Flow Battery vs Lithium-ion: Safety comparison and implications for deployment

As the share of renewable energy in power systems grows, the need for reliable and safe energy storage is critical. Safety considerations are central to the selection of storage technologies and also affect where these systems can be deployed. While lithium-ion batteries currently dominate the stationary storage market, they have a considerable fire risk, limiting their deployment to large open areas. **Flow batteries** on the other hand, are **non-flammable** and are significantly more **area efficient**, allowing them to be used in **land constrained and dense urban areas**, including **indoors**, enabling use cases unavailable to lithium batteries.

Overall safety and deployment comparison

The main concern with lithium battery energy storage systems (BESS) is thermal runaway, where heat generated within a cell can trigger a self-sustaining chain reaction, leading to fire or explosion. During such events, lithium-ion systems can release flammable and toxic gases which endanger first responders. Because the fire can spread easily between batteries, entire containers can be compromised if one unit fails. These fires are often especially difficult to extinguish, taking days in some cases. Due to several recent lithium-ion battery fires, citizens are increasingly worried about the fire risk of lithium battery sites near urban areas.[1] Fire regulations generally prevent their deployment in dense urban locations, so they must be located away from urban areas. Lithium-ion batteries are highly effective for short duration applications, generally 1-2 hours. However, costs rise significantly when projects require longer durations, as achieving 6+ hours of storage means adding multiple times more battery containers, significantly increasing the areal footprint and reducing cost efficiency.

Flow batteries operate using **water based liquid electrolytes** stored in external tanks. These electrolytes are **non-flammable,** making **thermal runaway impossible**. The absence of fire risk mean they can be deployed much more freely, with many installed in basements or in urban areas. The footprint is also significantly smaller, as they do not face spacing restrictions as they have no fire risk, and their design allows for more freedom and **efficiency in scalability**. A 2023 study found that flow batteries can achieve areal energy densities five times as high as with average lithium-ion based systems, due to their **vertical scalability**[2], making them especially well suited to deployment in land constrained areas, and in urban areas and buildings. If more energy capacity is needed, all that is needed it to add another tank, or make it taller, and if

[1] Woollacott, Emma. BBC News. *'We are playing with fire': Fears persist over battery storage.* 11 September, 2025. https://www.bbc.com/news/articles/czjvdpzw71po

[2] Reber, David, et al. September, 2023. *Beyond energy density: flow battery design driven by safety and location.* Royal Society of Chemistry, Energy Advances, volume 2, number 9. https://pubs.rsc.org/en/content/articlepdf/2023/ya/d3ya00208j

more power is needed, just add more stacks. This allows the battery to be scaled up with only a minimal increase to land area. The electrolyte used in flow batteries also allows them to operate safely in a very **wide range of temperatures, from -40C to 80C**, without compromising performance, making them ideal for extreme environments[3]. Because of this, they are being used in places where the heat would prohibit the use of lithium-ion, due to safety concerns, and could be used in extreme cold where lithium batteries are unable to operate. These factors make them ideal for powering **critical infrastructure**, have already been deployed for this role on military bases, hospitals, and data centres.

How safety is reflected in international standards

The IEC standards for lithium-ion BESS (e.g., IEC 62933-5-2 and IEC 62485-5) focus heavily on fire safety measures including spacing, fire-resistant enclosures, and emergency access, typically requiring 6 meters between containers depending on wall fire ratings and a 30-meter buffer from buildings. In contrast, the IEC 62932 series for flow batteries (e.g., IEC 62932-2-2:2020) addresses safety risks tailored to flow battery chemistries and hazards, such as electrolyte containment and toxicity, rather than fire propagation. Because flow batteries lack the severe thermal runaway risks of lithium-ion batteries, the IEC 62932 standards do not prescribe strict spacing distances for fire safety. Instead, they focus on risk reduction for chemical hazards and mechanical safety, enabling more compact system layouts. Thus, compared to IEC standards for lithium-ion BESS that require specific and often wider spacing to mitigate fire hazards, IEC 62932 flow battery standards allow **more flexible and generally smaller spacing requirements**. This reflects the fundamentally lower fire risk profile of flow batteries, which reduces the need for large fire separation distances and extensive fire-resistant building measures seen in lithium-ion BESS installations.

In conclusion, the non-flammability of flow batteries is a key point in the consideration of batteries for stationary storage. In addition, the scalability of flow batteries allows them to scale vertically, and more cost efficiently than lithium-ion, allowing them to achieve equal or higher areal energy density with a significantly smaller footprint. These factors make them ideal for many use cases where safety is paramount, and space is limited. For long-duration storage, especially in urban or land-constrained settings, flow batteries present a strong alternative to lithium-ion, due to their safety, reliability, and areal efficiency.

[3] Sumitomo Electric, *Vanadium Redox Flow Batteries: A safer Alternative to Lithium-Ion Technology*. 2 July, 2025. https://sumitomoelectric.com/products/flow-batteries/stories/the-safe-alternative-vanadium-redox-flow-vs-lithium-ion-batteries

Flow battery and Lithium-ion safety and deployment

FLOW BATTERIES EUROPE
A united voice for flow batteries

As renewable energy grows, long-duration, safe and reliable storage is critical. While lithium-ion (Li-ion) dominates the market, its fire risks have led to growing concerns. **Flow batteries** offer a **safer and vertically scalable alternative**, with major **advantages for urban and critical infrastructure** projects, and a significantly **smaller footprint**.

	Li-ion	Flow batteries
Safety profile	Risk of thermal runaway → **fires and toxic gas** release, difficult to extinguish, **requiring spacing**, **fire suppression, and cooling**.	Use non-flammable water-based electrolyte → **no fire risk, no toxic gas, safe across -40°C to 80°C**.
Deployment	**Limited siting flexibility**; fire safety concerns **restrict** use in **urban areas and buildings**. **Scaling up** capacity means increasing number of containers, raising **costs** and increasing areal **footprint**.	Can be freely deployed **indoors**, in basements, **or dense urban areas**, and in **extreme environments**. Outdoor deployment requires **minimal space**. Higher areal energy density and **easy scale up**, minimising land use, maximising deployment opportunity.
Safety requirements	International standards (IEC) generally **require** at least 6 meters **spacing** between containers **due to fire risks**, and 30 meters spacing from buildings.	Safety requirements **do not restrict spacing or deployment** and rather focus only on chemical hazards and mechanical safety.

Advantages of flow batteries:

- Non-flammable → **no fire risk**
- Operate safely across in **extreme heat & cold** with **no performance loss**
- Can be deployed inside **buildings and cities**
- Long life (**20+ years**) with no performance fade, **high cyclability**
- **Scalability** allows for increased power and energy within **smaller footprint**

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