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Repurposing batteries: viability, challenges and opportunities

ECONOMICS AND VIABILITY

$324/kWh

Average turnkey storage system price of four-hour duration in 2022, based on usable capacity

276 GWh

Annual availability of second-life batteries in 2035

$71.7/kWh

Cost to repurpose batteries in benchmark scenario

$52.9/kWh

Second-life battery product cost in benchmark scenario

$48/kWh

Expected price of second-life battery racks in 2030

Background

As the first wave of EVs approaches their end-of-life, millions of batteries can be allocated to second-life utilization. Second-life batteries may be used in various applications, including backup power, stationary storage and low-speed vehicles.

The volume of second-life batteries is expected to skyrocket after 2030, peaking at 276 GWh by 2035. Most battery packs are expected in China, followed by Europe, the US and the rest of the world, as seen in Figure 1.

Yet, the practicality of repurposing these batteries hinges on a delicate balance between initial affordability and diminishing performance over time.

Second-life battery availability by region

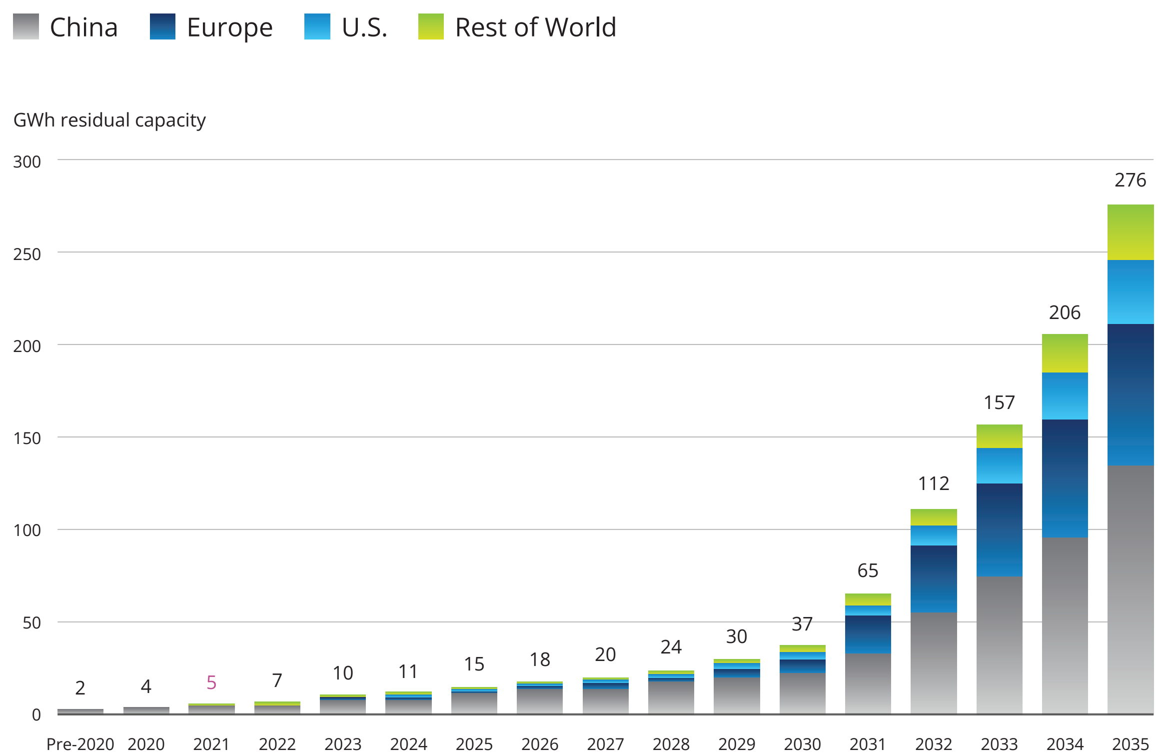

Figure 1. Current and expected availability of second-life batteries by region. Residual capacity of batteries is assumed to be 80% of the nameplate capacity. Based on [1].

Economics and viability

Second-life batteries are expected to become increasingly affordable, potentially offering a 30% cost reduction compared to new battery racks by 2030 [2]. Expected advances in repurposing technology will drive prices even lower.

Battery repurposing refers to the entire process from EV retirement to the delivery of the second-life product. This includes the collection of retired EV batteries, logistics, testing, sorting, disassembly, and second-life system integration.

Repurposing batteries is possible at the pack, module, or cell level, each offering unique advantages in terms of flexibility, reusability, product design, and applicable uses in second-life scenarios.

Figure 2 demonstrates second-life battery price outlook up to 2030, by which second-life product is expected to cost 30% less than new storage rack price.

Second-life battery rack price outlook

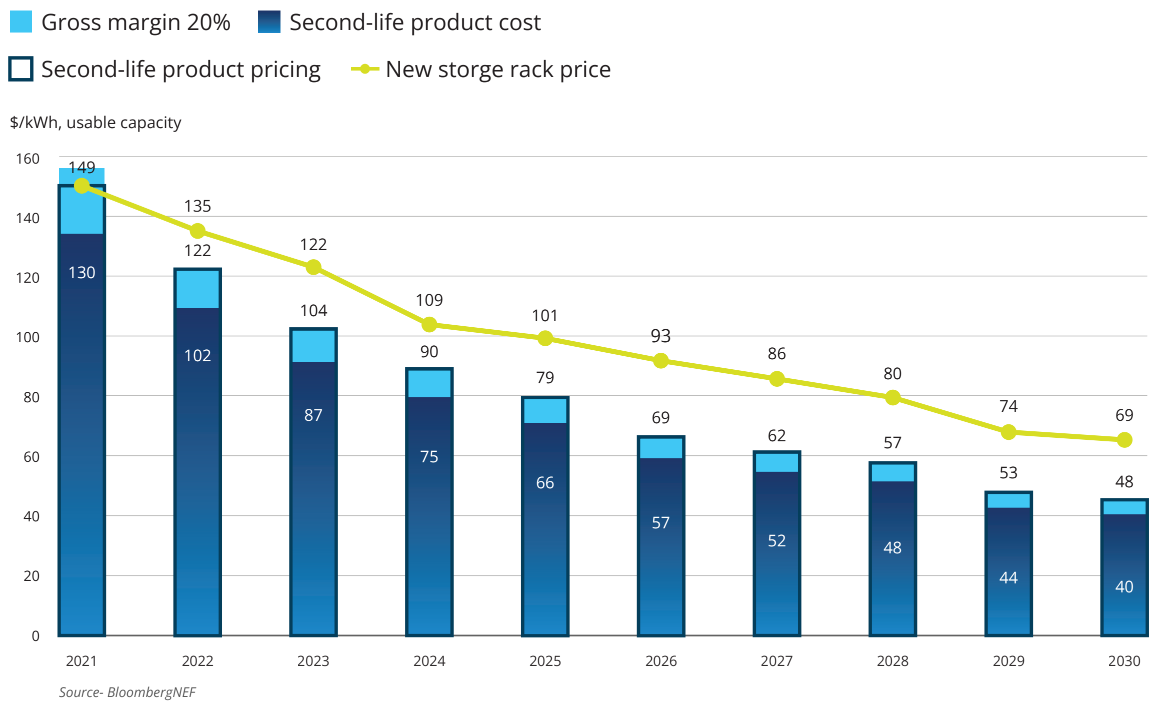

Figure 2. Current and expected second-life battery rack price, compared to energy storage based on new batteries. Second-life prices are broken into the product cost and an additional 20% margin. Based on [2].

Technological challenges and possible solutions

Battery cells are made of degradable materials, so eventually they need to be recycled. Repurposing battery packs into second-life energy storage systems may increase battery pack value and sustainability with less environmental impact.

Before they are deemed suitable for second-life markets, end-of-life EV batteries undergo several processing stages. The batteries are collected, tested, sorted, disassembled and assembled.

There are several approaches to repurposing which are implemented depending on the design of the second-life product and its intended application. Repurposing and reuse can occur at the pack, module, or cell level, as demonstrated in Figure 3.

Battery repurposing approaches and potential applications

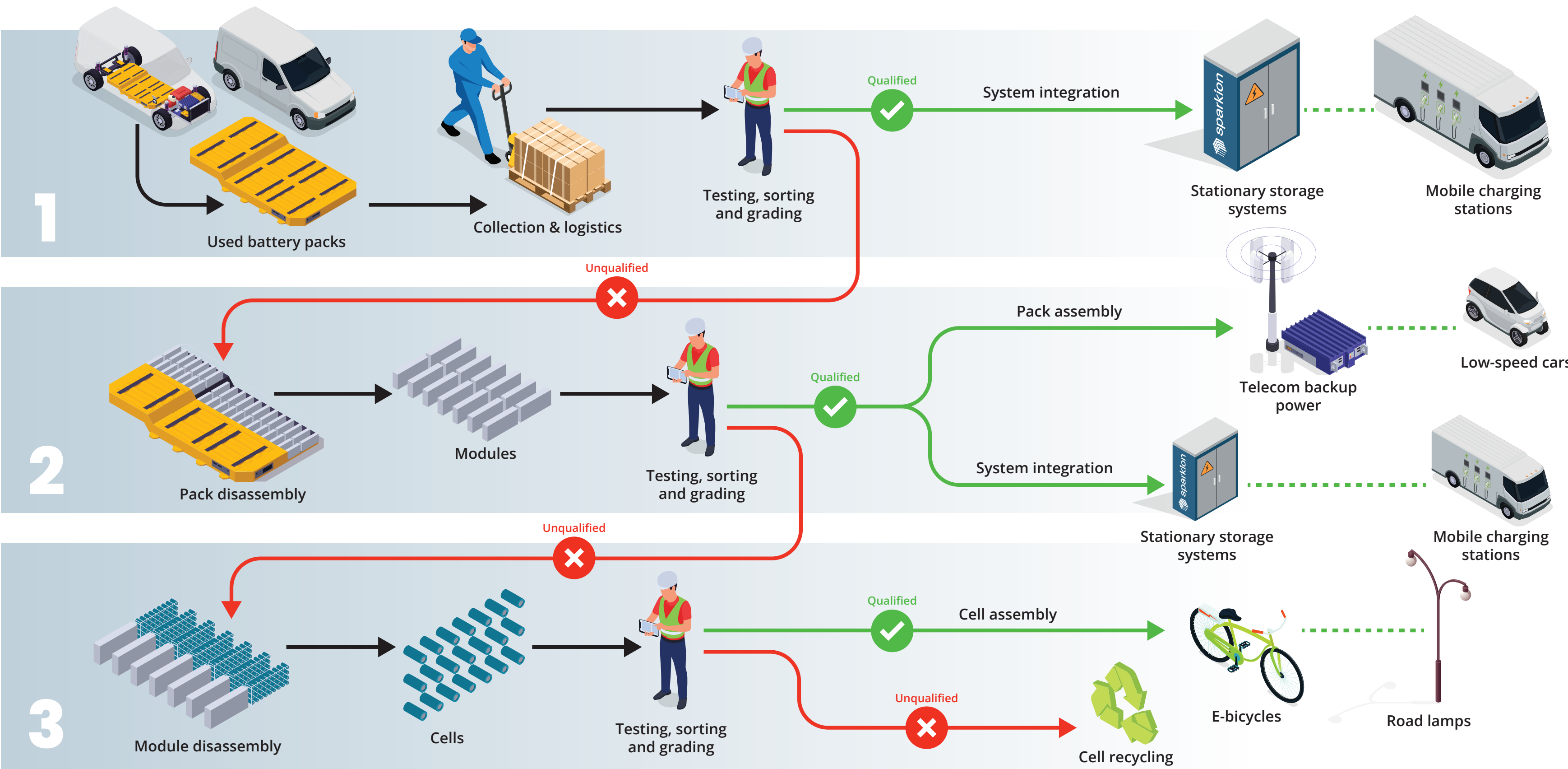

Figure 3. Energy packs undergo a serial process starting from the pack level, through the module and cell level. Repurposing stretches the value in initial battery materials, thereby decreasing the carbon footprint. Based on [1]

The different considerations to each method are demonstrated in Table 1:

	Advantages	Drawbacks
Pack level reuse	Reduces capital requirements Simpler process	The share of suitable packs is often low, since it requires consistency across all pack components
Module level reuse	Higher flexibility Easier logistics	Raises time & cost for testing, sorting and waste disposal
Cell level reuse	Allows for the highest reuse rate, as healthy cells can be easily identified and reused	Disassembly may be difficult and hazardous, as protections are likely to be destroyed during disassembly

Table 1. Considerations for methods of repurposing on the pack, module and cell levels

Currently, second-life battery initiatives are in their pilot phase, with companies from all across the supply chain experimenting with such projects. The second-life knowledge base is growing among various market players and technology is becoming increasingly viable.

Performance degradation presents a significant hurdle to players interested in reusing batteries, due to non-linear capacity deterioration, increased internal resistance,and shorter cycle lifespan. Advancements in technology pertaining to state-of-health diagnosis, residual value estimation, and system integration may enhance the reutilization of end-of-life batteries.

The viability of second-life batteries is also greatly affected by factors such as the initial purchase cost, battery storage and transport, and reusability rate.

The cost of end-of-life EV batteries is critical in determining whether repurposing batteries is worthwhile, as demonstrated in Figure 4. As the volume of retired EV batteries increases, price is expected to decrease. Issues such as supply and demand and state of health will also affect the purchase price.

Transport distance and logistics will also affect the viability of repurposing end-of-life batteries, due to associated storage and safety regulations, which vary by region (Figure 5).

Each retired battery must be separately packaged in a rigid container to prevent the risk of fire, chemical leakage or electrocution [2]. In the US, for example, used lithium-ion batteries are considered hazardous material by the US Department of Transportation. Trains and planes cannot be used for transport and truck drivers require special handling training. Additionally, transporting batteries across regions with various regulations can result in even higher costs.

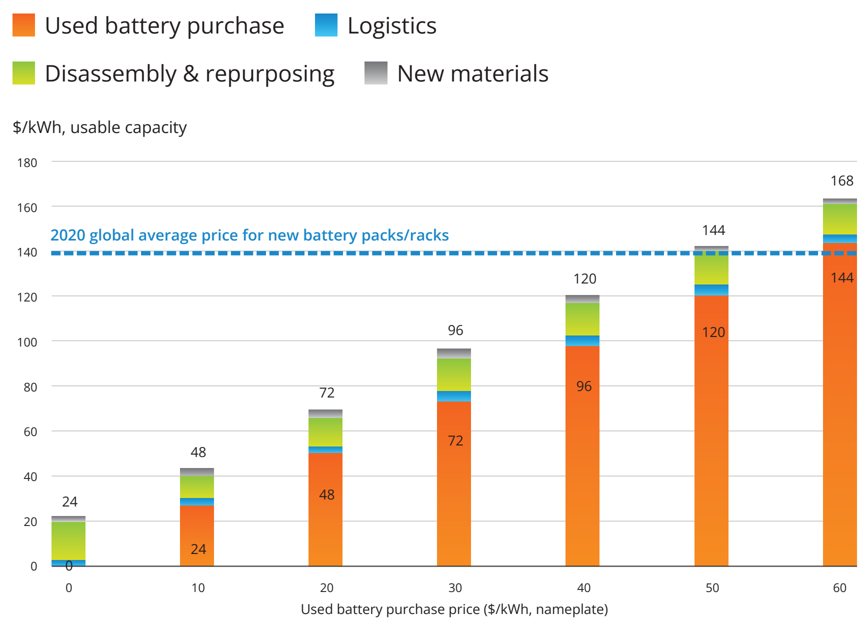

Figure 4. The price of used batteries is essential in determining the viability of repurposing retired batteries. This analysis calculates repurposing costs, and excludes additional revenues from recycling. Based on [2].

As residual capacity of retired EV batteries is not always straightforward to quantify, the reusable rate is key in determining the economic viability of repurposing, as demonstrated in Figure 6. A low reusable rate may lead to low output of second-life products, and would indicate that most batteries should go directly to recycling [2].

While repurposing batteries presents its challenges, the upcoming surge in out-of-use EV batteries is a promising opportunity. This is mainly due to the technology advancements, which optimize residual performance and maximize overall lifetime.

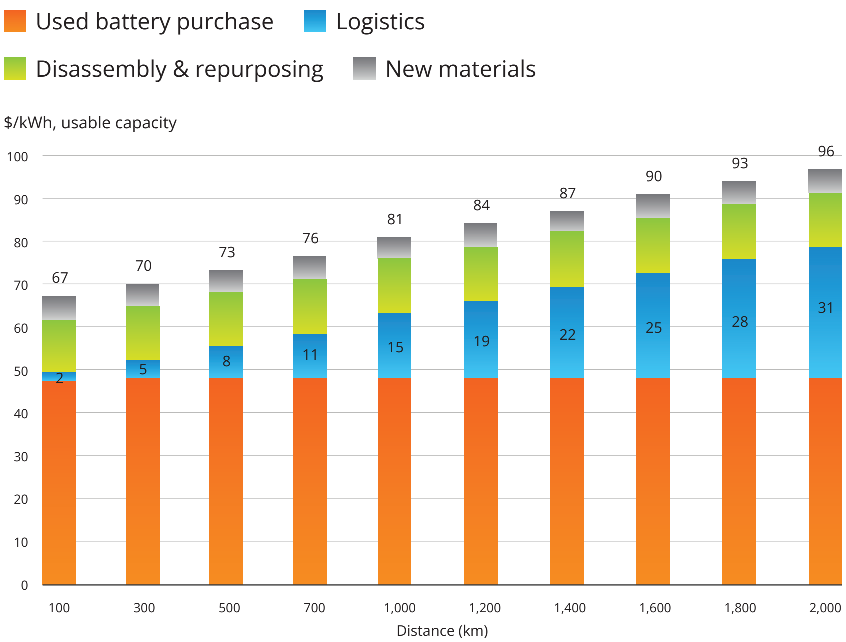

Figure 5. The cost of logistics increases linearly with the transport distance. Based on [2].

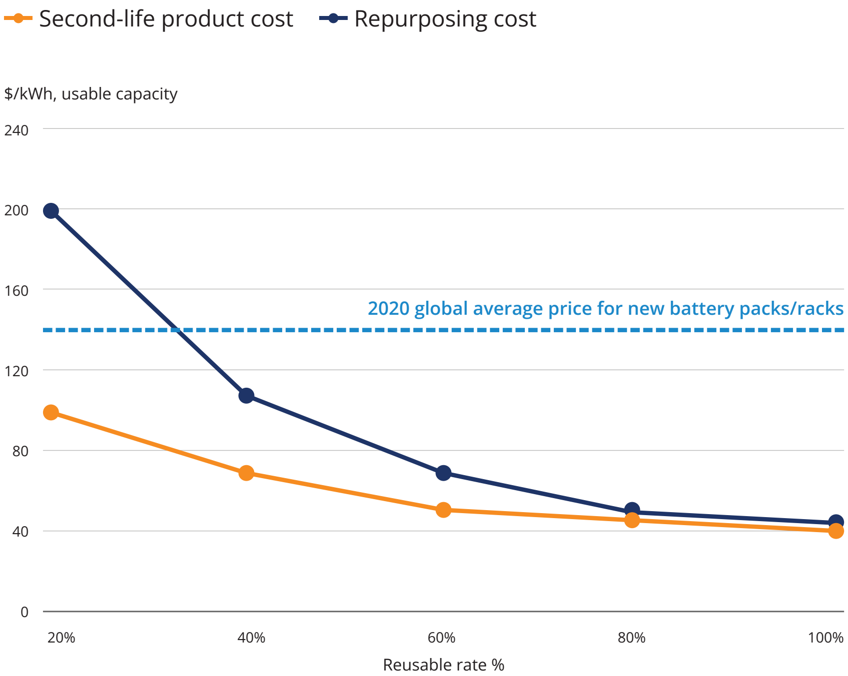

Figure 6. Reusability rate is crucial in determining the cost of repurposing, as more battery packs would be required to make up for a low rate.

Second-life batteries in fleets

The ownership and operation of batteries, along with the establishment of battery swapping networks, demand substantial capital and technological resources. Various stakeholders must collaborate to construct and manage the required infrastructure. These stakeholders include automakers, battery manufacturers, EV charging or car service firms, pack and storage system integrators, recyclers, and second-life battery producers.

The main cost in repurposing lies in purchasing used batteries. Should end-of-life batteries exceed $47/kWh in cost, repurposing expenses would surpass those of purchasing new batteries, making them unviable (considering the average market prices of new battery packs in 2020). [2]

This makes second-life projects especially attractive to battery owners, such as fleets. As the asset owners, they avoid the upfront cost of purchasing retired EV batteries. Such companies will aim to reuse batteries that are no longer suitable for use in EVs, and may use them for in-house battery repurposing to decrease exposure to fluctuating energy costs. By doing so, they will extract the maximum value of already purchased batteries.

CAPTIVE FLEETS

Captive fleets are fleets consisting of vehicles with scheduled predictable driving and refueling patterns.

There is immense potential for captive fleets that deploy energy storage, since the repetitive fleet operation enables operating the energy storage at optimal times. Captive fleets usually operate 8-10 hours a day, leaving enough time to charge the BESS when prices are low and discharging it when prices are high.

Integrating solar energy could foster even greater efficiency for captive fleets by charging energy storage with renewable energy.

References

[1] Daixin Li, 2021, Second-Life Batteries Part 1: Technology and Applications, 100610330920230227220102, BloombergNEF

[2] Daixin Li, 2021, Second-Life Batteries Part 2: Cost and Business Models, 100610330920230227190536, BloombergNEF

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