Oregon
Tina Kotek, Governor

OREGON DEPARTMENT OF ENERGY

550 Capitol St. NE
Salem, OR 97301
Phone: 503-378-4040
Toll Free: 1-800-221-8035
FAX: 503-373-7806
www.oregon.gov/energy

To: Energy Facility Siting Council

From: Thomas Jackman, Rules Coordinator

Date: May 2, 2025

Subject: Agenda Item C, Overview of Battery Energy Storage Systems for the May 16, 2025 EFSC Meeting

OVERVIEW

This report provides a comprehensive overview of Battery Energy Storage Systems (BESS) for the Oregon Energy Facility Siting Council (EFSC), highlighting EFSC's jurisdictional authority and recent legislative updates introduced by House Bill 4015 (2024). It reviews current utility-scale battery storage projects approved or operational across Oregon, discusses the predominant technologies, including lithium-ion and emerging alternatives, and identifies key issues surrounding safety, reliability, environmental impacts, and lifecycle management. The report also examines forthcoming technological advancements and their implications for future siting considerations.

EFSC JURISDICTION FOR BATTERY STORAGE & HB 4015 (2024)

In Oregon, EFSC traditionally oversees large energy generation projects (wind, solar, etc.) that meet certain thresholds. Until recently, standalone BESS was not even described in statute, although applicants have included battery storage as related and supporting facility components associated with EFSC jurisdictional projects. House Bill 4015, passed in 2024, addressed this gap by defining BESS in statute and allowing developers to opt-in to EFSC review for battery-only projects. Effective January 1, 2025, HB 4015 amended ORS 469.300(5) to define a *"battery energy storage system"* as a facility that stores and later discharges energy using rechargeable batteries (excluding personal, non-commercial systems). It also added ORS 469.320(8), giving developers (or local governments, in consultation with developers) the choice to have a standalone BESS reviewed through EFSC rather than solely through county processes.

Importantly, HB 4015 clarified that if a BESS is built in conjunction with another EFSC-jurisdictional energy facility (e.g. a solar farm), it does not require a separate site certificate – it can be permitted as a "related or supporting facility" under the primary project's certificate, although that was already the practice. However, the bill did not automatically authorize BESS in local land use zones (like Exclusive Farm Use land), so standalone projects still face land use consistency hurdles if county codes don't explicitly allow battery storage. Presumably, in Exclusive Farm Use zone lands they would be reviewed as a "utility facility necessary for public service"[1] which is a Type 1 review and only allows requirements that are specifically included with or referenced by that use.

Overall, HB 4015 expanded EFSC's purview to include large BESS projects, clarified their review under state standards while retaining local land use authority unless delegated.

UTILITY-SCALE BESS PROJECTS IN OREGON (APPROVED & OPERATIONAL)

Utility-scale battery projects in Oregon have grown alongside wind and solar developments. Many have been proposed as hybrid facilities (battery plus generation), and a few are now operating. Below is a summary of notable approved or operational BESS projects:

- **Port Westward (Columbia County)** – A 6 MW lithium-ion system, built as part of PGE's Port Westward gas plant site, became one of Oregon's first grid-scale batteries (approved via a site certificate amendment). It uses modular container units (44 ft long) on a compact pad (0.2 acres) and has been operational for several years.
- **Pachwáywit Fields (Gilliam County)** – Formerly Montague Solar, this 162 MW solar farm includes a 100 MW BESS (lithium-ion). The battery, composed of over 100 containerized units, is co-located with the solar arrays on 6.5 acres. Operational since April 2023, it's Oregon's largest solar-linked battery, providing up to 4 hours of energy to help meet PGE's peak demand.
- **Wheatridge Renewable Energy Facility (Morrow County)** – A wind/solar hybrid project (300 MW wind + 50 MW solar) that also includes a 30 MW battery system. The battery uses 41 container units (each 36 ft by 12 ft) and was one of the first large batteries deployed with a wind farm in the U.S. This facility became operational in 2021.
- **Bakeoven Solar (Wasco County)** – A 100 MW battery approved as part of the 303 MW Daybreak/Bakeoven solar complex. It will consist of containerized lithium-ion units (40 ft shipping containers) occupying 8 acres. This project is under construction – the deadline to complete construction is April 24, 2026.
- **Nolin Hills (Umatilla County)** – A wind + solar farm that received approval for a 120 MW battery (likely lithium-ion). The design calls for 240 shipping containers of batteries dispersed across the site. This project is approved, but not yet built.
- **Obsidian Solar Center (Lake County)** – A solar farm that includes a 50 MW battery. Notably, it plans to use vanadium flow battery, discussed below, instead of lithium-ion, with 134 large tank units proposed. The flow battery would spread over 25 acres, but offers longer duration storage. The project is approved, however the developer recently asked for a three-year extension, with a proposed construction commencement deadline of February 25, 2028.
- **Madras Solar (Jefferson County)** – A solar project approved in 2021, this facility recently received approval from EFSC to add up to 63 MW of storage. After seeking an extension, it has a construction commencement deadline of June 25, 2027.
- **Wagon Trail Solar (Morrow County**) – A 500 megawatt solar project with a proposed ***2,000 MW*** of battery energy. The developer has until September 20, 2027 to comply with applicable preconstruction conditions and begin construction on the facility.
- **Sunstone Solar (Morrow County)** was recently approved with ***500–1200 MW*** of battery power and up to 7,200 MW hours of capacity. The developer has until November 18,

[1] ORS 215.213 or 215.281(1)(c)

2027, to comply with applicable pre-construction site certificate conditions and begin construction.

- **Other Approved BESS** – Several other EFSC-approved facilities also have battery add-ons, including: **West End Solar** (70 MW battery), **Stateline Wind** (50 MW battery) and **Summit Ridge Wind/Solar** (up to 201 MW battery planned).
- **Proposed BESS:**
  - **Buckley Solar** in Sherman County would be 1,200 MW solar with 1,200 MW of battery storage.
  - PacifiCorp's **Sunrise** project in Morrow County would consist of a 800 MW solar facility and an 800 MW BESS.
  - The **Deschutes Solar and Battery Energy Storage** project in Wasco County would consist of a 1,000 MW solar facility with a 1,000 MW BESS.

Local utilities are also contracting standalone storage (PGE, for instance, has announced plans for hundreds of MW of battery storage)[2]. Oregon's first major standalone BESS, Salem Smart Power Center (5MW), came online in 2013. Now with EFSC's optional pathway, developers of large standalone batteries (perhaps > 50–100 MW) have the choice to seek a state site certificate, which could standardize review of issues like fire safety and the environmental impacts of these installations.

BATTERY TECHNOLOGIES FOR UTILITY-SCALE STORAGE

While lithium-ion (or Li-on) batteries have the lion's share of gird storage on the market today, several other technologies have emerged or are on the horizon which are either cheaper, safer, longer lasting, or some combination of those three. What follows is a summary of these technologies.

<u>Lithium-Ion Batteries (Li-ion)</u>

Over 90% of large-scale battery capacity in the U.S. uses lithium-ion chemistry[3]. Li-ion batteries have high energy density (compact size) and fast response, ideal for 1–4 hour storage needs.

---

[2] https://investors.portlandgeneral.com/news-releases/news-release-details/portland-general-electric-announces-first-quarter-2025-results

[3] https://www.eia.gov/todayinenergy/detail.php?id=63025

Most grid batteries use thousands of Li-ion cells packaged into modules, then racks, housed in containers or cabinets.

Physically, a utility Li-ion BESS often looks like rows of 20 or 40-foot shipping containers placed on concrete pads with inverters and a step-up transformer nearby. Each container might hold several MWh of batteries. For example, a 100 MW/400 MWh facility might require dozens of container units spread over a few acres. Li-ion systems are typically modular and scalable, making them popular for projects ranging from 1 MW to several hundred MW. Common chemistries include NMC (nickel manganese cobalt) and LFP (lithium iron phosphate). LFP batteries are increasingly favored for large BESS due to better fire safety (lower risk of thermal runaway) and avoidance of cobalt, which is largely sourced from Congo, often using less than ideal methods. LFP batteries have slightly lower energy density than NMC, but enjoy longer cycle life (exceeding 3,000 cycles compared to just 1,000 to 2,000 cycles for Li-ion).

Flow Batteries

Flow battery systems (e.g. vanadium redox flow batteries) store energy in liquid electrolytes held in large tanks, which are pumped through a reactor stack to charge and discharge the battery. This design allows the power (MW) and energy (MWh) capacity to be scaled independently – simply build bigger tanks for more duration and utilize more tanks for greater power. Flow batteries have a significantly lower energy density than lithium-ion batteries, so they occupy more space per MWh. A typical flow battery plant might resemble a tank farm or warehouse building but offer very long cycle life – over 20 years with minimal degradation and inherent safety, because there is no risk of thermal runaway.

In Oregon, flow batteries are not yet common, but as noted above, the Obsidian Solar Center plans to use a flow battery. Other demonstration projects in the U.S. (California, etc.) are already in use, proving flow technology is viable for multi-hour storage. Flow batteries are well-suited for longer durations (4–12+ hours), however their footprint tends to be larger – for instance, a 50 MW/200 MWh vanadium flow system could need several tens of acres.

A benefit of a flow battery is that it can fully discharge to 0% without damage and have almost unlimited cycling capability, making them ideal for daily deep-cycle (0 to 100 and back to 0) use and long-duration load shifting. Regulatory interest in flow batteries is growing as they can provide seasonal storage without the raw material constraints of Li-ion. The primary component (vanadium) is more abundant, and the electrolytes can be reused and recycled relatively easily.

Emerging Alternatives

Beyond Li-ion and vanadium flow, a few other battery types are on the horizon for utility scale:

- **Sodium-Ion Batteries** – A *next-generation* technology closely watched in 2024–2025. Sodium-ion batteries replace lithium with sodium, which is cheaper and more abundant. Companies like CATL have developed prototype sodium-ion cells with around 160 Wh/kg energy density (approaching lithium iron phosphate levels). These batteries are safer, with a nonflammable electrolyte, and perform better in cold temperatures. The drawback of this battery type is their slightly lower energy density and cycle life, at least for now. Stationary storage is a prime candidate for sodium-ion adoption (since weight/volume are less critical than for EVs). Industry experts predict sodium-ion batteries will start appearing in grid projects in the late 2020s once production scales up – potentially in combination with Li-ion (hybrid systems where sodium batteries provide bulk energy and lithium provides high power).
- **Solid-State Batteries** – Still in R&D, solid-state batteries replace the liquid electrolyte of Li-ion with a solid material (ceramic, etc.), enabling use of pure lithium metal anodes. They promise much higher energy density and improved safety (non-flammable). Companies are aiming for solid-state battery commercialization later this decade, primarily for EVs. If successful, utility-scale packs could follow, offering more compact storage or lower cooling needs. But currently no large solid-state BESS exists; this is a future watch item for EFSC as the technology evolves.
- **Iron-Air Batteries** – An ultra long-duration concept being pioneered by firms like Form Energy. These are not electrochemical cells in containers, but rather modular tanks that use iron, water, and air to store energy via reversible rusting. Iron-air batteries can theoretically provide 100+ hours of storage at very low cost, but with slow response (more for multi-day shifting than fast grid services). Form Energy is building a 10 MW/1000 MWh (100-hr) pilot in Minnesota slated for 2025. If that succeeds, Oregon might see interest in such multi-day storage for resiliency. The footprint is large (they resemble water treatment plants) and power density is low, so they complement rather than replace Li-ion: e.g. Li-ion for daily cycling, iron-air for extreme events or seasonal needs.
- **Zinc-Based Batteries** – Includes zinc-bromine flow batteries and zinc hybrid cathode batteries (like Eos Energy's Znyth technology). Zinc batteries are attractive due to cheap, non-toxic materials. Eos's systems, for example, use a water-based zinc chemistry in modular tank units for 3–4 hour storage. Several projects in California are testing these. They operate at ambient conditions and are non-flammable. Oregon's Sunstone Solar applied for and received permission to use lithium or zinc for its 1200 MW battery plan and Wagon Trail Solar recently requested the ability to convert a portion of its BESS (up to 15MWs) to Zinc-bromide, indicating developers are considering zinc as an alternative if it proves viable at scale.

In summary, lithium-ion remains the workhorse for almost all near-term projects – thanks to its maturity and declining costs – but EFSC should be aware of these alternatives. Flow batteries could play a role in providing longer-duration storage without the fire risks of Li-ion. And emerging chemistries (sodium-ion, solid-state, metal-air, zinc) may become relevant within the next decade, especially if they alleviate supply chain or safety concerns. Each technology comes with different physical footprints and siting implications – e.g. tank-based systems may need larger, flat sites; Li-ion container farms need access for maintenance and cooling; high-temperature batteries might need added safety buffers, etc. We turn to those key issues and concerns now.

KEY ISSUES AND CONCERNS WITH UTILITY-SCALE BESS

Deploying large battery systems raises several siting and operational concerns that EFSC and other regulators must consider:

<u>Safety & Fire Risk</u>

Battery facilities, especially Li-ion, carry a risk of thermal runaway and fire. Incidents have occurred globally – for instance, the Moss Landing BESS in California (300+ MW) experienced overheating events that took it offline in 2021–2022. In 2024, a thermal runaway resulted in a large fire at the same facility, incinerating all 300MW of battery capacity, but did not spread to nearby structures. Li-ion battery fires can be difficult to extinguish and emit toxic fumes. The good news is that the Moss Landing facility was one-of-a-kind, conceived and designed in 2018 before modern safety standards were adopted for large grid batteries. Battery safety standards have been updated multiple times since it was built.

Mitigation involves robust fire suppression systems (clean agent or water spray), thermal monitoring, and spacing of units to prevent cascade fires. Codes like NFPA 855 now provide standards for indoor/outdoor battery installations (e.g. maximum energy per enclosure, required fire separation distances, fire suppression requirements, etc.). Thermal management, such as sufficient HVAC cooling for containers, is also critical to prevent overheating.

Oregon’s facilities often are sited in remote areas, reducing public safety risk, but emergency responders still need training for BESS incidents. EFSC should be aware of industry safety standards (UL 9540A testing for battery racks, etc.) and the need for coordination with local fire authorities to ensure sufficient local response capabilities.

<u>Reliability & Degradation</u>

Unlike a substation, batteries are active devices that degrade with use. Li-ion batteries typically lose capacity over time – perhaps 1–2% per year depending on usage. For example, after 10 years, a BESS might have only 80% of its original capacity. Developers usually oversize the system or plan augmentation, such as adding new battery modules mid-life, to ensure the output meets the contract requirements over a project’s life. EFSC might see proposals where a 100 MW facility is built with 110 MW of batteries, expecting to use that headroom as cells age. Round-trip efficiency is another factor – Li-ion is about 85–90% efficient and these losses generate heat and degrade the cells. Flow batteries have lower efficiency (70–80%) but no significant degradation over tens of thousands of cycles. Ensuring that the project can meet performance and not create reliability issues on the grid (e.g. dropping out early due to degradation) is an operational concern. To address these concerns, utilities often require guarantees in contracts for capacity over a certain term.

<u>Lifecycle & Recycling</u>

Large-scale batteries have finite lifespans (around 10–15 years for Li-ion modules). What happens at end-of-life is a growing concern, but recycling programs for Li-ion are ramping up – there is a growing industry that aims to recycle and recover materials like lithium, cobalt, nickel, and copper from spent cells, reducing the environmental impact of disposal.

Oregon will want to ensure decommissioning plans include safe removal and recycling or disposal of battery systems. Site certificates require a decommissioning bond could potentially factor in battery recycling costs, as the salvage value of used battery metals is potentially significant and could offset some decommissioning expenses as recycling markets mature.

Supply Chain Constraints

Rapid growth in BESS deployment has raised concerns about the supply chain for critical materials. Li-ion batteries rely on minerals like lithium, cobalt, nickel, graphite. Globally, battery manufacturing is concentrated – over 80% of battery cell production capacity is in China[4]. This concentration has helped drive down costs but also poses supply risks as geopolitical or trade issues could affect prices and availability. Projects could face delays due to shortages of cells or components, which occurred in 2022–2023 when global lithium prices spiked.

The industry is responding by expanding manufacturing in the U.S. (thanks in part to incentives in the 2022 Inflation Reduction Act) and diversifying chemistries (like shifting to LFP, which uses no cobalt/nickel). Still, raw material mining and processing constraints are real – lithium and graphite processing are bottlenecks. EFSC doesn’t directly control these upstream issues, but it’s relevant in weighing the sustainability of a project. Using alternative chemistries (sodium, zinc, iron) could alleviate some supply pressures if those become commercially viable.

Environmental & Land Use Impacts

Compared to many energy facilities, BESS have a relatively small physical footprint, but there are still environmental factors. Large battery sites may require grading of land, installation of concrete pads or buildings, and perimeter fencing – all of which disturb soil and habitat. Visual impacts are generally low profile (the containers are usually <10 ft tall), and noise is minor (fans or HVAC units on containers produce a hum when cooling is needed). However, noise from inverters or cooling systems could be a concern if near residences. BESS can contain hazardous materials such as electrolytes, so spill containment and hazardous waste plans are important – especially for flow batteries, which have large volumes of liquid electrolyte (though typically in secure tanks).

For Li-ion, the hazard is mostly in fire scenario rather than leakage, as discussed above.

Grid Integration & Operations

Large BESS change how the grid operates. A key concern is ensuring they charge and discharge in a manner that supports reliability. At the local level, battery charging (which draws power) might impact transmission or create new peak loads if not managed. Most utility-scale batteries are operated under contract with a utility and provide services such as frequency regulation, capacity, etc. For EFSC, one relevant issue is making sure any new transmission or substation upgrades needed for the BESS are accounted for. Also, batteries can respond rapidly to grid

[4] https://insideevs.com/news/711990/how-china-became-global-battery-manufacturing-leader/

signals, which is a benefit, but if there's a control malfunction it could cause abrupt swings – thus control systems and compliance with interconnection requirements (like IEEE 1547, etc.) are examined. Reliability standards (NERC) now include battery storage as assets that must meet certain performance in contingencies. EFSC's process will likely incorporate ODOE and utility input to verify that a proposed BESS won't adversely affect grid stability (except in the positive ways intended).

The good news for all of the above (although it can make review more challenging) is that industry learning curves are steep – each year brings improvements in battery safety (better cooling, fire suppression, battery chemistries with lower risk) and in asset management (smarter battery management systems to extend life).

CONCLUSION

Battery Energy Storage Systems are rapidly becoming essential infrastructure as Oregon pursues ambitious renewable energy targets and seeks reliable, resilient power solutions. While Li-on technology remains dominant in current projects, ongoing advancements in battery chemistries and storage solutions promise to diversify options, enhance performance, and address safety, supply chain, and environmental concerns.

EFSC's potential for for jurisdiction under HB 4015 provides an important mechanism for thorough oversight of these facilities, ensuring that battery projects approved across Oregon meet rigorous standards for public safety, environmental stewardship, and grid reliability. As the landscape of utility-scale energy storage evolves, EFSC will play a pivotal role in guiding responsible and sustainable deployment that aligns with Oregon's energy future.