# Solid-State Batteries Today: What's Real, What's Semi-Solid, and Why the Industry Uses the Same Term

## Introduction

Solid-state batteries (SSBs) are one of the most talked-about developments in energy storage, with the potential to reshape how batteries are designed and used.
At the same time, the industry is still working toward a shared definition, and there is currently no single, formal certification that verifies a battery as "solid-state." This article breaks down today's SSB landscape, the rationale for the terminology, and what it could mean for Renogy's future.

## 1 Industry Situation: What "Solid-State" Means in Today's Market

### 1.1 The Simplest Definition

To understand what "solid-state batteries" are, it is necessary to grasp the basics of standard lithium-ion batteries. Simply put, a conventional lithium-ion battery consists of an anode, a cathode, a separator, an electrolyte (typically liquid). During charging, lithium ions travel from the positive electrode through the liquid electrolyte and the separator, then embed themselves in the negative electrode. This process reverses during discharge.
"Solid-state batteries," as the name implies, are a category of batteries that replace this traditional liquid electrolyte with solid or semi-solid materials.

### 1.2 The Key Realities in 2025

When we discuss "solid-state batteries," what are we truly talking about? In most discussions, people instinctively envision the "All-Solid-State Battery" (ASSB)—the industry's "holy grail." In this ideal form, the battery contains no liquid electrolyte whatsoever, a milestone that researchers and manufacturers are eagerly pursuing.
However, it is crucial to distinguish between this conceptual ideal and this current reality. Clarifying this gap helps consumers look past marketing hype and understand what this new technology can actually deliver today.
First, true all-solid-state batteries are still largely in the R&D phase. They have yet to achieve

widespread commercial use in electric vehicles (EVs), wearables, or grid-scale storage. According to Marija Maisch of pv magazine, major global manufacturers like Toyota and Nissan remain in the pilot production phase as of 2025, with large-scale manufacturing not expected until 2030. Even Solid Power, a leader in the field, does not anticipate mass production until the second half of 2026.

Consequently, most "solid-state" batteries currently in the consumer market are actually "semi-solid-state." Recent developments from Chinese EV makers highlight this trend. For instance, NIO launched the ET7 in June 2024, featuring a 150kWh semi-solid-state battery (a hybrid of liquid and solid electrolytes) capable of an estimated 609-mile (981km) range (Tim Levin, 2024). Similarly, SAIC Motor's MG4, released this September, utilizes semi-solid-state technology from QingTao Energy (Florian Treiss, 2025). This technical breakthrough allows the battery to pass nail-penetration tests without smoking or catching fire, effectively eliminating the risk of spontaneous combustion.

Furthermore, the industry is exploring various technical paths to bring solid-state technology to life. Some companies focus on replacing flammable liquid electrolytes with solid materials. QuantumScape, for example, uses oxide ceramics that do not melt during a puncture, preventing the chain reaction of thermal runaway. Meanwhile, CATL is pursuing multiple avenues, including oxides and sulfides, to achieve a technical breakthrough.

In addition to searching for the ideal solid-state electrolyte, several research teams are approaching the challenge from a different angle: innovating the battery's cathode and anode materials. Colorado-based Solid Power is a prime example; they use high-silicon anodes to boost charging speeds and ensure performance in cold temperatures. They are also exploring lithium-metal anodes, which could dramatically increase energy density, reducing battery weight while extending the range and efficiency of future EVs.

### 1.3 Why “Solid-State” and “Semi-Solid-State” Are Often Grouped Together

Given the R&D and market realities mentioned above, it is clear why "solid-state battery" has become an umbrella term used throughout the industry and media. There are two primary reasons for this:

- **Reason 1: Divergent Technical Pathways**

Currently, companies and research institutions are pursuing vastly different technical routes based on their specific expertise and market positioning. For example, solid electrolytes range from sulfide to oxide systems. When combined with various anode and cathode materials, this results in a wide array of technical configurations. Furthermore, the industry lacks a consensus on the definition of "solid." One company may label a battery "solid-state" if its liquid content is below 10%wt, while another may insist that it must be entirely liquid-free. This diverse pathways make it impossible to establish a single, unified technical specification.

- **Reason 2: Incremental Commercialization**

A significant engineering gap exists between "all-solid-state" lab prototypes and mass-produced commercial batteries. To bridge this gap, "semi-solid" or "hybrid solid-liquid" batteries have emerged as the most practical, near-term solution for vehicle integration. These transitional solutions retain some liquid electrolyte to address challenges such as ionic conductivity and high interfacial impedance. Regardless of whether a battery is "all-solid-state" or "semi-solid-state," the shared goal is clear: to gradually reduce, and eventually eliminate, flammable liquid electrolytes that lead to lithium dendrite growth.

### 1.4 Why There’s No “Official Stamped Solid-State Certification” Today

When shopping for a new refrigerator or washing machine, people often look for the "Energy Star" label to verify energy efficiency. Since the debut of solid-state battery products, consumers have frequently asked if there is a similar official "seal of approval" for solid-state technology. Unfortunately, no such industry-wide certification exists yet. This is simply because R&D paths are so diverse that the industry has not yet settled on a unified definition or set of testing conditions. As all-solid-state batteries move into true mass production, standardized definitions and certifications will follow.

However, the absence of an SSB-specific certificate does not mean these products lack safety credentials. Take Renogy’s solid-state batteries, for example: before they ever leave the factory, they must pass the same rigorous testing as any traditional battery. They are fully certified under standards such as CE, FCC, RoHS, R10, and UN38.8, ensuring complete safety during both transportation and daily use.

## 2. Why Solid-State? The Benefits (Without the Hype)

With major EV manufacturers and research institutions pouring massive capital and human resources into solid-state batteries (SSBs), many are asking: What real-world changes will this technology bring? To answer this, we will examine the prospects of SSBs through three key aspects: safety, energy density, and cycle life.

### 2.1 Safety

Conventional batteries rely on liquid electrolytes to shuttle ions between the anode and cathode, allowing the battery to store and release power. However, when a battery experiences a short circuit, overcharging, or physical damage, it can generate excessive heat (also known as thermal runaway). This abnormality can cause the flammable liquid electrolyte to ignite and even explode.

The core of solid-state technology is to replace these flammable liquids and low-strength separator (usually made of PP/PE) with non-combustible solid electrolyte, such as ceramics or polymers. Think of it as replacing the gasoline in a warehouse with bricks; you are fundamentally removing a primary ignition source. Theoretically, this dramatically improves battery stability under extreme conditions, such as nail penetration, high-impact collisions, or overcharge testing.

However, it is important to note that switching to a solid electrolyte is a promising technical direction, not an absolute guarantee of total safety. Battery safety is a holistic engineering challenge that still depends on robust physical structural design, intelligent Battery Management Systems (BMS), protective circuitry, and the consumer use.

### 2.2 Energy Density

Simply put, energy density measures how much energy a battery can store relative to its weight or volume. The higher the energy density, the further an electric vehicle can travel, or the longer a smartphone can stay powered on a single charge.

In traditional liquid-based batteries, common chemistries like graphite and lithium cobalt oxide (LCO) are widely used, but they offer relatively limited energy density. Solid-state cell designs, however, unlock the potential for higher-capacity electrode materials, such as lithium-metal anodes.

Lithium metal is difficult to use in liquid systems due to safety and stability concerns, but solid-state designs may offer a more stable alternative. That said, the energy density an all-solid-state battery can achieve depends on the specific materials and cell engineering each company uses.

## 2.3 Longevity

When we discuss battery durability, it is best understood through two metrics: **cycle life** and **long-term stability**. Cycle life refers to the number of full charge-discharge cycles a battery can undergo before its capacity drops to a specific percentage (typically 80% of its original state). Long-term stability describes how well the battery resists degradation across various environmental conditions. Several critical factors influence a battery's overall lifespan:

- **Depth of Discharge (DoD):** Draining a battery from 100% to 0% causes significantly more wear than partial usage (e.g., cycling between 90% and 30%). "Shallow" cycles are much better for long-term health. For users of lead-acid batteries, we specifically recommend keeping the Depth of Discharge at or below 50%.
- **Temperature:** Temperature extremes are detrimental to battery health. High heat is the "number one killer," as it accelerates internal chemical reactions and degradation. Conversely, extreme cold impairs performance. In standard lithium batteries, cold-weather usage can lead to the formation of lithium dendrites, needle-like crystals that can pierce the separator, causing short circuits, fires, or even explosions.
- **Charge/Discharge Rates:** Frequent reliance on "ultra-fast" charging or sustained high-power discharging puts additional stress on the battery's internal chemistry, which can shorten its usable life.

Theoretically, solid-state batteries offer superior durability. Their solid architecture is more stable and prone to fewer side reactions. Most importantly, the solid electrolyte can physically suppress the growth of lithium dendrites, potentially leading to much longer cycle lives and enhanced long-term stability.

# 3. Renogy's Solid-State Approach

### 3.1 What Renogy Means When We Say "Solid-State"

Renogy has taken a practical "middle-ground" approach by using semi-solid cells from QingTao Energy. These hybrid solid–liquid cells use oxide–polymer solid materials to significantly reduce the amount of liquid electrolyte inside the battery.

Compared to traditional lithium-ion batteries (typically 25%–35% liquid by weight), Renogy's semi-solid cells reduce liquid content by about 70%, bringing it down to roughly 10% by weight.

With more solid material in the cell, thermal resistance improves, so the battery's temperature rises more slowly. Even when heat continues to build, the risk of thermal runaway is greatly reduced. Furthermore, the cathode and anode of these hybrid cells are coated with a high-melting-point solid-state electrolyte that withstands temperatures up to 572°F (300°C).
In the event of external impacts or punctures, the cell remains stable and resists ignition or explosion. This technical breakthrough provides a massive safety upgrade for users in demanding, off-grid environments, such as RVing and marine applications, where reliability is paramount.

### 3.2 Why Combine This Approach with LiFePO4 (LFP)

Beyond semi-solid electrolytes, Renogy uses **Lithium Iron Phosphate (LFP)**, a market-proven chemistry celebrated for its stability and high energy density compared to lead-acid alternatives.
Safety is further enhanced by our proprietary **BMS**, featuring 60+ intelligent protections that balance rigorous safety with a smooth user experience. For added redundancy, we've included **Active Backup Protection** via self-control fuses, which instantly disconnect the circuit during abnormalities to prevent permanent damage.
By merging semi-solid technology with LFP chemistry and multi-layered protection, Renogy has successfully pioneered the world's first smart and portable solid-state battery for mobile energy storage.

### 3.3 Our Commitment to Solid-State Technology

As solid-state technology moves from the lab to the market, Renogy is committed to providing a clear and honest roadmap for our users based on three pillars:

- **Transparency:** We promise to use clear, accurate technical definitions. By avoiding marketing hype and industry jargon, we ensure you have the facts needed to make informed choices.
- **Targeted Innovation:** We are focusing our R&D on demanding off-grid applications, such as RVs, boats, and home backup systems. Our goal is to solve energy storage challenges where reliability and resilience matter most.
- **True Accessibility:** Our goal is to bring advanced battery technology to a wider audience; however, "accessibility" means more than just a lower price tag. We aim to make next-gen tech widely available without sacrificing quality or safety. By optimizing our manufacturing and supply chain, we deliver high-performance, cost-effective solutions that provide lasting value.

## Takeaways

When exploring products featuring emerging solid-state technology, the key takeaway is that there is currently no unified "solid-state" certification standard. Today, given the diverse technical pathways and the incremental nature of its commercialization, "solid-state battery" has become an umbrella term that encompasses a wide range of evolving technologies.
To find reliable and certified power solutions for your needs, we invite you to learn

more about Renogy's battery portfolio. Feel free to talk directly to our tech support team, or explore our educational resources on off-grid battery systems.

## FAQs

1. **Is there an official certification for "solid-state batteries"?**

No. There is currently no official, unified global standard or certification that formally defines or "stamps" a product as a solid-state battery.

2. **What's the difference between solid-state and semi-solid-state?**

An all-solid-state battery contains zero liquid electrolyte. A semi-solid-state battery is a hybrid that replaces most, but not all, of the liquid with solid materials (such as polymers or ceramics) to improve safety and performance.

3. **Are any fully all-solid-state (zero-liquid) large batteries available today?**

No. True all-solid-state batteries (ASSBs) are still in the laboratory and pilot production phases. Most major manufacturers do not expect large-scale commercial production until 2026–2030.

4. **Does "solid-state" automatically mean safer?**

Theoretically, yes, because it removes flammable liquids. However, absolute safety is a "holistic engineering" challenge that still depends on the battery's physical design, its battery management system (BMS), and proper user habits.

5. **Why do brands use the term differently?**

The term is used broadly because there is no consensus on definitions. Some brands call a battery "solid-state" if the liquid content is below 10%, while others believe it must be 0%. Additionally, companies are pursuing various material paths (e.g., sulfides vs. oxides).

6. **What should I look for when comparing batteries?**

Look for technical transparency and established safety credentials (like CE, FCC, and UN38.8). Beyond standard certifications, focus on the integrated safety design: the battery chemistry (e.g., LFP), the BMS, and other features or technologies that match your needs.

## References

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