture	Ergonomic furniture for productive workspaces.

Appendix #23 Binergy's Project Communication Matrix

Item	Communication	Description	Format	Attendants	Method	Frequency
1	Meeting Agendas	Lists meeting objectives and expectations	Email	Project Manager	Formal Written	Weekly
2	Weekly Meetings	Project status and task discussions	Meeting	Key Stakeholders	Formal Verbal	Weekly
3	Weekly Overall Project Progress Report	Brief project status summary with milestones	Email	Project Manager	Formal Written	Weekly
4	Meeting Minutes	Summarizes meeting key points and actions	Email	Project Manager	Formal Written	Immediate, post-meeting
5	Monthly Meetings	Monthly project review and updates	Meeting	Sponsors + Stakeholders	Formal Verbal	Monthly
6	Weekly Departmental Progress Reports	Department-specific progress updates	Email	Dept. Managers	Formal Written	Weekly
7	Kick-Off Meeting	Initial project alignment	Meeting	Sponsors + Stakeholders	Formal Verbal	As per Schedule
8	Handover Meeting	Transfers responsibilities to new process owners	Meeting	Sponsors + Stakeholders	Formal Verbal	As per Schedule
9	Close Out Meeting	Final review, lessons learned, and handover	Meeting	Sponsors + Stakeholders	Formal Verbal	As per Schedule
10	Ad-Hoc Meeting	Unplanned, topic-specific discussions	Meeting	To be confirmed	Formal Verbal	As required

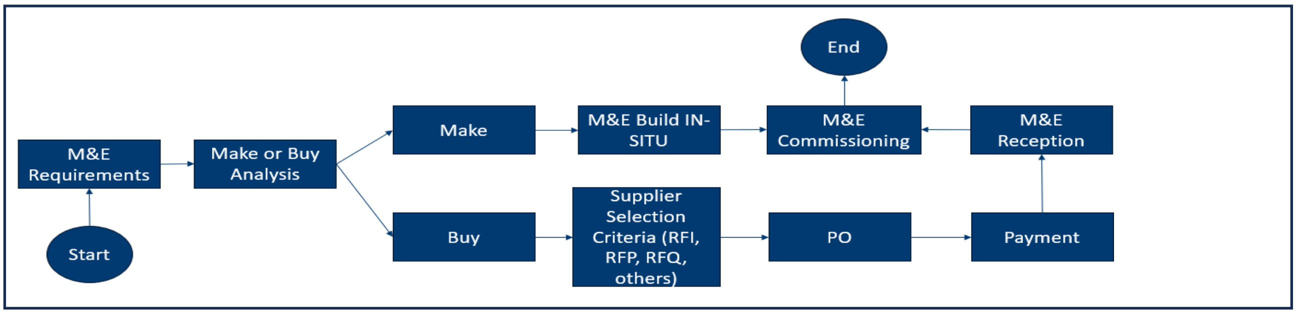
See Appendix #24. Binergy's Project Stakeholders Matrix.



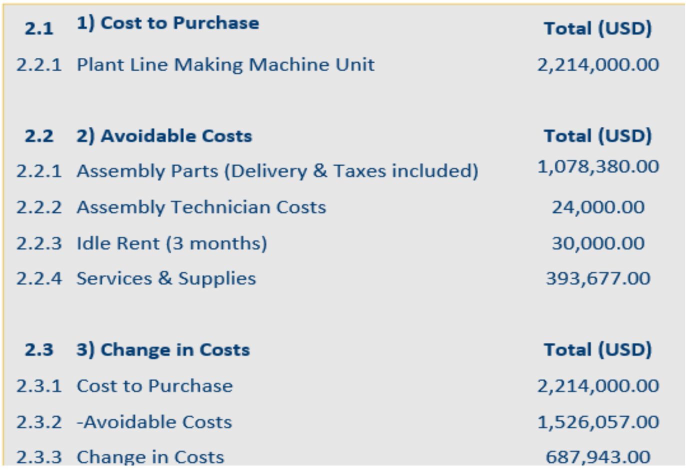
Item	Key Stakeholder I = Internal E=External	Title	Organization	Role	Communication Method
1	I	Chief Executive Officer (CEO)	Binergy	Overall project oversight and strategic direction.	Regular meetings & reports
2	I	Chief Operating Officer (COO)	Binergy	Operational execution and management of project resources.	Weekly meetings
3	I	Chief Financial Officer (CFO)	Binergy	Financial oversight, budget management, and funding strategies.	Monthly finance meetings
4	I	Chief Technology Officer (CTO)	Binergy	Drives technology strategy and product development.	Project updates & technical reviews
5	I	Chief Commercial Officer (CCO)	Binergy	Focus on market strategies and revenue generation.	Strategic planning sessions
6	I	Project Manager	Binergy	Manages project execution, timelines, and team coordination.	Daily stand-ups
7	I	R&D Manager	Binergy	Oversees research and development efforts related to the battery technology.	Bi-weekly project reviews
8	I	Battery Scientist/Engineer	Binergy	Develops and tests battery materials and designs.	Regular updates & team meetings
9	I	Lab Technician	Binergy	Conducts experiments and tests on battery prototypes.	Daily interactions
10	I	Production & Supply Chain Manager	Binergy	Manages production operations and supply chain logistics.	Weekly production meetings
11	I	Production & Supply Chain Specialist	Binergy	Supports supply chain management and process improvements.	Regular check-ins
12	I	Maintenance Technician	Binergy	Ensures maintenance of production equipment.	As needed
13	I	Quality Manager	Binergy	Oversees quality assurance and control processes.	Monthly quality reviews
14	I	Quality Specialist	Binergy	Supports quality assurance activities and compliance checks.	Regular updates
15	I	Finance & Administration Analyst	Binergy	Assists in financial analysis, budgeting, and administration.	Monthly financial reports
16	I	Marketing/Sales Manager	Binergy	Develops marketing strategies for the battery product.	Monthly strategy sessions
17	I	Marketing/Sales Analyst	Binergy	Conducts market research and analysis to support marketing efforts.	Weekly updates
18	I	HR Manager	Binergy	Manages hiring, staffing, and employee relations.	Regular HR meetings
19	I	HR Specialist	Binergy	Supports HR functions and employee engagement initiatives.	As needed
20	I	Legal & Strategic Partnerships Manager	Binergy	Manages legal contracts and strategic partnerships.	Regular strategy sessions
21	I	Legal & Strategic Partnerships Analyst	Binergy	Assists in legal and partnership assessments.	As needed
22	I	IT & Technology Specialist	Binergy	Provides IT support and technological solutions for project operations.	Daily check-ins
23	E	Suppliers	TBC	Provide materials for battery production.	Regular meetings
24	E	Research Institutions	TBC	Collaborate on research and development of solid-state battery technologies.	Joint meetings and reports
25	E	Regulatory Bodies	TBC	Ensure project compliance with safety and environmental standards.	Initial consultations & updates
26	E	Financial Bodies	TBC	Provide funding through various means such as VC, grants, and strategic partnerships.	Pitch presentations & reports

Appendix #25. Binergy's Procurement Strategies.

Binergy's Procurement Process Summary



Make or Buy Analysis



2.1	**1) Cost to Purchase**	**Total (USD)**
2.2.1	Plant Line Making Machine Unit	2,214,000.00
2.2	**2) Avoidable Costs**	**Total (USD)**
2.2.1	Assembly Parts (Delivery & Taxes included)	1,078,380.00
2.2.2	Assembly Technician Costs	24,000.00
2.2.3	Idle Rent (3 months)	30,000.00
2.2.4	Services & Supplies	393,677.00
2.3	**3) Change in Costs**	**Total (USD)**
2.3.1	Cost to Purchase	2,214,000.00
2.3.2	-Avoidable Costs	1,526,057.00
2.3.3	Change in Costs	687,943.00

Supplier's Selection Criteria for the Solid Battery Machine

Item: Solid State Cell Production Plant Line Making Machine

Supplier Selected: Dongguan Gelon Lib Co., Ltd

Picture of the equipment:

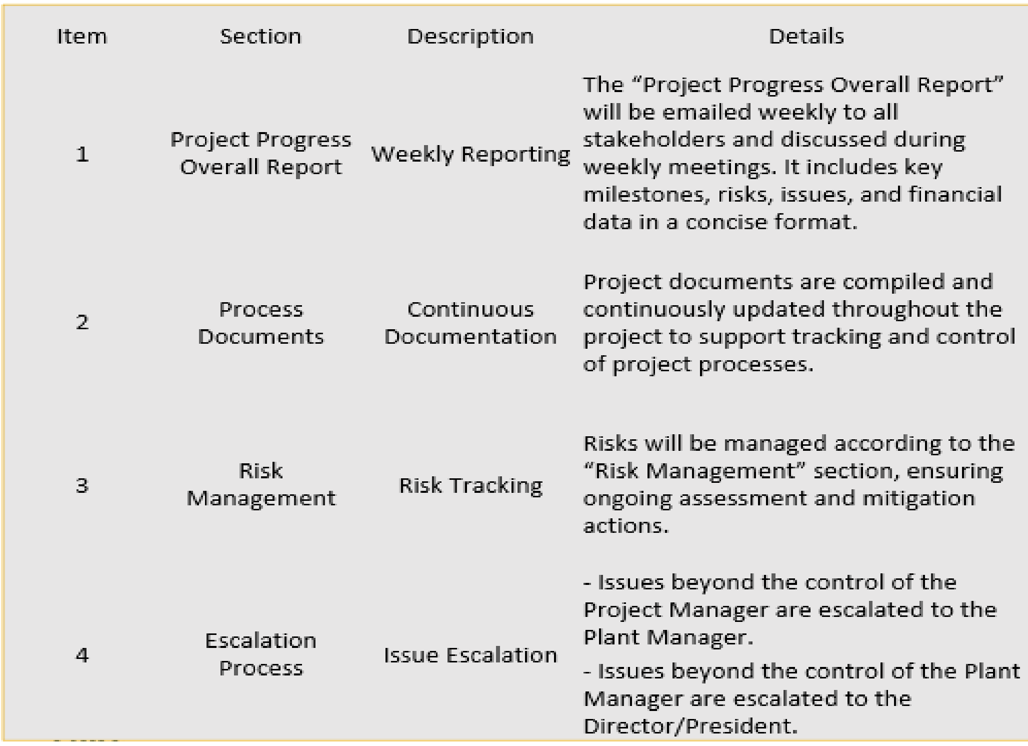
Item	**Criteria**	**Results**
1	Price Evaluation	Competitive pricing compared to other suppliers.
2	Value for Money	High-quality components and materials provided at a reasonable price.
3	Quality Assessment	The supplier's products meet or exceed industry standards. They have a robust quality control system in place to ensure consistency.
4	Reliability	Proven track record of on-time delivery and consistent performance. Supplier has a history of long-term reliability and strong customer satisfaction.
5	Responsiveness	Quick response to inquiries, technical support, and problem resolution. Demonstrates a willingness to adapt to changing project needs.
6	Flexibility	Ability to accommodate special requests or modifications, offering customizable solutions. Supplier is open to negotiation and adjusting terms to fit project requirements.

Appendix #26. QA and QC actions across different phases of the project.

Item	Phase/Activity	Quality Assurance (QAP) Actions	Quality Control (QCP) Actions
1	Preliminary R&D	Ensure technical feasibility and R&D adherence to standards.	Conduct technical inspections of R&D progress.
2		Monitor and document all R&D activities.	Validate raw materials and lab processes.
3	Administrative Operations Readiness	Oversee compliance with legal and operational requirements.	Verify legal entity establishment.
4		Document setup processes and ensure regulatory adherence.	Inspect office equipment and utilities installations.
5	Intellectual Property Management	Ensure thoroughness of IP strategies and compliance with regulations.	Review patent searches and protection strategies.
6		Document all IP activities and partnerships.	Verify compliance with legal agreements.
7	Integration & Manufacturing Trials	Monitor manufacturing processes for adherence to quality standards.	Inspect manufacturing equipment and materials.
8		Document and assess trial results.	Conduct performance and reliability testing.
9	Financial Planning	Ensure accurate financial planning and alignment with project goals.	Review financial documents and grant applications.
10		Document all financial transactions and audits.	Monitor budget against planned allocations.
11	Market & Sales Entry & Expansion	Ensure market strategies align with quality and project goals.	Evaluate sales channel development.
12		Document sales and market expansion plans.	Review distribution network expansion plans.
13	Regulatory Compliance	Oversee adherence to all regulatory requirements and standards.	Audit regulatory efforts and certifications.
14		Maintain records of compliance and certifications.	Verify compliance with safety and environmental standards.
15	Safety & Sustainability Assurance	Ensure implementation of safety and sustainability protocols.	Inspect safety equipment and protocols.
16		Document safety training and equipment procurement.	Conduct audits of sustainability practices.
17	Sustainability Practices	Monitor sustainable sourcing and environmental impact assessments.	Monitor sustainable material sourcing.
18		Document all sustainability efforts.	Audit energy-efficient practices and waste management.
19	Commercialization	Ensure readiness for market entry and cost competitiveness.	Review supply chain investments.
20		Document all commercialization efforts.	Ensure cost competitiveness is achieved.
21	Production Preparation	Oversee training programs and production trials.	Validate training program implementation.
22		Document all production preparation activities.	Review production trial results and readiness.

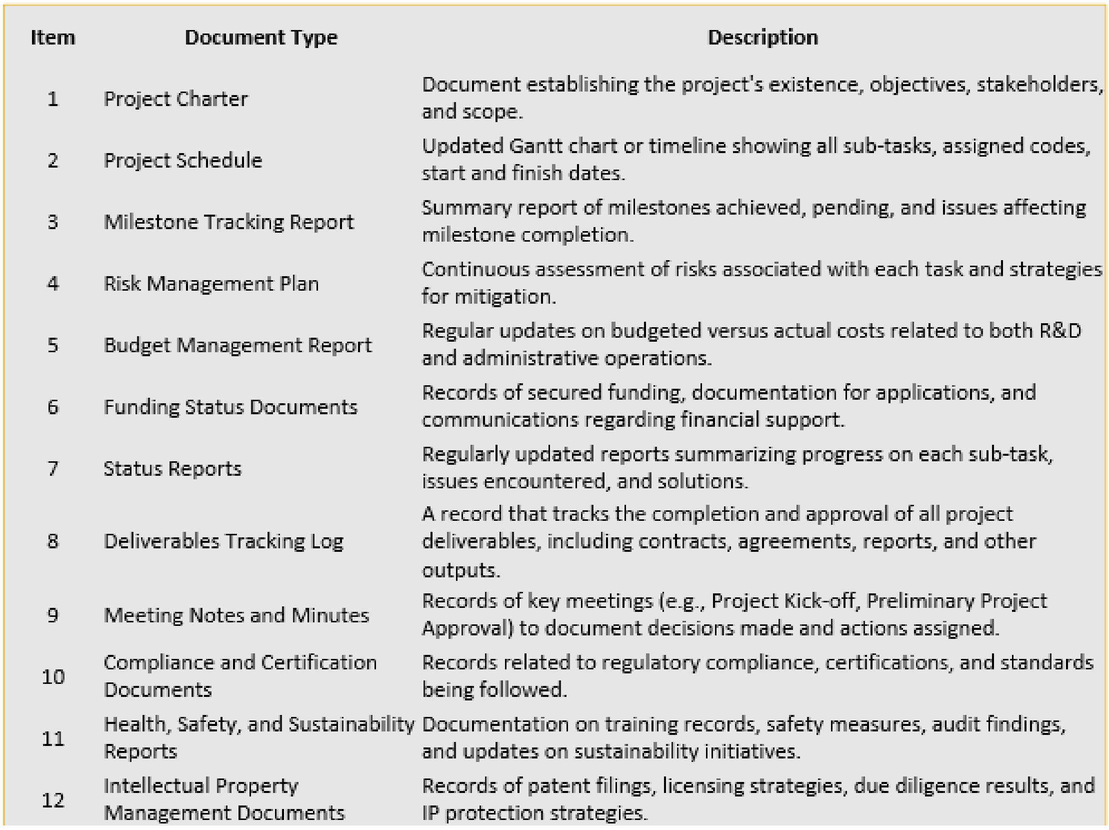
Appendix #27. Project Tracking, Control Procedures & Documents.

Control Procedures:



Item	Section	Description	Details
1	Project Progress Overall Report	Weekly Reporting	The “Project Progress Overall Report” will be emailed weekly to all stakeholders and discussed during weekly meetings. It includes key milestones, risks, issues, and financial data in a concise format.
2	Process Documents	Continuous Documentation	Project documents are compiled and continuously updated throughout the project to support tracking and control of project processes.
3	Risk Management	Risk Tracking	Risks will be managed according to the “Risk Management” section, ensuring ongoing assessment and mitigation actions.
4	Escalation Process	Issue Escalation	- Issues beyond the control of the Project Manager are escalated to the Plant Manager. - Issues beyond the control of the Plant Manager are escalated to the Director/President.

Control Documents:

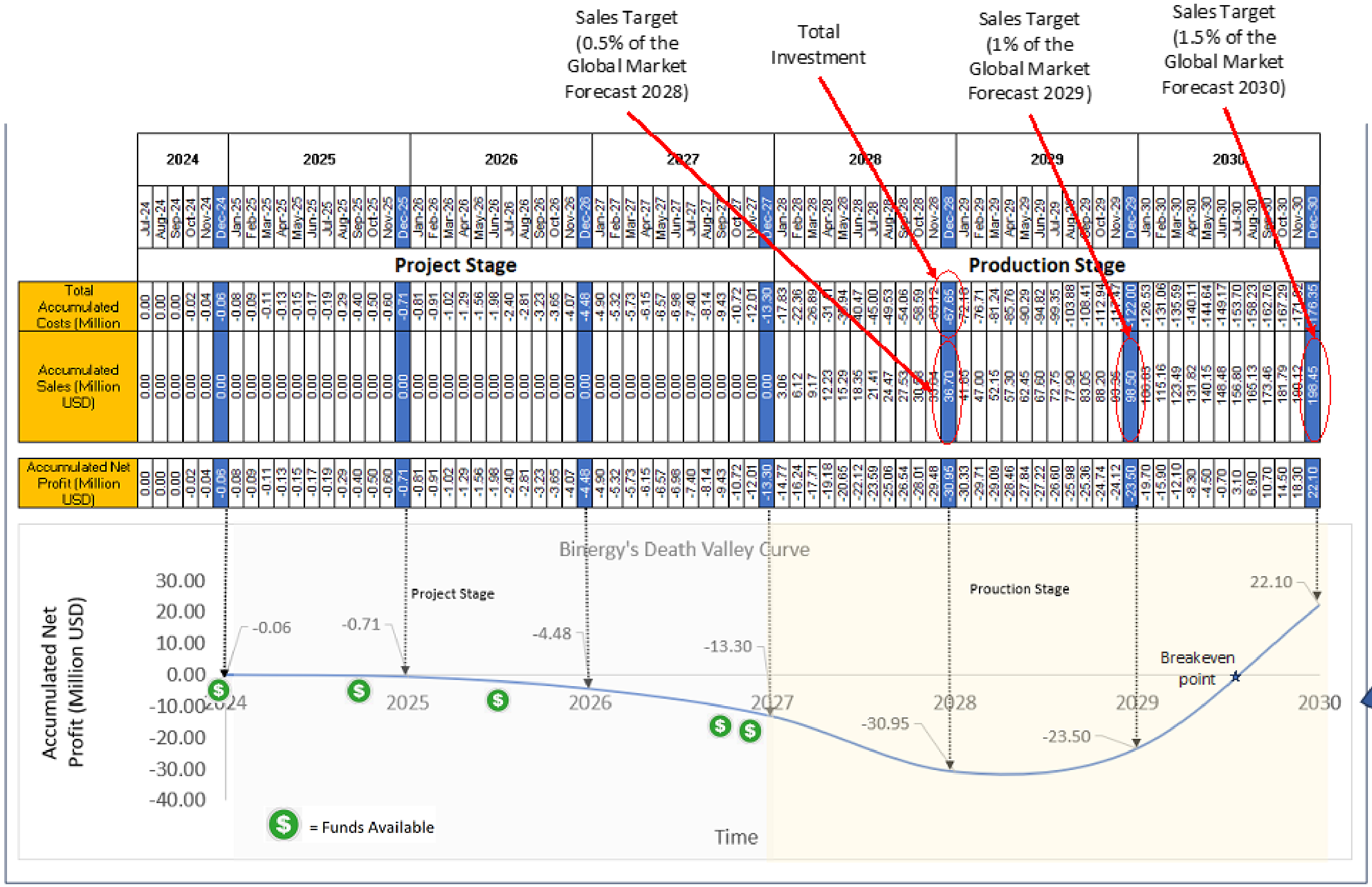


Item	**Document Type**	**Description**
1	Project Charter	Document establishing the project's existence, objectives, stakeholders, and scope.
2	Project Schedule	Updated Gantt chart or timeline showing all sub-tasks, assigned codes, start and finish dates.
3	Milestone Tracking Report	Summary report of milestones achieved, pending, and issues affecting milestone completion.
4	Risk Management Plan	Continuous assessment of risks associated with each task and strategies for mitigation.
5	Budget Management Report	Regular updates on budgeted versus actual costs related to both R&D and administrative operations.
6	Funding Status Documents	Records of secured funding, documentation for applications, and communications regarding financial support.
7	Status Reports	Regularly updated reports summarizing progress on each sub-task, issues encountered, and solutions.
8	Deliverables Tracking Log	A record that tracks the completion and approval of all project deliverables, including contracts, agreements, reports, and other outputs.
9	Meeting Notes and Minutes	Records of key meetings (e.g., Project Kick-off, Preliminary Project Approval) to document decisions made and actions assigned.
10	Compliance and Certification Documents	Records related to regulatory compliance, certifications, and standards being followed.
11	Health, Safety, and Sustainability Reports	Documentation on training records, safety measures, audit findings, and updates on sustainability initiatives.
12	Intellectual Property Management Documents	Records of patent filings, licensing strategies, due diligence results, and IP protection strategies.

Appendix #28. Costs Estimation per category in an Annual Basis

Cost Category	Description	Estimated Costs	Source
Technical Costs	R&D for electrolyte processing, material sourcing, and production scaling.	$10 million - $50 million annually	QuantumScape Investor Presentation BloombergNEF Report [63], [64], [65]
Sustainability Costs	Implementation of ESG measures and adoption of sustainable technologies in production.	$1 million - $5 million annually	McKinsey Report [66]
Regulatory Costs	Compliance with regulations like PSU reclamation and information security standards.	$500,000 - $2 million annually	Deloitte [67], [68]
Financial Costs	Solid-state battery production costs, which are at least double that of lithium-ion batteries.	$400,000 - $800,000 per MWh	BloombergNEF [69]
Commercialization Costs	Securing partnerships, developing supply chains, and marketing efforts.	$5 million - $15 million annually	IEA Reports PNNL [70], [71], [72]
Market Entry Costs	Costs related to production, OEM approval, and scaling manufacturing.	$3 million - $10 million annually	McKinsey Battery Reports [73], [74]
Intellectual Property (IP) Costs	Managing patents, legal fees, and IP protection strategies.	$100,000 - $500,000 annually	WIPO [75], [76]
Safety Costs	Safety testing, thermal management, and compliance with safety regulations.	$100,000 - $500,000 annually	NASA Deloitte [77], [78]
Workforce-Related Costs	Developing a skilled workforce, training, and continuous education.	$1 million - $5 million annually	BNEF Report [79]

Appendix #29. Death Valey Curve & Financials



2024	Jul-24	Aug-24	Sep-24	Oct-24	Nov-24	Dec-24
Total Accumulated Costs (Million	0.00	0.00	0.00	-0.02	-0.04	-0.06
Accumulated Sales (Million USD)	0.00	0.00	0.00	0.00	0.00	0.00
Accumulated Net Profit (Million USD)	0.00	0.00	0.00	-0.02	-0.04	-0.06

2025	Jan-25	Feb-25	Mar-25	Apr-25	May-25	Jun-25	Jul-25	Aug-25	Sep-25	Oct-25	Nov-25	Dec-25
Total Accumulated Costs (Million	-0.08	-0.09	-0.11	-0.13	-0.15	-0.17	-0.19	-0.29	-0.40	-0.50	-0.60	-0.71
Accumulated Sales (Million USD)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Accumulated Net Profit (Million USD)	-0.08	-0.09	-0.11	-0.13	-0.15	-0.17	-0.19	-0.29	-0.40	-0.50	-0.60	-0.71

2026	Jan-26	Feb-26	Mar-26	Apr-26	May-26	Jun-26	Jul-26	Aug-26	Sep-26	Oct-26	Nov-26	Dec-26
Total Accumulated Costs (Million	-0.81	-0.91	-1.02	-1.29	-1.56	-1.98	-2.40	-2.81	-3.23	-3.65	-4.07	-4.48
Accumulated Sales (Million USD)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Accumulated Net Profit (Million USD)	-0.81	-0.91	-1.02	-1.29	-1.56	-1.98	-2.40	-2.81	-3.23	-3.65	-4.07	-4.48

2027	Jan-27	Feb-27	Mar-27	Apr-27	May-27	Jun-27	Jul-27	Aug-27	Sep-27	Oct-27	Nov-27	Dec-27
Total Accumulated Costs (Million	-4.90	-5.32	-5.73	-6.15	-6.57	-6.98	-7.40	-8.14	-9.43	-10.72	-12.01	-13.30
Accumulated Sales (Million USD)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Accumulated Net Profit (Million USD)	-4.90	-5.32	-5.73	-6.15	-6.57	-6.98	-7.40	-8.14	-9.43	-10.72	-12.01	-13.30

2028	Jan-28	Feb-28	Mar-28	Apr-28	May-28	Jun-28	Jul-28	Aug-28	Sep-28	Oct-28	Nov-28	Dec-28
Total Accumulated Costs (Million	-17.83	-22.36	-26.89	-31.41	-35.94	-40.47	-45.00	-49.53	-54.06	-58.59	-63.12	-67.65
Accumulated Sales (Million USD)	3.06	6.12	9.17	12.23	15.29	18.35	21.41	24.47	27.53	30.58	33.64	36.70
Accumulated Net Profit (Million USD)	-14.77	-16.24	-17.71	-19.18	-20.65	-22.12	-23.59	-25.06	-26.54	-28.01	-29.48	-30.95

2029	Jan-29	Feb-29	Mar-29	Apr-29	May-29	Jun-29	Jul-29	Aug-29	Sep-29	Oct-29	Nov-29	Dec-29
Total Accumulated Costs (Million	-72.18	-76.71	-81.24	-85.76	-90.29	-94.82	-99.35	-103.88	-108.41	-112.94	-117.47	-122.00
Accumulated Sales (Million USD)	41.85	47.00	52.15	57.30	62.45	67.60	72.75	77.90	83.05	88.20	93.35	98.50
Accumulated Net Profit (Million USD)	-30.33	-29.71	-29.09	-28.46	-27.84	-27.22	-26.60	-25.98	-25.36	-24.74	-24.12	-23.50

2030	Jan-30	Feb-30	Mar-30	Apr-30	May-30	Jun-30	Jul-30	Aug-30	Sep-30	Oct-30	Nov-30	Dec-30
Total Accumulated Costs (Million	-126.53	-131.06	-135.59	-140.11	-144.64	-149.17	-153.70	-158.23	-162.76	-167.29	-171.82	-176.35
Accumulated Sales (Million USD)	106.83	115.16	123.49	131.82	140.15	148.48	156.80	165.13	173.46	181.79	190.12	198.45
Accumulated Net Profit (Million USD)	-19.70	-15.90	-12.10	-8.30	-4.50	-0.70	3.10	6.90	10.70	14.50	18.30	22.10

$$\mathrm{ROI} = \frac{\text{Current Value of Investment} - \text{Cost of Investment}}{\text{Cost of Investment}}$$

Year	Current Value of Investment	Cost of Investment	ROI
2030	22.1	67.65	-0.67
2031	67.60	67.65	0.00
2032	113.20	67.65	0.67
2033	158.80	67.65	1.35
2034	204.40	67.65	2.02
2035	250.00	67.65	2.70