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Research on the Dilemma and Countermeasures of R&D Value Transformation of Energy Storage Battery

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Abstract

Driven by the "double carbon" goal, the scale of China's energy storage battery industry has expanded rapidly. However, while R&D investment continues to grow at a high rate, the industry's profit center has shifted downward, and the value conversion efficiency is generally low. Here, "value transformation efficiency" is defined as the extent to which the growth of R&D investment is converted into corresponding technical output, product premium and business performance, rather than the absolute level of gross margin. This paper takes three listed companies of EVE Energy Co., Ltd. (EVE), Nandu Power and Guangzhou Great Power Energy and Technology Co., Ltd. (Great Power) as the research objects. Based on the resource-based theory and innovation value chain theory, this paper constructs an analysis framework of "R&D investment-technical output-productization-commercialization-operating performance". Combined with the annual report of the enterprise and the public data of the industry, this paper analyzes the difficulties and causes of value transformation in the three links of front-end topic selection, mid-end engineering and back-end value capture, and puts forward the optimization path of segmented implementation. Based on the case evidence of the three selected enterprises, the research shows that the transformation dilemma is a structural problem under the overcapacity and price downturn of the industry. It should be solved by optimizing the topic selection and transformation mechanism of enterprises, jointly building a pilot platform and unified standards in the industry, and the government's incentive from input to transformation efficiency, so as to provide reference for the high-quality development of the energy storage battery industry. Since the three cases were selected because they exhibit the dilemma, the findings are illustrative and should not be generalized to establish the prevalence of the problem across the whole industry.

Keywords

Energy Storage Battery, R&D Investment, Value Transformation, Innovation Value Chain, Optimize the Path

1. Introduction

Energy storage battery is the core cost and performance carrier of China's new energy storage system, and the speed of industrial expansion is amazing. According to the data released by CNESA DataLink, by the end of 2025, China's total installed capacity of electric energy storage was 213.3 GW, accounting for 43.0% of the total installed capacity in the world, with a year-on-year growth rate of 54%. Domestic enterprises have occupied the leading position in the global energy storage battery market (Yang, 2025). However, under the background of continuous expansion of the industry scale, the profit space continues to narrow. Zeng Yuqun, chairman of CATL, said at the 2025 World Energy Storage Conference that the price of energy storage system has fallen by nearly 80% in the past three years, and the quotation of some projects has fallen below the cost line of 0.4 yuan/Wh (Yao, 2025).

From the perspective of business data, R&D investment has increased year by year, product prices and gross profit centers have continued to move down, and the transformation of R&D results into business performance has not been sufficient, which has become a common problem in the industry. Several representative enterprises, such as EVE, will reduce the gross profit rate of energy storage batteries from 17.03% to 12.28% from 2023 to 2025. The R&D investment of Nandu Power Energy Storage related business in 2025 will increase by about 20 million yuan compared with that in 2023, and the gross profit rate will decrease from 19.19% to 12.86%, among which the gross profit rate will decrease significantly in 2024. From 2022 to 2024, the gross profit margin of lithium-ion batteries of Great Power decreased from 18.03% to 11.40%, pointing to the same kind of contradiction: the scale of R&D investment is expanding, but the technological achievements have not been transformed into higher product premium and profit (see **Table 1**). It should be emphasized that the transformation of R&D investment to profit itself has obvious lag and nonlinearity, rather than the former leading to the latter's causality: both are driven by stage overcapacity, low price competition and product price downturn. Therefore, the focus of this paper is not "whether R&D leads to a decline in profits", but under the common constraints of the industry, why the growth of R&D investment intensity of energy storage battery enterprises is difficult to be smoothly transformed into the corresponding technology premium and business performance?

In this paper, "value transformation efficiency" is defined as whether and to what extent the growth of R&D investment can be converted into technical output (patents, core technologies), productization (mass production of differentiated

products) and commercialization (customer acceptance, market premium and business performance), that is, the relative conversion relationship between R&D input and value output. Its observable evidence mainly includes three groups of indicators: the output-side indicators such as R&D intensity and R&D personnel, which reflect whether R&D forms technical assets; the engineering-side indicators such as pilot scale, mass-production yield and achievement conversion rate, which reflect whether technical achievements fall to products; and the value-side indicators such as segment gross margin, technology premium and overseas high-margin revenue share, which reflect whether products are paid a reasonable premium by the market. It should be emphasized that value transformation efficiency is different from the absolute decline of gross margin. As shown by the data of the three companies in Table 1, the decline of gross margin is mainly driven by the overcapacity and price downturn of the whole industry, and is also affected by the business mix, customer mix and disclosure caliber of each enterprise. Therefore, the decline of gross margin alone cannot be regarded as evidence of low value transformation efficiency; the latter emphasizes whether, under the same price downturn constraint, the enterprise that increases R&D investment can obtain a technology premium and performance compensation higher than the industry average. The following analysis evaluates this efficiency along the innovation value chain.

Table 1. Representative energy storage battery enterprise R&D investment and related business gross profit margin index (2022-2025).

particular year	EVE		Nandu Power		Great Power	
	R&D investment (billion yuan)	Gross profit margin (%)	R&D investment (billion yuan)	Gross profit margin (%)	R&D investment (billion yuan)	Gross profit margin (%)
2022	22.61	-	3.64	17.72	4.45	18.03
2023	28.71	17.03	4.77	19.19	3.80	15.75
2024	30.60	14.72	4.50	7.28	3.97	11.40
2025	34.35	12.28	4.97	12.86	5.35	12.37

Data source: annual report of each company from 2022 to 2025. Caliber description: the disclosure caliber of the three enterprises is not consistent—EVE is the "energy storage battery" branch, Nandu Power is the "sub-industry · electric energy storage" branch, Great Power does not separately disclose the energy storage branch, and the annual report discloses the "lithium ion battery" caliber; R&D investment is taken from the annual report of each company, including expensed R&D expenditure and capitalized development expenditure. Due to the inconsistent caliber, the gross profit rate of the three companies should not be directly compared horizontally. This table is only used to reflect the overall trend of the profitability of each company's related business during the price downward period.

From the perspective of practical significance, the energy storage battery industry is in a critical stage of transformation from "scale and capacity" to "technology and quality". Clarifying the value of R&D investment will help enterprises to use R&D in a direction suitable for their own development. From the theoretical point of view, the existing research on the relationship between R&D investment and enterprise performance is mostly a large sample measurement test. The conclusions are obviously different due to different industries, periods and methods. The

special analysis of the energy storage battery, a technology-intensive and B2 B attribute emerging intermediate product field, is relatively insufficient. This paper does not repeat the measurement verification, but takes the innovation value chain as the clue, and combines the public data of the enterprise to make a qualitative analysis of the value transformation.

2. Theoretical Basis and Analytical Framework

2.1. Theoretical Basis

The resource-based theory emphasizes that heterogeneous resources are the source of enterprises to build sustainable competitive advantages (Barney, 1991). When valuable, scarce, difficult to imitate and organized resources are satisfied, they can bring excess returns. R&D investment itself is not a competitive advantage. Only by transforming into technical assets that meet the above conditions can continuous performance returns be generated. This view suggests that the key to evaluating R&D is not how much is invested, but whether the investment has formed a technical capability that is difficult to replicate.

The innovation value chain theory further regards innovation as a cohesive chain. Hansen and Birkinshaw divided the innovation process into three stages: idea generation, idea transformation and idea diffusion, and pointed out that the weakness of any link will restrict the final effect of innovation (Hansen & Birkinshaw, 2007). When introducing this perspective, domestic scholars also emphasize that knowledge acquisition, knowledge transformation and knowledge utilization need to be coordinated (Lyu et al., 2020). Combining the two, whether the R&D investment of energy storage battery enterprises can be transformed into performance depends not only on whether the internal organization can integrate the dispersed elements into organized and supported technical assets, but also on whether the R&D results can be successfully marketized and finally recognized and paid by customers.

2.2. Value Transformation Analysis Framework

This paper establishes a value transformation chain analysis framework of "R&D investment → technical output → productization → commercialization → business performance". R&D investment forms technical output through research activities, realizes productization through pilot test and engineering, completes commercialization through customer certification and bidding, and finally realizes business performance. Along this chain, three types of internal leakage may occur in the transformation: the leakage of the topic, that is, the mismatch between the R&D direction and the market demand; transformation leakage, that is, insufficient factor coordination and difficult mass production of results; value capture leakage, that is, technical advantages are difficult to convert into premiums. Factors such as product bulk commercialization, low-cost collection, and standard certification constitute external constraints in the value capture process. The specific performance and causes of the above leakage are analyzed below.

2.3. Sample Selection and Data Caliber Description

This paper selects three listed companies with energy storage battery as an important business as case samples: EVE, Nandu Power and Great Power. In order to clarify the relationship between the sampling object of "energy storage battery enterprise" and the data measurement caliber, Table 2 is the proportion of the operating income of the energy storage business of the three enterprises.

Document-analysis procedure. The qualitative findings in this paper are derived from a systematic document analysis of the public disclosures of the three selected companies and the industry. The procedure consists of three steps. First, case selection: listed companies for which energy storage battery is an important business and whose energy storage revenue and gross margin can be identified and verified from the annual reports are selected; BYD is excluded because it does not separately disclose the energy storage revenue and gross margin, and CATL is retained only as an external benchmark and boundary condition. Second, source selection: the main source is the annual reports of the three companies from 2022 to 2025, supplemented by the industry public data released by CNESA DataLink, patent databases and authoritative media reports; all figures cited in this paper come from these verifiable sources, and the caliber differences among the three companies are explicitly stated in Table 1 and Table 2. Third, evidence assignment: according to the type of content, the evidence is assigned to the three transformation stages of the innovation value chain—R&D direction, topic selection and technical layout disclosed in the annual reports and patents are assigned to the front-end stage (input → technical output); pilot, engineering and mass-production related disclosures and industry-university cooperation are assigned to the middle-end stage (technical achievements → productization); segment revenue and gross margin, customer certification, bidding and overseas business disclosures are assigned to the back-end stage (commercialization → business performance). This procedure clarifies how the qualitative analysis in Sections 3 and 4 is based on the verifiable public evidence.

Table 2. The proportion of energy storage business revenue of representative energy storage battery enterprises.

Company	2022	2023	2024	2025	Data sources
EVE	—	—	39.14%	39.76%	Annual Report 2024-2025 Sub-product Data
Nandu Power	—	50.39%	49.06%	74.90%	Annual Report 2023-2025
Great Power	54.00%	55.40%	58.40%	63.90%	Annual Report 2022-2025 Sub-product Data

Note: The annual report of EVE does not include the energy storage income from 2022 to 2023, so it is not listed; the text of Great Power's annual report does not list the energy storage income separately, and its proportion is based on the company's Hong Kong stock listing documents and related business calculations for reference. Nandu is the total caliber of the power energy storage + industrial energy storage division, including lithium and lead, which is not completely consistent with the other two calibers, only for trend reference.

From Table 2, it can be seen that the proportion of energy storage business in Nandu and Great Power has increased in recent years, almost becoming the main

business, but 2022-2024 is less than 60%; EVE storage business accounts for about 40%, which is roughly equivalent to the power and consumption business. The whole sample is not the absolute main business of energy storage in the whole region. The value output is given priority to the annual report disclosure of consistent sub-business indicators (such as the gross profit rate of EVE's "energy storage battery" and Nandu Power's "electric energy storage"), not replaced by a comprehensive gross profit rate to prevent other business pollution; because the annual report of R&D investment is not allocated according to the part, the company's merger caliber data is used to approximate the agent. Not included in the Contemporary Amperex Technology Co., Ltd. (CATL), BYD: BYD did not separately disclose energy storage income, gross profit margin, only the scale of shipment, do not meet the evidence can be verified; the energy storage revenue in the CATL accounts for about 15%, mainly driven by power. However, with the system scheme, scale and overseas customers, the price downward period still maintains more than 26% of the energy storage gross margin. It is a "benchmarking" case that successfully breaks through the common constraints of the industry. It is only used as an external control and boundary condition, not included in the dilemma case, and avoids vague conclusions.

It should be acknowledged that the three companies are selected because their public data clearly show the value transformation dilemma, i.e., R&D investment grows while the gross margin of related business declines. This outcome-based selection means that the findings of this paper can illustrate the existence and the internal mechanism of the dilemma, but cannot be used to infer the prevalence of the problem in the whole industry. The sample covers only three listed companies and is not randomly representative, so the conclusions of this paper should be understood as case-based and exploratory rather than as an industry-wide generalization.

3. The Realistic Representation of the Value Transformation Dilemma of R&D Investment in Energy Storage Battery Enterprises

3.1. Front-End Dilemma: The Transformation from R&D Investment to Technological Output Is Blocked

The dilemma is concentrated in the convergence of R&D direction and the lack of key core technologies. In recent years, a large number of enterprises have invested R&D resources in the process optimization and cost reduction of large-capacity lithium iron phosphate batteries such as 280Ah, 314Ah, 500Ah+, etc. (Yang, 2024). The track is crowded and the innovation direction is highly coincident. This kind of R&D mostly stays on the process fine-tuning of the existing material system, and the investment in the underlying technologies such as long cycle and intrinsic safety is too small. It is difficult to form a technical barrier that is difficult to replicate. The lack of key core technologies will directly weaken the support of technology to enterprise performance (Feng et al., 2025). The homogenization of

the front end makes the industry lack differentiation in the stage of technical output, and the lack of deep cultivation in the fine field has not formed a solid technical barrier, which lays a foundation for the difficulty of capturing the back-end value. The front-end convergence is consistent with the annual-report evidence of the three selected companies: from 2022 to 2025, their R&D intensity remained high or even increased (EVE around 6.2% → 5.6%, Nandu Power from 3.1% → 6.7%, Great Power around 4.4% → 4.9%), while the gross margin of their energy-storage related business declined significantly (**Table 1**). The continuous high R&D input accompanied by the decline of related business margin suggests that the incremental R&D resources did not form a differentiated technology premium. It should be noted that the annual reports of the three companies do not disclose the detailed breakdown of their R&D directions, so the claim that "enterprises crowd into the R&D of large-capacity batteries such as 280Ah, 314Ah and 500Ah+" is a proposed explanation inferred from the industry reports and product release information rather than a directly disclosed fact of the cases.

3.2. Middle-End Dilemma: The Transformation of Technological Achievements to Products and Markets Is Not Smooth

This dilemma mainly occurs in the process of engineering and achievement transformation. From laboratory prototypes to mass-produced products, energy storage batteries must cross the three levels of practical research, engineering development and large-scale demonstration. Each link faces yield, consistency and cost issues. The scheme with excellent performance verified in the laboratory may not be able to withstand the test of mass production. For example, some new negative electrode materials have outstanding performance in the electric test, but there are problems such as cracking in the engineering links such as rolling and pole piece preparation. The transformation of achievements is also subject to the lack of connection between data and platforms between enterprises and scientific research institutes. Although there are many patents in the field of energy storage, the applicants are concentrated in scientific research institutes and enterprises, and the proportion of cooperative patents between the two sides is low (Dong & Liu, 2024; Chen et al., 2024). For products such as energy storage batteries that require high consistency and reliability, the strength of pilot and mass production engineering capabilities largely determines whether R&D investment can fall from "technical paper" to "product physical". In terms of the case evidence, the annual reports of the three companies disclose their production capacity construction and pilot projects, but do not separately disclose the yield, consistency and mass-production conversion rate of each product line, so the specific middle-end leakage of the three companies cannot be verified directly. The claims about "yield and consistency difficulties in mass production" and "the low proportion of cooperative patents between enterprises and scientific research institutes" are mainly based on the existing literature and industry practice, and are proposed explanations here, to be verified by further factory-level data in the future.

3.3. Back-End Dilemma: The Transformation from Business Value to Business Performance Is Limited

This dilemma means that it is difficult for technical achievements to be realized in the market as corresponding business performance. Energy storage battery is a typical B2 B intermediate product. Downstream customers are mainly system integrators, OEMs and large energy power companies. Products entering the customer supply chain need to go through multiple links such as sample delivery, testing, certification, and fixed-point. The cycle is often months or even years. In the domestic large-scale energy storage power station project, the bidding and procurement is mainly based on the "lowest bid" for a long time. The long-term performance value of the battery, such as long cycle life and intrinsic safety, is difficult to be identified and paid separately in the procurement price, which makes it difficult for enterprises to obtain a corresponding premium in the current period even if they have invested in the underlying technology. In the typical enterprises listed in Table 1, the increase of R&D investment and the weakening of profit efficiency appear at the same time. However, as mentioned above, this is mainly related to the overcapacity of the industry and the downward effect of prices. Overlay R&D returns lag, cost pressure and other factors, can not be directly interpreted as R&D investment led to a decline in profitability; previous studies have pointed out that there is a nonlinear threshold relationship between R&D investment and enterprise performance, and the marginal revenue may decrease after crossing a certain inflection point, which provides a reference for understanding the common constraints of value transformation in the industry (Han & Dong, 2018). The back-end value capture of the three companies is directly reflected in their disclosed segment gross margin and performance: from 2023 to 2025, the energy-storage battery gross margin of EVE declined from 17.03% to 12.28%, the electric-energy-storage gross margin of Nandu Power declined from 19.19% to 12.86% (with a sharp drop to 7.28% in 2024 accompanied by a net loss of 1.497 billion yuan), and the lithium-ion battery gross margin of Great Power declined from 15.75% to 12.37%. These disclosures, which come from the annual reports of the companies, are the observable evidence of the difficulty of converting technology premium into current business performance.

On the whole, the value transformation dilemma of energy storage battery enterprises is segmented along the innovation value chain: the front-end R&D direction is convergent, the core technology is insufficient, the mid-end engineering and achievement transformation are not smooth, and the back-end technology premium is difficult to be realized. The three types of dilemmas are not isolated from each other, but the projection of the common contradiction of the overall low efficiency of value transformation in different links.

4. Analysis of the Causes of Value Transformation Dilemma

4.1. Internal Causes

The internal causes mainly act on the front-end and middle-end leakage. One is

the mismatch between R&D topics and market demand. Some enterprises are guided by technology hotspots or policy directions, rather than terminal demand and cost constraints, and R&D results are out of touch with the market. The second is the lack of resource allocation and factor coordination. R&D investment is often manifested in the same proportion expansion of funds, personnel and equipment. There is a lack of joint project approval and achievement transfer mechanism among departments. Materials, processes, systems and other links are separated from each other, and it is difficult to form a joint force. The third is the absence of pilot production and achievement transformation mechanism. The risk of engineering links is high, the cycle is long, and the willingness and incentive of enterprises to invest are insufficient. The fourth is the lack of coordination between the organization and the customer, the connection between research and production and marketing is not close enough, the joint development with the downstream is limited, and the research and development department does not have a deep understanding of the real working conditions of the power station and the customer's demands, which will also affect the pertinence and transformation efficiency of the technical achievements. From the annual-report evidence of the three companies, the number of R&D personnel continued to increase from 2022 to 2025 (EVE from 4192 to 6597, Nandu Power from 551 to 662, Great Power from 1385 to 1507), while the gross margin of their related business kept declining, suggesting that the incremental R&D resources did not directly translate into product premium. However, the annual reports do not disclose the internal allocation of resources among departments or the pilot mechanism of the companies, so the mechanisms of "lack of factor coordination" and "absence of pilot production mechanism" listed above are proposed explanations inferred from the organizational characteristics and industry practice, and need to be further verified by the internal data of the enterprises.

In addition, intellectual property disputes in the flow of talents are hidden obstacles to the transformation of R&D achievements. The core technical personnel of the energy storage industry flow frequently, and the dispute over the attribution of technical achievements directly affects the efficiency of R&D output. Typical disputes such as CATL and Xiamen Hithium Energy Storage Technology Co., Ltd. (HiTHIUM) dispute: Since 2023, CATL has sued many times, involving unfair competition and patent infringement. The core disputes are large-capacity energy storage battery technology and commercial secrets. HiTHIUM part of the equity and the founder's shareholding platform equity have been judicially frozen. Such disputes not only delay the industrialization of technology, but also expose the institutional defects of unclear attribution of technological achievements, which makes R&D output face legal risks.

4.2. External Causes

External causes mainly constrain the realization of back-end value. From the per-

spective of industry competition, the energy storage industry is in a period of rapid expansion (Lin, 2024). The expansion of production capacity and the homogenization of products have led to oversupply and downward prices. The price of energy storage system has fallen by about 80% in three years, and the gross profit center has generally moved down. In the first half of 2025, more than 30 small and medium-sized integrators withdrew from the market. The net interest rate of head enterprises generally fell below 3%, and the industry's "more installed, more loss". In terms of technology, large-capacity batteries lack a unified specification interface, the size has not yet been finalized, the differentiated design makes the integrator repeat the adaptation, and the industry falls into the "wait-and-see innovation" internal friction; overseas certification barriers are high, and high gross profit market entry depends on compliance and localization. Under the common constraints of enterprise differentiation, the head is still highly valued by system solutions, customers and overseas structures. In 2025, the overall gross profit rate of overseas business (including all business such as power battery and energy storage) in CATL is 31.44%, which is higher than the overall 24.00% in China; this is a sub-regional merger caliber, non-energy storage separate data, but overseas energy storage is an important pull for high overseas gross profit. For example, the single order gross profit rate of the Saudi Red Sea New City energy storage project is about 38%, indicating that the overseas energy storage technology premium is greater. The following overseas-margin evidence is descriptive and is used only to illustrate the possible value-capture space of overseas markets under the common price downturn of the industry, rather than to attribute the margin gap to a technology premium. In 2025, the overall gross profit rate of overseas business (including all business such as power battery and energy storage) in CATL is 31.44%, which is higher than the overall 24.00% in China. However, this is a consolidated regional caliber covering all businesses, not energy-storage specific data, and the gap may also be explained by the differences of business mix (power vs. storage), customer mix (such as the higher proportion of overseas customers and system solutions) and project characteristics, which cannot isolate the contribution of technology premium. For example, the single order gross profit rate of the Saudi Red Sea New City energy storage project is about 38%, but a single project estimate is affected by its specific scale, procurement rules and local conditions, and should be regarded as a descriptive example rather than evidence of a technology premium. From the perspective of system and policy, the lowest price of domestic bid evaluation is dominant, and it is difficult to identify the long-term performance value of payment; some support policies are arranged according to the scale of investment, or induce heavy investment and light transformation. These external conditions determine the extent to which the technological achievements market achieves a reasonable premium.

In summary, the internal causes mainly correspond to the front-end and middle-end leakage: the mismatch of topic selection deviates from the front-end R&D direction, and the lack of factor coordination and pilot mechanism makes the

transformation of middle-end achievements poor; the external causes mainly constrain the realization of the back-end value and determine whether the technological achievements can obtain a reasonable premium.

5. Optimize the Path of R&D Investment Value Transformation (Table 3)

Table 3. Value transformation dilemma, causes and optimization path correspondence.

transformation processes	dilemma representation	main causes	optimization path
Front end (input →technical output)	Direction convergence, lack of core technology	Mismatch between topic selection and demand, lack of original incentive	Optimize the quality of topic selection, organize joint research, and hierarchical technical layout
Mid-end (results → productization)	Poor engineering transformation, more samples and less mass production	Lack of pilot mechanism and insufficient factor coordination	Build a shared pilot platform, improve research, production and marketing coordination and incentives
Back-end (commercialization → business performance)	Difficult premium technology, corporate profit differentiation	Low-cost centralized mining, homogenization surplus, certification barriers	Reform comprehensive evaluation, enhance the ability of system solutions, and expand overseas
external environment	The common cost is high and the attribution of results is unclear.	The standards are not uniform, and the policy focuses on investment.	Improve standards and intellectual property rules, incentives from input to transformation

5.1. Front-End-Oriented: Improve the Quality of R&D Investment Direction

In view of the convergence of R&D direction and the lack of core technology, enterprises, as the main body of core responsibility, should optimize the selection of R&D topics, combine market demand with technological trends as the basis for project establishment, compress low-level repeated investment, build differentiated technological advantages based on hierarchical R&D layout, and head enterprises. Deeply cultivate cutting-edge next-generation energy storage technology, small and medium-sized enterprises focus on segmenting racetracks to avoid homogeneous competition. For example, EVE has planned to build a solid-state battery mass production base and layout a sodium-ion battery energy storage system. This diversified layout for the next generation of technology is worth learning from the industry. At the industry level, we should promote joint research on generic technology, build a R&D efficiency monitoring and benchmarking system, and guide enterprises to shift from "input" to "output." The testable indicators are the pressure drop of industry homogenization R&D investment, the increase of the proportion of original R&D, and the significant improvement of the overall R&D input-output efficiency.

For the three sample enterprises, differentiated R&D positioning is particularly necessary. EVE, with relatively sufficient R&D resources, can further advance next-generation battery engineering verification. Nandu Power needs to distin-

guish R&D resources between lead-carbon storage and lithium-ion storage to avoid scattered investment. Great Power, as a medium-sized manufacturer, can focus on segmented application scenarios instead of fully competing in large-capacity mainstream battery tracks.

5.2. Facing the Middle End: To Open up the Mechanism of Productization and Transformation of Achievements

Enterprises need to improve the research, production and marketing coordination mechanism and achievement transformation incentive system, strengthen the pilot, engineering and mass production capabilities, and open up the internal multi-sectoral R&D collaboration and data sharing link. The industry relies on the leading industry chain and scientific research institutions to build a public platform for sharing pilot and reliability testing, promote the standardization of pilot research and development platforms, build an industrial joint innovation mechanism, realize industry resource sharing and risk sharing, and reduce the threshold of small and medium-sized enterprise industrialization. For example, the national new energy storage innovation center uses the innovative operation mode of "company + alliance", integrates the leading shareholders of the industrial chain and hundreds of alliance units, builds a comprehensive pilot platform and empirical base, and provides a replicable platform model for the industry. The testable indicators are the improvement of the conversion rate of pilot and industrialization of industrial technical achievements, the improvement of the reuse rate of pilot resources, and the effective reduction of the overall cost of industrialization of achievements.

Constrained by capital scale, Nandu Power and Great Power cannot afford full-scale independent pilot lines for multiple new technical routes. Participating in industry-shared pilot platforms can help them reduce trial-and-error costs. For EVE, it is necessary to strengthen internal R&D-manufacturing-marketing information flow, so as to shorten the cycle from laboratory prototype to mass-produced energy-storage products.

5.3. For the Back-End: Enhance the Ability to Realize Commercial Value

Enterprises focus on the upgrading of system solution capabilities, deepen long-term strategic cooperation between upstream and downstream, rely on differentiated products and business models to avoid low-price involution, and actively expand overseas high-end markets and optimize the overall profit structure. The industry optimizes the procurement evaluation rules, establishes a full-cycle comprehensive evaluation system that takes into account cost, performance and safety, and enables high-quality technical performance to achieve a market premium. For example, EVE has established cooperation with overseas customers such as Australia's EVO Power and Roche Energy to start large-scale global delivery. The expansion of overseas markets will help improve the overall profit structure. The

testable indicators are that the industry's low-price disorderly competition situation has eased, the technology business premium capacity has increased, and the overall profit quality of the company and the proportion of overseas market revenue have steadily increased.

Among the samples, EVE has already started overseas delivery. Nandu Power and Great Power still rely heavily on domestic low-price bidding projects. Expanding compliant overseas markets and building complete system solution capacity will become important ways for the two enterprises to get rid of the pressure of domestic gross-margin compression.

5.4. External Environment Support

The industry and regulatory authorities should coordinate and unify the technical standards and interface specifications of energy storage batteries, rectify the industry's adaptation chaos, reduce the common operating costs, improve the definition rules of technical ownership in intellectual property protection and talent flow, and avoid the risk of industrial technical disputes. At the policy level, we should optimize the support orientation, promote the policy from "incentive input" to "incentive transformation," establish a normalized R&D efficiency monitoring mechanism, and implement classified support and fault-tolerant mechanism for cutting-edge technology research. The testable indicators are the continuous improvement of the industry standardization system, the continuous optimization of industrial innovation and development ecology, and the steady improvement of the overall innovation and comprehensive competitiveness of the industry. In 2025, the Ministry of Industry and Information Technology and other eight departments issued the "Action Plan for High-Quality Development of New Energy Storage Manufacturing Industry," and put forward the goal of significantly improving the innovation and comprehensive competitiveness of the new energy storage manufacturing industry by 2027, which provides policy guidance for the industry to shift from scale expansion to high-quality development (Ministry of Industry and Information Technology of the People's Republic of China et al., 2025).

6. Research Conclusion

Based on the case evidence of the three selected enterprises, the conclusions of this paper can be summarized into three points. First of all, for the three selected enterprises, the value transformation dilemma of energy storage battery enterprises is structurally significant. It leaks along the innovation value chain. The front-end, middle-end and back-end correspond to three types of problems: R&D direction, engineering transformation and value capture, respectively. It is not an accidental state of an enterprise. Given that the sample covers only three selected companies and is not randomly representative, this finding should be understood as case-based and illustrative rather than as evidence of the prevalence of the dilemma across the whole industry. Secondly, the dilemma is caused by internal and exter-

nal factors: the mismatch of R&D topics, the lack of factor coordination, the absence of pilot mechanism, the intellectual property disputes in the flow of talents and other internal factors make it difficult for R&D investment to land, and external constraints such as mass commercialization of products and low-cost collection make it difficult to realize technological achievements. At the same time, it should be noted that the correlation between the expansion of R&D investment and the weakening of current profit is mainly in the context of industry overcapacity and price downturn, and the R&D return is lagging behind, which should not be explained as the causal relationship between R&D and profit decline. Finally, the solution to the dilemma should be implemented in stages along the transformation chain: enterprises should optimize the topic selection and transformation mechanism, the industry should jointly build a pilot platform and unified standards, the government should shift the incentive orientation from input to output efficiency, and improve the system of intellectual property protection and achievement attribution in talent flow. In addition, the conclusions of this paper are subject to the following limitations: the small, outcome-based case sample cannot establish the industry-wide prevalence of the dilemma; the disclosure caliber of energy storage business is inconsistent among the three companies, and the company-wide R&D expenditure is used as a proxy for the segment R&D investment; and the profitable benchmark CATL is excluded from the dilemma cases and used only as a boundary condition. Future research can expand the sample and combine quantitative panel data to verify the mechanisms proposed in this paper.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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