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4R ENERGY

**2019 GLOBAL ELECTRIC BATTERY REUSE (2ND LIFE) AND RECYCLING
COMPETITIVE STRATEGY INNOVATION AND LEADERSHIP AWARD**

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Background and Company Performance

Industry Challenges

The reuse and recycling of spent electric vehicle batteries is expected to have a significant effect on the lithium-ion (Li-ion) battery industry by reducing manufacturers' reliance on the import of critical battery materials, such as lithium and cobalt, and by having a low impact on the environment. At the end of their life span, typically ranging between 8 to 10 years, electric vehicle Li-ion batteries are retired from automotive use, and their residual capacity is repurposed as energy storage services for residential and light commercial end users, utilities, and grid operators, a model that supports a circular economy. Also, electric vehicle battery reuse helps in reducing battery costs because it allows the reuse of metals that ensure battery functioning, which is less expensive than freshly mining and processing critical raw materials. Ultimately, reusing lithium-ion batteries can help in reducing CO2 emissions, protect natural resources, mitigate effects of climate change, and enable a circular economy.

Frost & Sullivan estimates the global electric vehicle reuse and recycling market at \$61.5 million as of 2018 and expects it to reach \$7809.1 million by 2025, recording a CAGR of 99.8%. Today, close to 4,500 end-of-life electric vehicle batteries have reached the market for reuse in second-life applications as against a few hundred five years ago. By 2025, it is expected that close to 500,000 batteries will reach the reuse market. Currently, reuse is the dominant segment in terms of revenue; however, with escalating metal prices, especially cobalt, and impending new legislative drivers such as the dedicated EU Directive for electric vehicle batteries recycling, which is expected to be announced in the next couple of years, the recycling market is expected to kick start with exponential growth from 2021 onwards.

One of the biggest challenges battery reuse and recycling companies face is the collection of used electric vehicle batteries from the market. Several automakers have forged a joint effort to collect and repurpose lithium-ion batteries from retired electric vehicles. In the current environment, recycling electric vehicle batteries is not cost effective because recycling technologies are still in the development stage. Additionally, owners of electric vehicles often consider refabricated batteries unsafe and not a viable option when compared to new car batteries. However, companies constantly iterate the fact that refabricated batteries are as safe as new ones and provide the same performance.

Early market participants are trying to keep a finger on the pulse of the customer and entrench themselves in this nascent, yet lucrative space with solid business models and differentiated products that provide the best possible solution for the price. Frost & Sullivan recognizes that companies must have great understanding of the local regulatory landscape and be able to identify the best products available to end users. Strong, viable business models and strategic partnerships are crucial for penetrating a market. Hence, rather than recycling the batteries that are not economically feasible, repurposing them in energy storage services for residential and light commercial end users, utilities, and grid operators will be a viable option in the present scenario. To support this initiative, many automobile companies have begun to enter into partnerships with battery manufacturers and

companies that prioritize second-life to develop a market for post-automotive Li-ion battery packs.

Strategy Innovation and Customer Impact

4R Energy Corporation was established in 2010 as a joint venture between Nissan and Sumitomo. The factory, located in the town Namie in Eastern Japan, is currently operated by 4R Energy Corporation. Over the years, 4R has gained valuable expertise in the field of battery refabrication and reuse through its extensive research and development process. In fact, the facility is the first in the world to provide exchangeable refabricated batteries for electric vehicles; it aims at reusing, reselling, refurbishing, and recycling electric vehicle batteries which will be used in large-scale storage systems and electric forklifts. Currently, 4R Energy Corporation repurposes only a few hundred batteries because the market is still in its nascent stage; however, the facility has a capacity to repurpose several thousands battery packs a year. Also, 4R Energy Corporation has adequate property to expand its unit once the market starts to receive volumes of end-of-life EV batteries.

Strategy Effectiveness

Ten years ago, 4R Energy Corporation was established primarily to create residual value from end-of-life electric vehicle batteries and to help in reducing carbon dioxide emissions. At the end of the 5-year-warranty period for Nissan LEAF batteries, customers reach out for getting their batteries replaced with refabricated ones rather than purchasing new batteries, which are thrice as expensive. Alternatively, battery pack modules with capacities over and above 80% are often utilized for the replacement of Nissan LEAF batteries. Modules with lesser capacities are repurposed and assembled for utilization in various second-life applications such as forklifts, golf carts, and streetlamps.

With the rise in electric vehicle adoption, more batteries are entering the company's reuse value chain, where these batteries are refabricated and returned to the automotive and sustainable energy markets.

Frost & Sullivan's electric vehicle battery reuse and recycling research identified that 4R Energy Corporation stands out as a trusted market participant propelled by innovation, a robust value, chain and clear vision of delivering a strategy to cost-effectively refabricate batteries to meet various end-user requirements.

Competitive Differentiation

4R Energy Corporation brings together decades of experience and the latest technology to deliver energy-saving and cost-efficient benefits for customers. New technology has been introduced by 4R to gauge battery pack and individual module performance at a quicker rate when compared to industry standards, giving it a chance to assess which components and subassemblies can be reused and which ought to be recycled. For instance, LEAF Nissan batteries are sent to the Namie factory where the modules are examined. Normal industrial ways to examine a battery's quality take up to 10 days; in contrast, with its new technology, 4R's facility in Japan can analyze Nissan LEAF battery packs (48 modules) in

only four hours; 4R is going to reduce such time though. Since a procedure that previously took 16 days, thereby, effectively reducing their operating hours. Parts with residual energy capacity can be reused and reassembled into “refabricated” battery packs that are often used as a low-cost replacement option for older electric vehicles.

4R Energy Corporation holds the advantage of being founded by Nissan. Nissan not only supports and backs 4R Energy Corp but also provides it with knowledge about how Nissan LEAF batteries are designed and developed. This insight gives 4R a firm understanding of the battery management system, which helps it to prepare the battery for reuse in a shorter time period than its competitors achieve. Moreover, other companies involved in refabricating batteries often face the challenge of lack of battery design specifics and info about the related battery chemistry, compensation for which consumes a lot of time and research.

4R Energy Corporation is the first organization worldwide to be certified to UL 1974, the Standard for Evaluation for Repurposing Batteries. UL describes its certification process this way: UL 1974 helps identify a battery’s state-of-health and introduces ratings to determine the viability for their continued use. Through this process, performance-validated ‘second-life’ batteries can be utilized for energy storage systems to provide a safe, reliable, clean energy source.”¹

The company’s approach to focus solely on battery reuse while being technology-agnostic has strongly increased trust amongst battery end users. Frost & Sullivan believes that this approach is proof of 4R Energy Corporation’s agility and ability to act fast, even though the company currently deals with fewer batteries when compared to that of its top competitors.

Price and Performance Value

The industry recognizes 4R Energy Corporation for setting a benchmark in delivering the highest quality products at the most competitive prices in Japan, where the company has refabricated LEAF batteries that are put to use in powering heavy equipment. Also, 4R Energy Corporation has partnered with Marubeni Corp for the development of the world’s first mass produced multi-super-fast EV charger in Namie.

Nissan is using the battery-refabrication facilities of 4R Energy Corp to offer refabricated batteries to replace old electric vehicles batteries for customers owning 100% electric Nissan LEAF. Currently, new battery packs cost about USD 6,200 for 24kWh; USD 7,600 for 30 kWh; and USD 7,800 for 40 kWh, but through the new program, 4R Energy Corporation can offer refabricated batteries at a significantly lower price, such as USD 2,850 for a 24kWh battery pack.

4R Energy Corporation has considered entering into partnerships with companies that help in retrieving reusable materials because it is hard for 4R to dismantle and recycle electric vehicle batteries on its own. In collaboration with Relectrify, for instance, 4R is developing second-life battery storage solutions. The products in development include repurposing used

¹ [UL press release, 2019](#)

batteries from Nissan LEAF and using Relectrify's battery and inverter control technology to allow 4R Energy to address significant opportunities in the storage market.

Frost & Sullivan asserts that 4R Energy Corporation has gone one notch higher than its competitors by contributing impressively to the electric vehicle battery value chain. The company strongly believes that it will be performing at a greater scale in the coming years with the rise in end-of-life batteries. Apart from its ability to perform better, 4R Energy Corporation has also made significant efforts to be sustainable, an initiative that will act as a best practice for other electric vehicle battery second-life companies to replicate.

Customer Purchase Experience

4R Energy Corporation is recognized for its in-depth knowledge of refabricating electric vehicle batteries. Its customers involve owners of Nissan LEAF cars, grid operators, as well as residential and commercial energy storage end users. Since 4R Energy Corp solely refabricates Nissan batteries and understands fully the battery specifics and design, it can offer the quality desired by end users, making the whole purchase experience much easier.

4R Energy Corporation's customer-centric approach and its reputation as a trusted partner of Nissan drive its growth excellence strategy. Frost & Sullivan finds that the company's reputation for service experience is unmatched in the industry. Having a presence in the business for over two years, the company has not received any complaints with regards to the refabricated batteries that have been installed in the Nissan LEAF vehicles. Additionally, the company provides a quality check report to customers who send their electric vehicle batteries to be treated. This system helps build customer trust concerning the viability of second-life batteries and will contribute to the future growth of energy storage systems.

Frost & Sullivan concludes that 4R Energy Corporation clearly understands customer pain points and has developed a comprehensive and responsive customer service unit that upholds its reputation of delivering an industry-leading service experience.

Brand Equity

The company is well-known in Japan and has gained a significant reputation there amongst its competitors for its operations and services. Due to its backing by Nissan, 4R Energy Corporation has the benefit of being a major pioneer of EV battery reuse business in Japan. The company is proud to mention that it was established a decade ago, thereby having the time advantage over other competitors who are just setting foot into the reuse and recycling business. Its facility was built after having invested significant time and money into the research and development process, despite the many challenges the company faced. 4R Energy proudly possesses an exceptional quality label in treating only Nissan's electric vehicle batteries where battery design specifics and other related information are available in a clear and concise manner.

In the future, 4R Energy Corporation has plans for international expansion, focusing on regions such as Europe, the United States, and Asia. The company's expansion plans will

involve a hub and spoke model, wherein partnering companies that have established facilities will provide 4R's technological processes to treat end-of-life EV batteries. Right now, the company is extremely focused on establishing a strong base in Japan.

The 4R Energy Corporation name is synonymous with innovation, reliability, and quality. Frost & Sullivan recognizes 4R Energy Corporation as the number-one brand in Japan in the electric vehicle reuse business. End users are aware of the brand mainly because of Nissan's automotive business and its ability to offer best-in-class battery reuse solutions.

Conclusion

4R Energy Corporation has established its brand prominence in the electric vehicle battery reuse market by delivering an innovative and cost-effective process to create an aftermarket for second-life electric vehicle batteries. The company's relentless dedication to addressing current and future customers' needs while delivering cost-competitive performance is commendable. 4R Energy Corporation is on the verge of international expansion that has the potential to alter the global approach to Li-ion battery recycling as well as to shape new commercial business models for the electric vehicle industry.

4R Energy Corporation demonstrates its social responsibility by reducing carbon dioxide emissions and by establishing residual value for its end-of-life electric vehicle batteries. Such initiatives equate the brand globally with environmental stewardship.

For its strong overall performance, 4R Energy Corporation has earned Frost & Sullivan's 2019 Competitive Strategy Innovation and Leadership Award in the electric vehicle battery reuse (2nd life) and recycling industry.

Significance of Competitive Strategy Innovation and Leadership

Any successful approach to achieving top-line growth must take into account what competitors are and are not doing; meet customer demand with a comprehensive, value-driven product or service portfolio; and establish a brand that resonates deeply with customers and stands apart from other providers. Companies must succeed in these 3 areas—brand, demand, and positioning—to achieve best-practice levels in competitive strategy.



Understanding Competitive Strategy Innovation and Leadership

Driving demand, brand strength, and competitive differentiation play critical roles in delivering unique value to customers. This three-fold focus, however, must ideally be complemented by an equally rigorous focus on Strategy Innovation and Customer Impact.

Key Benchmarking Criteria

For the Competitive Strategy Innovation and Leadership Award, Frost & Sullivan analysts independently evaluated Strategy Innovation and Customer Impact according to the criteria identified below.

Strategy Innovation

- Criterion 1: Strategy Effectiveness
- Criterion 2: Strategy Execution
- Criterion 3: Competitive Differentiation
- Criterion 4: Executive Team Alignment
- Criterion 5: Stakeholder Integration

Customer Impact

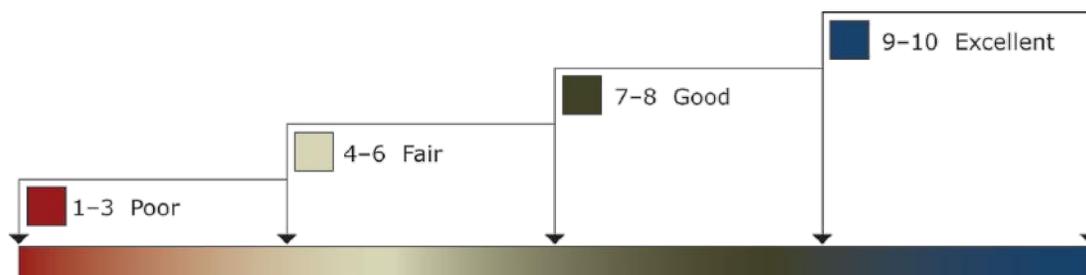
- Criterion 1: Price/Performance Value
- Criterion 2: Customer Purchase Experience
- Criterion 3: Customer Ownership Experience
- Criterion 4: Customer Service Experience
- Criterion 5: Brand Equity

Best Practices Award Analysis for 4R Energy Corporation

Decision Support Scorecard

To support its evaluation of best practices across multiple business performance categories, Frost & Sullivan employs a customized Decision Support Scorecard. This tool allows research and consulting teams to objectively analyze performance according to the key benchmarking criteria listed in the previous section, and to assign ratings on that basis. The tool follows a 10-point scale that allows for nuances in performance evaluation. Ratings guidelines are illustrated below.

RATINGS GUIDELINES



The Decision Support Scorecard considers Strategy Innovation and Customer Impact (i.e., the overarching categories for all 10 benchmarking criteria; the definitions for each criterion are provided beneath the scorecard). The research team confirms the veracity of this weighted scorecard through sensitivity analysis, which confirms that small changes to the ratings for a specific criterion do not lead to a significant change in the overall relative rankings of the companies.

The results of this analysis are shown below. To remain unbiased and to protect the interests of all organizations reviewed, Frost & Sullivan has chosen to refer to the other key participants as Competitor 1 and Competitor 2.

<i>Measurement of 1-10 (1 = poor; 10 = excellent)</i>			
Competitive Strategy Innovation and Leadership	Strategy Innovation	Customer Impact	Average Rating
4R Energy Corporation	10	9	9.5
Competitor 1	8	8	8
Competitor 2	7	8	7.5

Strategy Innovation

Criterion 1: Strategy Effectiveness

Requirement: Strategy effectively balances short-term performance needs with long-term aspirations and vision for the company.

Criterion 2: Strategy Execution

Requirement: Adoption of best-in-class processes supports the efficient and consistent implementation of business strategy.

Criterion 3: Competitive Differentiation

Requirement: Unique competitive advantages with regard to solution or product are clearly articulated and well accepted in the industry.

Criterion 4: Executive Team Alignment

Requirement: The executive team is aligned with the organization’s mission, vision, strategy, and execution.

Criterion 5: Stakeholder Integration

Requirement: Strategy reflects the needs or circumstances of all industry stakeholders, including competitors, customers, investors, and employees.

Customer Impact

Criterion 1: Price/Performance Value

Requirement: Products or services offer the best value for the price, compared to similar offerings in the market.

Criterion 2: Customer Purchase Experience

Requirement: Customers feel they are buying the optimal solution that addresses both their unique needs and their unique constraints.

Criterion 3: Customer Ownership Experience

Requirement: Customers are proud to own the company’s product or service and have a positive experience throughout the life of the product or service.

Criterion 4: Customer Service Experience

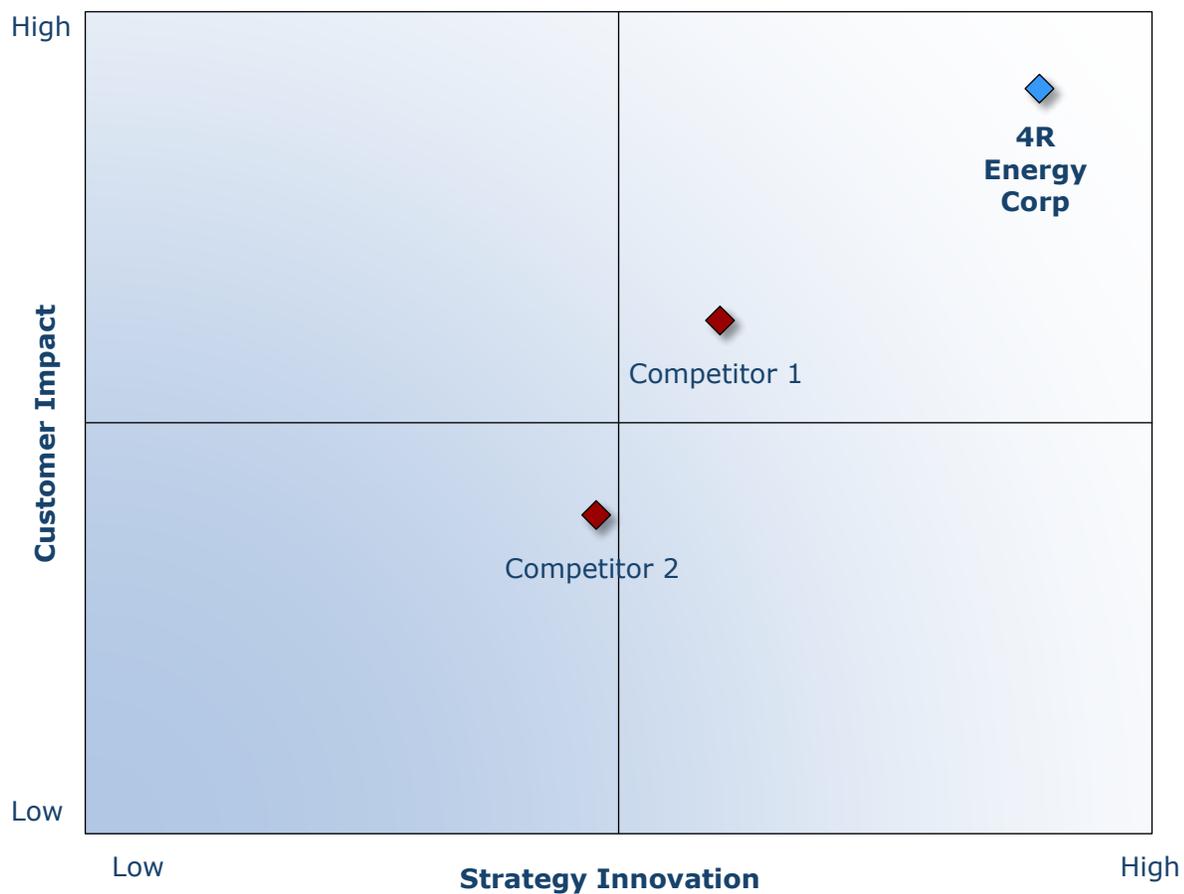
Requirement: Customer service is accessible, fast, stress-free, and of high quality.

Criterion 5: Brand Equity

Requirement: Customers have a positive view of the brand and exhibit high brand loyalty.

Decision Support Matrix

Once all companies have been evaluated according to the Decision Support Scorecard, analysts then position the candidates on the matrix shown below, enabling them to visualize which companies are truly breakthrough and which ones are not yet operating at best-in-class levels.



Best Practices Recognition: 10 Steps to Researching, Identifying, and Recognizing Best Practices

Frost & Sullivan analysts follow a 10-step process to evaluate award candidates and assess their fit with select best practices criteria. The reputation and integrity of the awards are based on close adherence to this process.

STEP	OBJECTIVE	KEY ACTIVITIES	OUTPUT
1 Monitor, target, and screen	Identify Award recipient candidates from around the world	<ul style="list-style-type: none"> • Conduct in-depth industry research • Identify emerging industries • Scan multiple regions 	Pipeline of candidates that potentially meet all best practices criteria
2 Perform 360-degree research	Perform comprehensive, 360-degree research on all candidates in the pipeline	<ul style="list-style-type: none"> • Interview thought leaders and industry practitioners • Assess candidates' fit with best practices criteria • Rank all candidates 	Matrix positioning all candidates' performance relative to one another
3 Invite thought leadership in best practices	Perform in-depth examination of all candidates	<ul style="list-style-type: none"> • Confirm best practices criteria • Examine eligibility of all candidates • Identify any information gaps 	Detailed profiles of all ranked candidates
4 Initiate research director review	Conduct an unbiased evaluation of all candidate profiles	<ul style="list-style-type: none"> • Brainstorm ranking options • Invite multiple perspectives on candidates' performance • Update candidate profiles 	Final prioritization of all eligible candidates and companion best practices positioning paper
5 Assemble panel of industry experts	Present findings to an expert panel of industry thought leaders	<ul style="list-style-type: none"> • Share findings • Strengthen cases for candidate eligibility • Prioritize candidates 	Refined list of prioritized award candidates
6 Conduct global industry review	Build consensus on award candidates' eligibility	<ul style="list-style-type: none"> • Hold global team meeting to review all candidates • Pressure-test fit with criteria • Confirm inclusion of all eligible candidates 	Final list of eligible award candidates, representing success stories worldwide
7 Perform quality check	Develop official award consideration materials	<ul style="list-style-type: none"> • Perform final performance benchmarking activities • Write nominations • Perform quality review 	High-quality, accurate, and creative presentation of nominees' successes
8 Reconnect with panel of industry experts	Finalize the selection of the best practices award recipient	<ul style="list-style-type: none"> • Review analysis with panel • Build consensus • Select recipient 	Decision on which company performs best against all best practices criteria
9 Communicate recognition	Inform award recipient of recognition	<ul style="list-style-type: none"> • Present award to the CEO • Inspire the organization for continued success • Celebrate the recipient's performance 	Announcement of award and plan for how recipient can use the award to enhance the brand
10 Take strategic action	Upon licensing, company may share award news with stakeholders and customers	<ul style="list-style-type: none"> • Coordinate media outreach • Design a marketing plan • Assess award's role in strategic planning 	Widespread awareness of recipient's award status among investors, media personnel, and employees

The Intersection between 360-Degree Research and Best Practices Awards

Research Methodology

Frost & Sullivan's 360-degree research methodology represents the analytical rigor of the research process. It offers a 360-degree view of industry challenges, trends, and issues by integrating all 7 of Frost & Sullivan's research methodologies. Too often, companies make important growth decisions based on a narrow understanding of their environment, resulting in errors of both omission and commission. Successful growth strategies are founded on a thorough understanding of market, technical, economic, financial, customer, best practices, and demographic analyses. The integration of these research disciplines into the 360-degree research methodology provides an evaluation platform for benchmarking industry participants and for identifying those performing at best-in-class levels.

360-DEGREE RESEARCH: SEEING ORDER IN THE CHAOS



About Frost & Sullivan

Frost & Sullivan, the Growth Partnership Company, helps clients accelerate growth and achieve best in class positions in growth, innovation and leadership. The company's Growth Partnership Service provides the CEO and the CEO's growth team with disciplined research and best practices models to drive the generation, evaluation and implementation of powerful growth strategies. Frost & Sullivan leverages nearly 60 years of experience in partnering with Global 1000 companies, emerging businesses and the investment community from 45 offices on 6 continents. To join Frost & Sullivan's Growth Partnership, visit <http://www.frost.com>.