DOCKETED	
Docket Number:	25-OPT-02
Project Title:	Prairie Song Reliability Project
TN #:	269156
Document Title:	City of Vacaville Disallows Lithium Ion Technology
Description:	Parts 1 -3 Combined
Filer:	Marianna Brewer
Organization:	Ruthie Brock
Submitter Role:	Public
Submission Date:	3/12/2026 4:14:04 PM
Docketed Date:	3/12/2026

Agenda Item No. 11A
March 10, 2026

TO: Honorable Mayor and City Council Members
Attention: Savita Chaudhary, City Manager

FROM: Erin Morris, Director of Community & Economic Development
(Staff contact: Albert Enault, Senior Planner (707) 449-5364)

SUBJECT: RESOLUTION OF THE CITY OF VACAVILLE CITY COUNCIL AFFIRMING THE BATTERY ENERGY STORAGE SYSTEM ORDINANCE IS EXEMPT FROM ENVIRONMENTAL REVIEW PURSUANT TO SECTION 15061(b)(3) OF THE CALIFORNIA ENVIRONMENTAL QUALITY ACT GUIDELINES; *and*

ORDINANCE OF THE CITY OF VACAVILLE CITY COUNCIL AMENDING TITLE 14 OF THE CITY OF VACAVILLE MUNICIPAL CODE BY ADDING CHAPTER 14.09.271 ENTITLED BATTERY ENERGY STORAGE SYSTEMS, TO CREATE NEW POLICIES, PROCEDURES, AND STANDARDS FOR REGULATING BATTERY ENERGY STORAGE SYSTEMS IN THE CITY OF VACAVILLE (FIRST READING)

ACTION FOR CONSIDERATION:

The City Council will consider affirming the Battery Energy Storage Systems (BESS) ordinance is exempt from environmental review and adopting a Zoning Ordinance for regulating BESS facilities in the City of Vacaville.

RECOMMENDATION:

1. By simple motion, adopt the subject resolutions; and
2. By title only, introduce the subject ordinance and waive reading of the title per Government Code §36934.

BACKGROUND:

On May 14, 2024, the City Council adopted an interim ordinance (Ordinance No. 1933), which imposed as an urgency measure a prohibition on the application acceptance, approval, commencement, establishment, operation, relocation, or expansion of grid-scale BESS facilities within the City. On June 25, 2024, the interim ordinance was extended until May 14, 2026, to promote public health, safety, and welfare to provide City staff time to research and develop a local ordinance to address grid-scale BESS facilities. The moratorium was intended to protect Vacaville from potential proposals that would conflict with the requirements of the City's General Plan and zoning regulations and produce irreversible incompatible land uses and adverse impacts on residents, businesses, and neighborhoods that could be considered detrimental to the public health, safety, or welfare.

On January 9, 2024, the City Council authorized the City Manager to enter into an agreement with Larsen & Toubro (L&T) for the preparation of a feasibility study for the development of a series of energy hubs throughout Vacaville. Following City Council's decision to impose a temporary BESS moratorium on May 14, 2024, the scope of work with L&T was amended to include a report on different battery chemistries and technologies that are technically and commercially viable for utility-scale deployment. On December 11, 2025, the City received the L&T report, which is intended as a technical and policy resource for city staff, officials, and community stakeholders involved in BESS-related decision-making. The L&T report (Attachment 4) aims to support the City's efforts to:

- Compare and shortlist BESS technologies that meet the scale, safety, and reliability standards required for long-duration storage and grid support.
- Guide ordinance development and permitting frameworks as the City considers how to refine or lift the BESS moratorium.
- Clarify tradeoffs between leading BESS technologies, especially in terms of fire risk, siting constraints, and long-term cost-effectiveness

BESS technologies were evaluated based on their operational characteristics, safety risks (e.g., thermal runaway and flammability), discharge duration, lifecycle performance, and overall commercial readiness. The L&T report identifies two leading candidates based on safety, performance, and regulatory alignment: (a) Lithium-Ion Batteries (LIB), particularly the Lithium Iron Phosphate (LFP) subtype; and (b) Flow Batteries, specifically Vanadium Redox Flow Batteries (VRFB) as an emerging complementary long-duration solution. Table 1 below is an excerpt from the report, which shows various common, uncommon, and emerging technologies.

Table 1 – BESS Technologies Suitable for Utility-Scale & Industrial

Technology	Duration	Utility-Scale Use	Industrial Use	Safety Profile
Lithium-ion (LFP)	2-4 hours	Yes	Yes	Fire Risk – Low
Lithium-ion (Nickle Manganese Cobalt, NMC)	2-4 hours	Yes	Yes	Fire Risk – High
Vanadium Redox Flow (VRFB)	6-12+ hours	Yes (Emerging)	Emerging	Fire Risk – None
Sodium-Sulfur (NaS)	6 hours	Yes	Uncommon	Fire Risk – Low
Lead-Acid	1-4 hours	No	Yes	Fire Risk – None
Zinc-based (e.g., Zn-Br flow, Zn-ion)	4-10 hours	Yes (Emerging)	Emerging	Fire Risk – None

As shown in Table 1 above, Lithium-ion battery types of the NMC varietal pose the greatest risk of fire from a thermal runaway event. Flow batteries represent one of the most promising emerging alternatives to lithium-ion for long-duration and utility-scale energy storage with little to no thermal safety concerns. Their non-flammable, water-based electrolyte characteristics nearly eliminate the thermal runaway risks inherent even in the safest lithium-ion chemistries. In addition, their independent scaling of energy and power, along with a 20- to 30-year design life, enable predictable long-term operation.

<u>City Council Direction</u>

On December 9, 2025, the Vacaville City Council held a study session on the draft ordinance, received public comments, and provided feedback to staff. During the public comment period, many commenters expressed concern about the dangers of thermal runaway from lithium-ion battery chemistry, the potential for toxic gas and fumes to affect nearby sensitive uses, insufficient buffers from residential uses, and the potential regional effects from a thermal runaway event. At the close of the public hearing, City Council deliberated and provided the following directions to staff:

A. Battery Chemistry – Council expressed a desire to prohibit any battery chemistry with high volatility and the potential for a thermal runaway event that would affect residents, businesses, and the City's public safety divisions responsible for responding to such events. As supported by the L&T report (Attachment 4), staff has updated the draft ordinance to prohibit any Lithium-ion battery chemistry within the City of Vacaville.

B. Proximity to Town of Elmira – Council expressed a desire to prohibit any BESS facilities near the Town of Elmira out of concern that such facilities would create additional hardship for the unincorporated Solano County town. Elmira contains the former Elmira wood treatment facility (APN 0142-010-130), which was identified by the California Department of Toxic Substances Control as a contaminated site.[1] In addition to concerns about existing hardship, staff conducted further research on the two potential sites near Elmira (Attachment 2).

   1. Easterly Wastewater Treatment Plant (EWWTP) – Previously, staff identified as a potential BESS site some land surrounding the City's wastewater treatment plant located at 6040 Vaca Station Road. After further evaluation, staff can confirm that this location would not be suitable due to the following:

      a. Risk – The risk of a potential closure of the EWWTP due to any type of emergency event stemming from a BESS facility located near the EWWTP facility would be unacceptable. Although the draft ordinance would prohibit volatile chemistry types, the larger utility grid-scale facilities are not flawless, and the potential still exists for an emergency event caused by calamity, such as earthquakes or flooding.
      b. Expansion – The City has observed the overall volume of sewer discharge received at the EWWTP, which has decreased because of Statewide regulations for water conservation. This decrease creates a higher concentration of solids that must be extracted from the effluent. The vacant land surrounding the EWWTP must be reserved by the City to allow for the future expansion of associated facilities that can accommodate the increase of bio-solids, such as drying beds and injection wells.
      c. Ownership – It should be noted that the vacant land surrounding the EWWTP is owned by the City, which provides an additional layer of protection from potential BESS facilities utilizing the streamlined process with the California Energy Commission, as the land could not be developed without the City's explicit approval as the owner.

   2. Brighton Landing Parcel (E95) – Located east of Brighton Landing, this vacant 95-acre parcel is located within the city limits, but outside of the City's Urban Growth Boundary, which means no development can occur until after March 2028. After engaging the property owner of this parcel, staff can confirm this location is not suitable for development because the property owner will be seeking to develop this site with future residential development that would complement the existing Brighton Landing

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[1] Toxic backyards: State dollars pay for abandoned sites. April 25, 2014. KCRA3. URL: https://www.kcra.com/article/toxic-backyards-state-dollars-pay-for-abandoned-sites/6413268#:~:text=So%20much%20contamination%20occurred%20at%20this%20site,had.%20California%20Department%20of%20Toxic%20Substances%20Control.

subdivision. Development of the site would not be pursued until the Urban Growth Boundary has expired.

New Opt-In Certification Project

On January 28, 2026, the California Energy Commission (CEC) notified the City of Vacaville about a new BESS project that was submitted through their “Opt-In Certification” program. The new BESS project is labeled the Vaca Dixon Power Center Project (26-OPT-01) and is located on a 10-acre site along Kilkenny Road on Assessor Parcel Number 0133-060-060, within Vacaville city limits. Vaca Dixon BESS LLC and Arges BESS LLC are proposing two BESS facilities consisting of a 57 megawatt-hour (MWh) BESS and 400 MWh. Attachment 1 includes a vicinity map depicting the location existing BESS project under the CEC “Opt-In” process. Attachment 5 depicts the referral sent to the City of Vacaville. In response to this referral, the City issued a letter to notify the CEC about the draft ordinance and requested future BESS projects comply with the City’s ordinance when located within Vacaville city limits. The City’s letter is also included under Attachment 5.

Revisions to Draft Ordinance

The information in the L&T report supports the City Council’s direction to disallow any Lithium-ion chemistry type that has the potential for a thermal runaway event. The draft ordinance has been revised to exclude any Lithium-ion battery types until such a time when the threat of thermal runaway is eliminated. In addition, staff has conducted further analysis to determine whether any sites remain suitable for potential BESS facilities, which is also described below.

DISCUSSION:

Staff is proposing amendments to the VMC by adding Chapter 14.09.271 entitled “Battery Energy Storage Systems” to create new policies, procedures, and standards for regulating BESS facilities within the City of Vacaville (Exhibit B to the subject ordinance). Pursuant to VMC Chapter 14.09.020, the Planning Commission is responsible for making a recommendation on the proposed zoning text amendments, and the City Council shall have the final decision to either approve, modify, or deny the amendments. The following sections describe the ordinance framework, edits made to address City Council’s comments, and additional analysis on the suitability of potential sites.

Draft Ordinance

The proposed ordinance is intended to implement the goals and objectives of the General Plan and to guide and manage BESS facilities within the city. Existing General Plan policies help protect the physical, social, and economic stability of residential, commercial, industrial, and other land uses within the city to ensure its orderly and beneficial development. Proposed standards are designed to reduce hazards to the public and emergency responders resulting from the inappropriate location, use, or design of buildings and other improvements. Included as Exhibit B to the subject ordinance, the draft framework of the ordinance is outlined below:

1. Definitions and Applicability
   - Describes the purpose and applicability of the ordinance
   - Defines Battery Energy Storage Systems and provides definitions
   - Revised to prohibit any Lithium-ion battery chemistry

2. Land Use & Siting Standards
    - Conditionally Permitted in PF, IP, and BP zoning districts
    - Not allowed in high or very high fire hazard severity zones
    - Not allowed in Nut Tree Airport Compatibility zones
    - Not allowed in the Northeast Growth Area until the Specific Plan is prepared
    - Increased buffer distance from 300 to 500 feet from sensitive uses (e.g., residential, hospitals, schools)

3. Development Standards
    - Lighting and Noise
    - Security and Screening
    - Battery Chemistry Technology
    - Landscaping

4. Permitting Process
    - Preliminary Application Process
    - Formal Application Process
    - Submittal Requirements
    - Technical Studies (e.g., Plume Analysis, Hazard Mitigation Analysis)
    - Environmental Review

5. Public Benefit Agreement Criteria
    - Applicable to Tier 2 and Tier 3 (NFPA)
    - Examples could include training and equipment for emergency personnel, investments in local organizations or community projects, contributions to City initiatives, or projects that benefit the community

6. Commissioning/Decommissioning
    - Added language to require additional financial assurances at commissioning and decommissioning of BESS facility
    - Safety Requirements
    - Ownership Changes

<u>Suitability Analysis</u>

Previously, staff prepared a suitability analysis to determine whether Vacaville had any locations that could accommodate BESS facilities with the implementation of the draft ordinance. As shown by Attachment 2, the previous mapping exhibits depicted three potential sites: EWWTP, the E95 Parcel east of Brighton Landing, and the former Gibson Canyon Wastewater Treatment Plant (GCWWTP). As noted above, the EWWTP and E95 Parcel would not be suitable for potential BESS facilities, so these areas have been removed from consideration. However, staff further evaluated the GCWWTP location including potential scenarios with increased setbacks from sensitive uses with buffers at 300 feet, 500 feet, and 700 feet.

As shown by Attachment 3, the GCWWTP location contains sufficient land to accommodate larger setbacks from sensitive uses. The alternate suitability analysis is intended to show that the GCWWTP should not be outright prohibited under the ordinance because the site is large enough to include larger setbacks, earthen berms, and landscaping that can help provide sufficient screening from adjoining properties. Staff found that the City could increase protection for sensitive receptors by increasing the buffer distance from 300 ft. to 500 ft. Staff evaluated a scenario for a 1,000 ft. buffer but found that the increased buffer would eliminate almost the entire property. As proposed, the revised ordinance increases the minimum buffer from sensitive uses from 300 ft. to 500 ft. Ultimately, the City retains the authority as the property owner to control any proposal seeking to develop on this location. Staff believes this location still holds the potential for a grid-scale BESS facility, while simultaneously providing larger setbacks to address community concerns.

Solano County Airport Land Use Commission

Pursuant to California Public Utilities Code (PUC) Section 21676(b) and VMC Section 14.09.110.070, any proposed amendment to the zoning ordinance that may impact airport operations must be referred to the Solano County Airport Land Use Commission (ALUC) to determine consistency with land use compatibility plans for the Nut Tree Airport and Travis Air Force Base. California PUC Section 21676(b) and VMC Section 14.09.110.070.A require that the ALUC review the proposed Zoning Text Amendments for consistency prior to action being taken by the decision maker. Pursuant to VMC Section 14.01.030.020.A.3, the City Council is the decision maker for the project. On January 8, 2026, the ALUC reviewed the amendments and found the proposed ordinance was consistent with the compatibility plans for the Nut Tree Airport and Travis Air Force Base.

Planning Commission Meeting

On January 20, 2026, the Planning Commission held a hearing to consider the proposed project, staff analysis, and public comments. Staff made a presentation outlining the project and specific concerns with the deviations. Members of the public also spoke regarding the project, expressing support for the regulations and the prohibition on lithium-ion battery technology. To better inform the City Council, the report includes a few pertinent questions with responses from staff:

1. Why does the ordinance include standards for regulating lithium-ion technology when the ordinance prohibits all lithium-ion chemistry?

   Staff's Response: Applications submitted to the CEC through the "Opt-In Certification" process may include lithium-ion battery technology. Although such chemistry is prohibited within Vacaville, City regulations would be superseded by State regulations, which may allow such technology. CEC applications referred to the City would be evaluated for compliance with the City's ordinance. If no standards exist for lithium-ion technology, then the City's comments would be limited and ineffective. Including standards for regulating lithium-ion technology provides additional protection and the City can urge voluntary compliance with our standards.

2. Why does the ordinance not mention public outreach requirements?

   On January 28, 2020, the Vacaville City Council adopted the Vacaville Public Involvement Strategy for Land Use Planning (Resolution No. 2020-018) that outlines minimum requirements for public notification based on a tiered scale approach. Future development would need to comply with this resolution. New BESS facilities would be categorized as a "large impact" project, meaning that the project has the potential to impact a large area of the City. Notification for these types of projects include an expanded mailing distribution, social media and website posts, newspaper publications, community meetings and public hearings.

3. Are there standards for regulating the accidental discharge of chemicals?

   The draft ordinance includes two areas that explicitly require remediation for accidental failure. Under Section 14.09.271.030.B.2, the ordinance requires BESS facility owners to reimburse the City and property owners for costs associated with damage and remediation to the environment, agriculture, residents, and businesses resulting from a thermal runaway incident or other hazardous incident.

   Under Section 14.09.071.050.B.5.f, the ordinance requires a Financial Assurance Plan, including liability insurance that provides coverage for thermal runaway events or other hazardous incidents, pollution and other environmental damages. The Financial Assurance Plan requires the BESS facility owner to reimburse all damaged parties.

At the conclusion of the meeting, the Planning Commission voted unanimously (7-0) to recommend approval of the draft ordinance to the City Council, with no modifications or alterations. The Planning Commission staff report is included as Attachment 7.

Public Outreach

The public outreach for this project was conducted in accordance with the City's Public Involvement Strategy for Land Use Planning (Resolution No. 2020-018). Table 2 outlines the notification efforts for this project.

Table 2 – Public Outreach Schedule

Date	Meeting Type	Notice Requirements
Oct. 22, 2025	Community Meeting	Website, Social Media, Newspaper Notice
Nov. 18, 2025	PC Study Session	Website, Social Media, Newspaper Notice
Dec. 9, 2025	CC Study Session	Website, Social Media, Newspaper Notice
Jan. 20, 2026	PC Public Hearing	Website, Social Media, Newspaper Notice
Mar. 10, 2026	CC Public Hearing	Website, Social Media, Newspaper Notice

ENVIRONMENTAL IMPACTS

The draft ordinance is exempt (Common Sense Exemption) from the provisions of the California Environmental Quality Act (CEQA) pursuant to CEQA Guidelines Section 15061 (b) (3) since there is no possibility that the addition of regulations for BESS facilities to the Vacaville Municipal Code may have a significant effect on the environment. Proposed future BESS facilities will be reviewed under CEQA at the time of application to determine appropriate environmental review.

FISCAL IMPACT:

Amount Requested: None

Funding Source: Community & Economic Development Department (2022)

Budget Distribution: The budget for any expenses related to this item is included in the Community & Economic Development annual operating budget.

ALTERNATIVES

1. The Council could choose to modify the Planning Commission's recommendation by adding or removing language. Staff advises caution with this option because the ordinance has been drafted in consultation with the City Attorney's Office and Fire Department.
2. The Council could choose to no adopt the ordinance. Staff does not advise this option because the ordinance is needed to help protect the public health, safety, and welfare of the community.

STRATEGIC PLAN GOAL/INITIATIVE:

Goal #1 – Ensure Public Safety

Goal #2 – Strengthen the Local Economy
Initiative 2B: Manage Impacts from Growth

Goal #4 – Maintain Effective and Efficient Services
Initiative 4A: Ensure Fiscal Sustainability

LEVINE ACT: No

ATTACHMENTS:

Resolution – Action Item
  Exhibit A – Findings of Fact

Ordinance – Action Item
  Exhibit A – Findings of Fact
  Exhibit B – Zoning Text Amendments

Attachment 1: Vicinity Map
Attachment 2: Previous Suitability Analysis
Attachment 3: Updated Suitability Analysis
Attachment 4: Larsen & Toubro Study
Attachment 5: Notification of Vaca Dixon Power Center BESS Project
Attachment 6: Public Comments
Attachment 7: Planning Commission Staff Report from January 20, 2026

RESOLUTION NO. 2026-

RESOLUTION OF THE CITY OF VACAVILLE CITY COUNCIL AFFIRMING THE BATTERY ENERGY STORAGE SYSTEM ORDINANCE IS EXEMPT FROM ENVIRONMENTAL REVIEW PURSUANT TO SECTION 15061(b)(3) OF THE CALIFORNIA ENVIRONMENTAL QUALITY ACT GUIDELINES

WHEREAS, there is a growing demand for Battery Energy Storage Systems ("BESS") facilities in the state of California due to increased demand for renewable electricity to reach the State's clean energy goals and mechanisms to ensure reliability of the State's electric system, among other things; and

WHEREAS, there have been several recent fires at BESS facilities both in California and nationwide. BESS facilities that use lithium-ion batteries create particularly unique fire and explosion hazards. Information suggests that lithium-ion batteries are inherently safe and stable when installed properly, however certain conditions elevate the risk of fire and thermal runaways, such as impact, puncture, or mechanical damage, overcharging, overheating, and/or short circuits; and

WHEREAS, the City of Vacaville does not have land use policies or standards in place to regulate the location and operation of BESS facilities within the City of Vacaville which would address compatibility with surrounding uses and safety among other issues; and

WHEREAS, the potential for the development of new grid-scale BESS facilities within Solano County without adequate land use policies and standards in place to prevent potentially catastrophic interference with nearby communities presented an immediate threat to the public's safety and welfare, and the approval of land use entitlements for such uses would result in that threat to public safety and welfare; and

WHEREAS, on May 14, 2024, the City Council adopted, by a four-fifths affirmative vote (7-0), an interim ordinance imposing as an urgency measure a prohibition on the application acceptance, approval, commencement, establishment, operation, relocation or expansion of grid-scale BESS facilities within City limits (Ordinance No. 1993); and

WHEREAS, on June 25, 2024, the City Council adopted, by a four-fifths affirmative vote (7-0), to extend the interim ordinance pursuant to Government Code Section 65858 for an additional period of up to 22 months and 15 days, establishing a temporary moratorium until May 14, 2026 (Ordinance No. 1994); and

WHEREAS, the City of Vacaville has prepared a draft ordinance to establish policies, procedures and standards for regulating BESS facilities within city limits, and has provided opportunity for public comments during study sessions with the Vacaville City Council and Planning Commission; and

WHEREAS, pursuant to Section 15061(b)(3) of the California Environmental Quality Act (CEQA), the City of Vacaville Community Development Department has determined that the project is exempt from additional environmental review because it can be seen with certainty that there is no possibility that a project will have a significant effect on the environment; and

WHEREAS, the Planning Commission held a duly noticed public hearing on January 20, 2026, to consider the proposed BESS Ordinance where they received testimony from City staff, the Applicant, and all interested persons regarding the draft ordinance; and

WHEREAS, the Planning Commission voted 7-0 to recommend that the City Council affirm the BESS Ordinance is exempt from environmental review pursuant to CEQA Section 15061(b)(3), and adopt the Zoning Text Amendments for the BESS Ordinance, based on the Findings of Fact as shown in Exhibit A; and

WHEREAS, the City Council held a duly noticed public hearing on March 10, 2026, to consider the proposed environmental determination and BESS Ordinance, where they received testimony from City staff and all interested persons regarding the proposed project, and also considered testimony and evidence submitted at the Planning Commission hearing; and

NOW, THEREFORE, BE IT RESOLVED by the City Council of the City of Vacaville as follows:

Section 1. The City Council hereby finds that the facts set forth in the recitals to this Resolution are true and correct and establish the factual basis for the City Council's adoption of this Resolution.

Section 2. The City Council has considered the BESS Ordinance and all potential impacts to the environment, and hereby affirms the Zoning Text Amendments are exempt from environmental review in accordance with CEQA Section 15061(b)(3) because it can be seen with certainty that there is no possibility that the text amendments will have a significant effect on the environment, as supported by the findings shown in Exhibit A.

Section 3. This Resolution shall take effect immediately upon its adoption.

I HEREBY CERTIFY that the foregoing resolution was introduced and passed at a regular meeting of the City Council of the City of Vacaville, held on the 10th day of March 2026, by the following vote:

AYES:

NOES:

ABSENT:

ATTEST:

____
Michelle A. Thornbrugh, City Clerk

List of Exhibits

Exhibit A – Findings of Fact

EXHIBIT A TO RESOLUTION NO. 2026-____

BATTERY ENERGY STORAGE SYSTEMS ORDINANCE
CEQA Findings of Fact
Citywide Ordinance
Categorical Exemption, Zoning Text Amendment, and Airport Area of Influence Review
File No. 24-059

Code sections referenced below are from the Vacaville Municipal Code (VMC) or the California Environmental Quality Act (CEQA), unless otherwise specified.

SUMMARY OF EVIDENCE

The decision-maker bases its decision on the following information: (1) the project application, including attachments and related studies; (2) the staff reports, City files, records and other documents prepared for and/or submitted to the City relating to the environmental review and the project itself; (3) the evidence, facts, findings and other determinations set forth in this resolution; (4) the Vacaville General Plan, the Vacaville Land Use and Development Code and other applicable plans, codes and resolutions of the City of Vacaville; (5) all documentary and oral evidence received at public workshops, neighborhood meetings, and hearings or submitted to the City during the comment period relating to the project or the environmental review; (6) the minutes and recordings at public hearings; and (7) all other matters of common knowledge to the to the City, including, but not limited to, City, state, and federal laws, policies, rules, regulations, reports, records and projections related to development within the City and its surrounding areas.

ENVIRONMENTAL REVIEW FINDINGS

VMC Section 14.03.021.010 Exemptions

Pursuant to CEQA Section 15061(b)(3), the City of Vacaville Community Development Department has determined that the project is exempt from the provisions of CEQA because it can be seen with certainty that there is no possibility that the project will have a significant effect on the environment. The determination is supported by the following factual evidence.

A. The Vacaville City Council hereby adopts the following findings to support the decision that the project is exempt from environmental review under CEQA Section 15061(b)(3):

Finding: The Lead Agency has evaluated the potential for project-related impacts resulting from the draft zoning text amendments and hereby concludes that the proposed changes will not result in any foreseeable impact to the environment. This determination is supported by the following claims: (1) the ordinance does not authorize or approve entitlements to construct or make any physical change to the environment; (2) the policies, procedures, and standards provide directions for processing new development applications that will require subsequent environmental analysis; (3) the ordinance does not exempt any future project from environmental review and ensures consistency with the California Environmental Quality Act; (4) the ordinance requires the submittal of technical information that will help determine the level of environmental impacts required for any new Battery Energy Storage Systems (BESS) facility; (5) the ordinance does not authorize new uses or physical development and does not expand *the range of allowable land uses beyond what is already permitted under existing state law; and (6) the ordinance modifies and clarifies local permitting procedures to ensure consistency with state requirements.*

Environmental Review Conclusion

The City Council has concluded that no additional environmental review is required pursuant to CEQA Section 15061(b)(3) of the CEQA Guidelines.

ORDINANCE NO.
(First Reading)

IORDINANCE OF THE CITY OF VACAVILLE CITY COUNCIL AMENDING TITLE 14 OF THE CITY OF VACAVILLE MUNICIPAL CODE BY ADDING CHAPTER 14.09.271 ENTITLED BATTERY ENERGY STORAGE SYSTEMS, TO CREATE NEW POLICIES, PROCEDURES, AND STANDARDS FOR REGULATING BATTERY ENERGY STORAGE SYSTEMS IN THE CITY OF VACAVILLE

WHEREAS, there is a growing demand for Battery Energy Storage Systems ("BESS") in the state of California due to increased demand for renewable electricity to reach the State's clean energy goals and mechanisms to ensure reliability of the State's electric system, among other things; and

WHEREAS, there have been several recent fires at BESS facilities both in California and nationwide. BESS facilities that use lithium-ion batteries create particularly unique fire and explosion hazards. Information suggests that lithium-ion batteries are inherently safe and stable when installed properly, however certain conditions elevate the risk of fire and thermal runaways, such as impact, puncture, or mechanical damage, overcharging, overheating, and/or short circuits; and

WHEREAS, the City of Vacaville does not have land use policies or standards in place to regulate the location and operation of BESS facilities within the City of Vacaville which would address compatibility with surrounding uses and safety among other issues; and

WHEREAS, the potential for the development of new grid-scale BESS facilities within Solano County without adequate land use policies and standards in place to prevent potentially catastrophic interference with nearby communities presented an immediate threat to the public's safety and welfare, and the approval of land use entitlements for such uses would result in that threat to public safety and welfare; and

WHEREAS, on May 14, 2024, the City Council adopted, by a four-fifths affirmative vote (7-0), an interim ordinance imposing as an urgency measure a prohibition on the application acceptance, approval, commencement, establishment, operation, relocation or expansion of grid-scale BESS facilities within City limits (Ordinance No. 1993); and

WHEREAS, on June 25, 2024, the City Council adopted, by a four-fifths affirmative vote (7-0), to extend the interim ordinance pursuant to Government Code Section 65858 for an additional period of up to 22 months and 15 days, establishing a temporary moratorium until May 14, 2026 (Ordinance No. 1994); and

WHEREAS, the City of Vacaville has prepared a draft ordinance to establish policies, procedures and standards for regulating BESS facilities within city limits, and has provided opportunity for public comments during study sessions with the Vacaville City Council and Planning Commission; and

WHEREAS, pursuant to Section 15061(b)(3) of the California Environmental Quality Act (CEQA), the City of Vacaville Community Development Department has determined that the project is exempt from additional environmental review because it can be seen with certainty that there is no possibility that a project will have a significant effect on the environment; and

WHEREAS, the Planning Commission held a duly noticed public hearing on January 20, 2026, to consider the proposed BESS Ordinance where they received testimony from City staff, the Applicant, and all interested persons regarding the draft ordinance; and

WHEREAS, the Planning Commission voted 7-0 to recommend that the City Council conclude the BESS Ordinance is exempt from environmental review pursuant to CEQA Section 15061(b)(3), and adopt the Zoning Text Amendments for the BESS Ordinance, based on the Findings of Fact as shown in Exhibit A; and

WHEREAS, the City Council held a duly noticed public hearing on March 10, 2026, to consider the proposed environmental determination and BESS Ordinance, where they received testimony from City staff and all interested persons regarding the proposed project, and also considered testimony and evidence submitted at the Planning Commission hearing; and

WHEREAS, the City Council has considered the BESS Ordinance and all potential impacts to the environment, and concluded the Zoning Text Amendments are exempt from environmental review in accordance with CEQA Section 15061(b)(3) because it can be seen with certainty that there is no possibility that the text amendments will have a significant effect on the environment, which is hereby referenced as City Council Resolution No. 2026-_____.

NOW, THEREFORE, THE CITY COUNCIL OF THE CITY OF VACAVILLE DOES ORDAIN AS FOLLOWS:

SECTION 1. The City Council hereby finds that the facts set forth in the recitals to this Ordinance are true and correct and establish the factual basis for the City Council's adoption of this Ordinance.

SECTION 2. Based on the entire record for the BESS Ordinance, the City Council hereby finds that the amendment to the Vacaville Municipal Code meets the findings and supporting facts and evidence are set forth in detail in the Findings of Fact document attached hereto as Exhibit A, which is hereby incorporated by this reference into this Ordinance as if fully set forth herein.

SECTION 3: The City Council hereby approves and adopts the proposed amendments to the Vacaville Municipal Code as set forth in Exhibit B hereto, such zoning amendments being approved in accordance with Vacaville Municipal Code Chapter 14.09.020.

SECTION 4: If any section, subsection, phrase, or clause of this ordinance is for any reason held to be unconstitutional, such decision shall not affect the validity of the remaining portions of this ordinance. The City Council hereby declares that it would have passed this ordinance and each section, subsection, phrase or clause thereof irrespective of the fact that any one or more section, subsection, phrases or clauses be declared unconstitutional.

SECTION 6: This ordinance shall be published in accordance with the provisions of Government Code Section 36033, and shall become effective thirty (30) days after its passage.

I HEREBY CERTIFY that this ordinance was **INTRODUCED** at a regular meeting of the City Council of the City of Vacaville on the 10th day of March 2026, by the following vote:

AYES:

NOES:

ABSENT:

ATTEST:

____
Michelle Thornbrugh, City Clerk

List of Exhibits

Exhibit A: Findings of Fact
Exhibit B: Zoning Text Amendments

EXHIBIT A TO ORDINANCE NO. ______

BATTERY ENERGY STORAGE SYSTEMS ORDINANCE
Zoning Text Amendments Findings of Fact
Citywide Ordinance
Categorical Exemption, Zoning Text Amendment, and Airport Area of Influence Review
File No. 24-059

Code sections referenced below are from the Vacaville Municipal Code (VMC) or the California Environmental Quality Act (CEQA), unless otherwise specified.

SUMMARY OF EVIDENCE

The decision-maker bases its decision on the following information: (1) the project application, including attachments and related studies; (2) the staff reports, City files, records and other documents prepared for and/or submitted to the City relating to the environmental review and the project itself; (3) the evidence, facts, findings and other determinations set forth in this resolution; (4) the Vacaville General Plan, the Vacaville Land Use and Development Code and other applicable plans, codes and resolutions of the City of Vacaville; (5) all documentary and oral evidence received at public workshops, neighborhood meetings, and hearings or submitted to the City during the comment period relating to the project or the environmental review; (6) the minutes and recordings at public hearings; and (7) all other matters of common knowledge to the to the City, including, but not limited to, City, state, and federal laws, policies, rules, regulations, reports, records and projections related to development within the City and its surrounding areas.

ZONING TEXT AMENDMENT FINDINGS

VMC Section 14.04.030.040 Findings Required for Approval

In order to approve a Zoning Text Amendment, the City Council shall find that:

A. That the proposed amendment is internally consistent with the goals, objectives, and policies of the General Plan, the Zoning Ordinance, and the Land Use and Development Code;

Finding: The ordinance meet this finding, because: (1) the ordinance implements General Plan Goal LU-18 to ensure orderly, well-planned growth in the Northeast Growth Area; (2) the ordinance protects established neighborhoods from incompatible uses by prohibiting lithium-ion battery chemistry and requiring buffers from sensitive uses, as required by Policy LU-P1.4; (3) the City has provided notification and public hearings to discuss the zoning text amendments as required by Policy LU-P7.1; (4) the City used traditional and new media tools for communicating with the public, including USPS mail, emails and a separate website dedicated to providing information to the public (Policy LU-P7.2); (5) the project is consistent with the City's Zoning Ordinance because notification of public hearings has been provided to the public; and (6) the City provided adequate notification about the project in accordance with VMC Section 14.09.030.070.

B. That the proposed amendment would not be detrimental to the public health, safety, or welfare of the community;

Finding: The project meets this finding because: (1) the amendment establishes policies, procedures, and standards for regulating the construction and operation of BESS facilities in Vacaville; (2) any new development application for a BESS facility will be required to comply with the new ordinance and conduct environmental analysis to determine project-related impacts on the environment; (3) any new BESS facility will be required to comply with the California Building Code and the California Fire Code; and (4) the amendment will not conflict with the existing land use compatibility plans for the Nut Tree Airport and Travis Air Force Base.

C. That the proposed amendment would maintain an appropriate balance of land uses within the City;

Finding: The project meets this finding because: (1) the zoning text amendments establishes location requirements and development standards that would prevent the proliferation of BESS facilities throughout Vacaville; (2) the zoning text amendments will prohibit lithium-ion batteries and will require increase buffers away from sensitive land uses to protect the public health, safety, and welfare; and (3) the zoning text amendments will not displace any existing land uses and will not result in a disproportionate balance of land uses.

D. That the anticipated land uses on the subject site would be compatible with existing and future surrounding uses;

Finding: The project meets this finding because: (1) the ordinance does not authorize any new BESS facilities; (2) the policies, procedures, and standards within the draft ordinance are intended to avoid potential incompatibility issues with existing and future surrounding land uses by imposing setback standards from sensitive uses; (3) the ordinance will prohibit volatile technologies such as Lithium-Ion batteries to reduce the risk for thermal runaway events; and (4) the ordinance includes requirements for technical reports to help determine the potential impacts on existing and future surrounding uses.

E. That the potential impacts to the City's inventory of residential lands has been considered; and

Finding: The project meets this finding because: (1) the potential sites do not have the capacity to accommodate residential development, and the project will not affect any existing residential inventory; and (2) the ordinance includes development standards with setbacks to provide safe separation from residential lands and other sensitive uses.

F. That the proposed amendment is consistent with any development-related application that is processed and approved concurrently with the amendment application.

Finding: Not applicable. There are no development-related applications that are being approved concurrently with the amendment application.

<u>Zoning Text Amendment Conclusion</u>

Based on the facts and findings above, the project meets the required findings for approving the proposed Zoning Text Amendments.

EXHIBIT B TO ORDINANCE NO. ______

BATTERY ENERGY STORAGE SYSTEMS ORDINANCE
Draft Ordinance Language
Citywide Ordinance
Categorical Exemption, Zoning Text Amendment, and Airport Area of Influence Review
File No. 24-059

New text is shown below in underlined font, and text to be removed is shown in ~~strikethrough~~ font.

SECTION I

Division 14.09 of the Vacaville Municipal Code is amended to create Chapter 14.09.271 and add the following text to the chapter:

Chapter 14.09.271
Battery Energy Storage Systems.

Section 14.09.271.010 Purpose and Applicability

A. Purpose. The provisions of this Title are hereby established and adopted to protect and promote the public health, safety, morals, comfort, convenience, and welfare, and more particularly to:

1. Implement the goals and objectives of the general plan and guide and manage development within the city in accordance with such plan.

2. Protect the physical, social, and economic stability of residential, commercial, industrial, and other land uses within the city to assure its orderly and beneficial development.

3. Reduce hazards to the public and emergency responders resulting from the inappropriate location, use, or design of buildings/structures and other improvements.

4. Attain the physical, social, and economic advantages resulting from comprehensive and orderly land use and resource planning.

5. To prioritize public safety over exploitation of corporate profit.

B. Applicability. The requirements of this ordinance shall apply to all Tier 2 and Tier 3 front-of-the-meter Battery Energy Storage Systems that are permitted and installed in the City of Vacaville after the effective date of this ordinance. This ordinance does not extend to the general maintenance and repair of battery energy storage systems permitted, installed, or modified prior to the effective date of this ordinance. This ordinance does not apply to behind-the-meter Battery Energy Storage Systems supporting residential, commercial, agricultural, and industrial uses.

C. Exclusions. Tier 2 and Tier 3 Battery Energy Storage Systems that contain “Lithium-ion” or any technology type with documented occurrences of thermal runaway events shall not be permitted within the City of Vacaville.

Section 14.09.271.020 Definitions

"Energy Storage" means any technology that is capable of absorbing electricity, storing the electricity for a period of time, and redelivering the electricity.

"Battery Energy Storage System" (BESS) means an electrochemical device, with a rated capacity of equal to or greater than 1,000-kilowatt hours (1 megawatt hour), that charges or collects energy from the grid or a generation facility, stores that energy, and then discharges that energy at a later time to provide electricity or other grid services when needed. For the purpose of this chapter, the definition or term “BESS” shall not include any chemistry type involving “Lithium-ion” or any technology type with documented occurrences of thermal runaway events.

“Behind-the-meter (BTM) Battery Energy Storage System” refers to a Battery Energy Storage System (BESS) installed on the customer’s side of the utility meter. These systems are designed to support energy use by providing backup power, demand charge management, load shifting, or renewable energy integration.

“Commissioning” means a systematic process that provides documented confirmation that a battery energy storage system functions according to the intended design criteria and complies with applicable code requirements.

“Decommissioning Plan” means a plan to retire the physical facilities of the Project, including decontamination, dismantlement, rehabilitation, landscaping and monitoring. The plan contains detailed information on the proposed decommissioning and covers the schedule, type and sequence of decommissioning activities; waste management, storage and disposal of the waste from decommissioning; the timeframe for decommissioning and site rehabilitation.

“Front-of-the-meter (FTM) Battery Energy Storage System” refers to a Battery Energy Storage System (BESS) that is directly connected to the transmission or distribution grid and primarily serves wholesale market functions such as grid support, frequency regulation, or energy arbitrage.

Hazard Mitigation Analysis (HMA) is a systematic method that considers the various hazards related to the installation, identifies potential failure modes as well as their causes and effects, and develops appropriate mitigation solutions. HMAs evaluate the consequences of thermal runaway conditions, failure of an energy storage management system, failure of a required ventilation or exhaust system, and failure of a required smoke/fire detection system, fire suppression, or gas detection system.

“IEEE” is the Institute of Electrical and Electronics Engineers is a global professional organization dedicated to advancing technology for the benefit of humanity. IEEE develops and maintains international standards in various fields of electrical and electronic engineering, computer science, and related disciplines.

“Lithium-ion” batteries refers to a battery where the negative electrode (anode) and positive electrode (cathode) materials serve as a host for the lithium ion (Li+). Lithium ions move from the anode to the cathode during discharge and are intercalated into (i.e., inserted into voids in the crystallographic structure of) the cathode. The ions reverse direction during charging. Since lithium ions are intercalated into host materials during charge or discharge, there is no free lithium metal within a lithium-ion cell and thus, even if a cell does ignite due to external flame impingement or an internal fault, metal fire suppression techniques are not appropriate for controlling the lithium-ion fire. Lithium ion is a generic term covering a number of different technologies, which can be broken down into the following three main groups that are currently commercially available:

1. Lithium metal oxide cathodes with a carbon anode [e.g., nickel cobalt aluminate (NCA) and nickel manganese cobaltate (NMC)]

2. Lithium phosphate cathode with a carbon anode [e.g., lithium iron phosphate (LFP)]

3. Lithium metal oxide cathode with a titanium oxide anode [e.g., lithium titanate (LTO)]

“National Fire Protection Association” (NFPA) is a nonprofit organization dedicated to eliminating death, injury, property, and economic loss due to fire, electrical, and related hazards. Established in 1896, the NFPA develops and publishes over 300 consensus codes and standards intended to minimize the risk and effects of fire by establishing criteria for building, processing, design, service, and installation in the United States and internationally. The NFPA’s mission extends beyond code development; it also focuses on research, training, education, and advocacy to promote safety and preparedness.

“National Electric Code” (NEC), also known as NFPA 70, is a set of standards for the safe installation of electrical wiring and equipment in the United States. Its primary purpose is to ensure the safety of electrical installations by setting forth requirements to protect people and property from electrical hazards. The NEC covers the installation of electrical conductors, equipment, and raceways; signaling and communications conductors and equipment; and fiber optics. It is updated every three years to incorporate new technologies and improve safety measures.

“NFPA 855” the Standard for the Installation of Stationary Energy Storage Systems, provides comprehensive guidelines for the safe installation of stationary energy storage systems (ESS), including those using lithium batteries. These standards address various aspects of installation to mitigate fire and explosion risks associated with energy storage technologies. It covers topics such as system design, construction, operation, and maintenance to ensure safety and reliability.

“Sensitive Receptors” shall include locations with hospitals, schools, and day care centers, residential uses, and such other locations as the air district board or California Air Resources Board may determine pursuant to the California Health and Safety Code §42705.5(a)(5).

“Thermal Runaway” refers to an uncontrollable, self-sustaining exothermic chain reaction within a battery energy storage system, initiated by a failure mechanism (e.g., internal short circuit, overcharging, physical damage, or thermal exposure). This reaction results in a rapid increase in cell temperature, leading to the release of flammable electrolytes, generation of toxic gases (e.g., hydrogen fluoride, carbon monoxide), and potential cascading failures to adjacent cells. If unmitigated, thermal runaway may cause fire, explosion, or hazardous material release, posing risks to public safety, property, and the environment.

Tier 1 (Residential-Scale) battery energy storage systems have a maximum stored energy capacity less than or equal to 20 kWh and, if in a room or enclosed area, consist of only a single energy storage system technology. The aggregate rating of the ESS shall not exceed the following for each location listed:

1. 40 kWh within utility closets, basements, and storage or utility spaces.

2. 80 kWh in attached or detached garages and detached accessory structures.

3. 80 kWh where outdoor wall or ground mounted.

Tier 2 (Medium-Scale/Commercial) battery energy storage systems have an aggregate energy capacity greater than 40 kWh, up to 600 kWh.

Tier 3 (Industrial-Scale/Public Utility) battery energy storage systems have an aggregate energy capacity greater than 600 kWh, ~~up to, but not exceeding, 200 mega-watt hours (MWh),~~ or battery energy storage systems with more than one storage battery energy technology (e.g., Lithium-ion, Lead-acid, Flow batteries, Nickel-based, Sodium-ion, and Solid-state batteries) is provided in a room or enclosed area. A HMA as outlined in NFPA 855 shall be required for lithium-ion ESS that exceed 600 kWh (2,160 MJ) for outdoor ESS installations, ESS installations in open parking garages and on rooftops of buildings, and mobile ESS equipment.

“UL 9540” is a standard for ESS and equipment. It is designed to ensure the safety of these systems and covers their construction, performance, and testing requirements. UL 9540 certification is essential for verifying that energy storage systems, such as batteries and related equipment, meet rigorous safety standards to prevent hazards related to electrical, mechanical, and environmental conditions.

Section 14.09.271.030 Land Use and Siting Standards

A. Land Use. Table 14.09.271.A, Land Use Regulations – Energy Uses, establishes the land use regulations for specific energy uses. In cases where a specific land use or activity is not defined, the Director of Community Development shall assign the land use or activity to a classification that is substantially similar in character. Land uses not listed in the table and not substantially like the uses identified below are prohibited. Within the Northeast Growth Area, the supplemental regulations identified in Section 14.09.060.040 are applicable.

TABLE 14.09.271.A: LAND USE REGULATIONS – ENERGY USES

“P” = Permitted Use; “M” = Minor Use Permit required; “C” = Conditional Use Permit required; “–” = Use Not Allowed				
Land Use Classification	**PF**	**IP**	**BP**	**Additional Regulations**
Transportation, Communication, and Utility Uses				
Battery Energy Storage Systems	C	C	C	See Chapter 14.09.191
No Battery Energy Storage Systems are allowed within the Nut Tree Airport Compatibility Plan area.				

1. Unincorporated County. New BESS facilities proposed on unincorporated land located within Solano County that desire to annex into Vacaville city limits must be located within the city’s Sphere of Influence and shall be required to amend the Vacaville General Plan and Zoning Map to ensure the subject site is designated and zoned consistently with this ordinance.

2. Tier 1 Battery Energy Storage Systems are allowed in all zoning districts, subject to the applicable requirements of the most current (or adopted per Title 24) editions of the NEC, NFPA 70, NFPA 855, and Title 24 of the California Code of Regulations, and all equipment shall be UL 9540 listed. Tier 1 systems, if installed outside a structure, shall meet all established setbacks for the zone they are within, and shall be protected by fencing and screened from view of any adjacent property and the public Right of Way.

3. Natural Disaster Zone Exclusion. A Battery Energy Storage System facility shall not be located on a parcel in the following areas that are subject to impacts from natural disasters:

a. BESS facilities are not permitted in High or Very High Fire Hazard Severity Zones as determined by Cal Fire within a State Responsibility Area or a Local Responsibility Area. Applicants must submit mapping of the proposed site demonstrating compliance with this section. If the maps listed are updated prior to permit issuance, the application must be amended to reflect most recent maps.

b. BESS facilities are not permitted within a FEMA designated floodplain unless the parcel or developed area where the BESS, including perimeter roads for emergency vehicles, is to be installed, is raised to at least two feet above the Base Flood Elevation (BFE) through engineered fill or equivalent flood protection measures. A Conditional Letter of Map Revision (CLOMR) shall be obtained from FEMA prior to site grading or fill, demonstrating that the project will not result in an increase in BFE or adverse floodplain impacts, demonstrating that the proposed project meets all applicable NFIP requirements.

c. Front-of-the-meter BESS modules will not be permitted indoors.

B. Development Standards.

1. Development Regulations. Table 14.09.271.B, Development Regulations – Energy Uses, establishes standards for new BESS facilities, which shall comply with these standards. In addition, Battery Energy Storage Systems shall comply with NFPA 855 requirements related to setbacks and buffers. In the event of a conflict between standards, the standard providing the greatest level of protection to City residents shall prevail, as determined by the Director of Community Development and Vacaville Fire Chief. An applicant may request a waiver of these requirements or submit an Alternate Means and Methods Request under California Title 24, under circumstances where an engineered solution may satisfy setback requirements outlined in NFPA 855. The Director of Community Development shall make the final determination on a requested waiver of development requirements.

TABLE 14.09.271.B: DEVELOPMENT REGULATIONS – ENERGY USES

Standard	PF	IP	BP	Additional Regulations
Setbacks (setbacks are measured from property line or back of sidewalk, whichever results in a greater setback)				
Minimum Front Setback & Corner Street Side (ft)				
Buildings/Batteries	100	100	100	
Guardhouses	75	75	75	
Perimeter Wall/Fence	50	50	50	
Minimum Interior Side (ft)				
Buildings/Batteries	50	50	50	
Perimeter Wall/Fence	30	30	30	
Minimum Rear Setback (ft)				
Buildings/Batteries	50	50	50	
Perimeter Wall/Fence	30	30	30	
Minimum Setback Adjoining Freeway (ft)	200	200	200	
Minimum Setback from Residentially Zoned Property and Parcels Developed with Sensitive Receptors (ft)	500	500	500	Setback also applies to properties in Solano County
Height Standards				
Maximum Building Height (ft)	20	20	20	Standard is applicable to structures used to enclose batteries.

2. Lighting Requirements. BESS facilities shall comply with the following City standards:

a. Interior and perimeter lighting shall be provided to ensure all areas are illuminated to an intensity between 1-to-3-foot candles. Interior lighting shall be dimmable to turn off when no motion is detected after 5 minutes.

b. Lighting poles or fixtures mounted to cabinets and perimeter walls/fences that are located on the interior of a BESS facility shall not exceed a height 20 feet above the ground. Lighting poles and fixtures located on the exterior of a BESS facility shall not exceed 8 feet, excluding street lighting located along the public right-of-way.

c. All lighting shall be directed downward and shall not shine across adjoining properties.

d. Other requirements specified in state statutes or code for electrical infrastructure that are appropriate to apply to BESS.

e. Access roads for emergency responders shall be illuminated as well as all emergency disconnects.

3. Security and Screening. BESS facilities shall comply with the following security and screening requirements:

a. The facility shall have a non-scalable and transparent perimeter fence of at least 10 feet in height. The perimeter fence shall have at minimum two entrance gates equipped with a rapid access system chosen in consultation with Vacaville Fire Department; and shall have the discretion to require more entrances. Fencing shall consist of tubular-steel, powder-coated black fence or equivalent. Click to Enter and Knox-Switches shall be required on all gates.

b. The facility shall be equipped with a security system to prevent break-ins including cameras and barbed wire that is visible from public roads. The cameras must be monitored 24 hours a day, 7 days a week, with any threats immediately reported to law enforcement.

c. The facility shall comply with NFPA 855 specifications related to barriers and buffering.

d. BESS modules shall not be visible from the public right of way and freeway.

e. Reflective Signage shall be located on BESS modules, perimeter fences and any other security barriers. Signage shall include an illuminated site map. Signage shall contain 24-hour emergency contact information, product description, site owner and hazard warnings. Signage or maps should identify isolation distances response personnel shall maintain from BESS during an emergency. Signage shall be provided for grid-interactive BESS operating in parallel with other power generating sources. Signage shall be provided indicating explosion hazard zones. Signage must be compliant with all NFPA 704 standards and must be reflective of local amendments by the City of Vacaville.

4. Noise Requirements. The average noise generated from BESS facilities, components, and associated ancillary equipment, measured at the nearest building, lot line that can be built upon, or public way, shall not exceed any noise limits established under Section 14.09.240.140, Noise.

5. Utility Lines and Electrical Circuitry. All on-site utility lines shall be placed underground to the extent feasible and as permitted by the serving utility, with the exception of the main service connection at the utility company right-of-way and any new interconnection equipment, including without limitation any poles, with new easements and right-of-way. In accordance with Chapter 14.12.050, Undergrounding of Utilities, a developer shall provide for the undergrounding of all existing and proposed utility distribution or transmission facilities, which include but are not limited to electric, natural gas, irrigation district canals, cable television, telephone and other communication facilities, within or abutting the subdivision or development.

6. Landscaping. No landscaping is required on the interior side of the screen walls, regardless of the percentage of open space landscaped. At minimum, the facility shall provide a 20-foot-wide fire access road around the perimeter of the site, which must be designed to support emergency services apparatus weighing 80,000 lbs. At the discretion of the Vacaville Fire Department, additional maintenance roads may be required. The first 30 feet of setback along a street frontage and freeway shall be landscaped and irrigated with a combination of dirt mounding a minimum of 3 feet tall.

7. Must provide a water supply that is approved by the Vacaville Fire Department.

8. Must have Click to Enter and Knox-Switches on all gates for emergency responders.

9. Tier 2 and 3 systems must be provided with fire extinguishing systems.

B. Battery Chemistry Technology

1. Best Available Technology. BESS facilities shall utilize commercially available battery technologies that minimize the risk of thermal runaway. Applicants are strongly encouraged to select technologies with no or low thermal runaway risk. All BESS applications must include third party written documentation evaluating whether the proposed battery technology poses a risk of thermal runaway.

a. If the proposed battery technology is determined by the City of Vacaville to present a thermal runaway risk, the applicant shall submit a comprehensive technology comparison analysis. This analysis must include, at a minimum: A techno-economic comparison of alternative battery technologies based on publicly available information; an assessment of hazardous chemicals involved in the event of thermal runaway, qualitative and quantitative risk analysis of thermal runaway; A thermal runaway plume modeling analysis; and any additional information deemed necessary by the Director of Community Development and/or the Fire Chief.

b. If the proposed battery technology is determined by the City of Vacaville to present no risk of thermal runaway, then the Applicant shall submit Third-party verification of system stability (e.g., material safety analysis, abusetolerance testing results) and basic chemical hazard documentation to demonstrate no risk of hazardous emissions or thermal runaway propagation.

2. Owner Responsibility for Thermal Runaway. BESS facility owners must reimburse the City of Vacaville and emergency response agencies, including fire agencies, for all costs associated with a thermal runaway event. This includes thermal runaway response costs, as tracked by the Vacaville Fire Department. In the event of thermal runaway, the BESS facility owner/operator shall provide three scopes of work for the hiring of a subject matter expert to conduct a root-cause analysis of the event, which shall be subject to review and authorization by the Vacaville Fire Department. The Vacaville Fire Department shall act as the lead coordinator is directing the preparation of the analysis, and all costs shall be funded by the BESS facility operator/owner.

The BESS facility owner must also reimburse costs of an assessment of damage to the environment, agriculture, residents, and businesses conducted by one or more third party consultants selected by the City of Vacaville and all testing, damages and remediation conducted by responsible entities that is required to return all sites in the path of the plume caused by thermal runaway to the previous condition after thermal runaway incident or other hazardous incident.

Section 14.09.271.040 Permitting and Environmental Compliance

A. Conditional Use Permits. All new applications for Tier 2 and Tier 3 Battery Energy Storage Systems shall require a Conditional Use Permit, which shall be processed in accordance with Chapter 14.09.300, Use Permits.

B. Development Agreement. All new applications for Tier 2 and Tier 3 Battery Energy Storage Systems shall require a Development Agreement in accordance with Division 14.17, Development Agreements, to strengthen the public planning process, encourage private participation in comprehensive planning by providing a greater degree of certainty in that process, to ensure that the community's safety is addressed, and to ensure that the public benefits provided by the development are appropriate.

C. Modifications. Applications for periodic augmentation to maintain the capacity of the Battery Energy Storage System or nominally increase the capacity of the system shall constitute a Modification. For applications to modify an approved use permit for a Battery Energy Storage System for which a land use or building permit has been approved (including after project completion), the Director of Community Development shall determine the level of permit modification that shall be required based on the criteria outlined under Section 14.09.030.110, Modifications to an Approved Project and/or Permit.

D. Environmental Compliance. An Applicant shall comply with, and receive the necessary permits for, relevant state and federal environmental and wildlife laws prior to commencing construction and operation of the Battery Energy Storage System.

Section 14.09.271.050 Application Submittal Procedures.

A. Preliminary Application Process.

1. Purpose. The purpose of the Preliminary Application is to allow the Planning Division to work with the applicant and coordinate an internal review of Battery Energy Storage Systems. This process is intended to provide feedback to the applicant early in the process by helping applicants understand the approval process, identifying potential issues to be addressed, and facilitating community outreach. The Preliminary Application is not intended to be a comprehensive review of the project, does not result in any approvals, and is not subject to appeal. The outcome of the Preliminary

Application process is a comprehensive letter describing the approval process, summarizing major planning concerns and issues noted during internal review and a fee estimate. The fee estimate for the project application may differ from the Pre-App estimate.

2. Applicability. A Preliminary Application for Tier 2 and Tier 3 Battery Energy Storage Systems shall be required to provide neighborhood notification and a minimum of one Planning Commission study session to discuss the proposed project and to document community concerns. The Director shall have discretion to require additional community meetings prior to the Planning Commission Study Session. The Director may require additional meetings if it is determined that additional meetings will be beneficial to the community. Preliminary Applications must include written confirmation demonstrating compliance with requirements outlined under NFPA 855.

3. Community Meeting Requirements. The applicant is responsible for arranging the community meeting venue and presenting the project to the community. Meetings shall occur at a publicly accessible venue within the City, preferably at the project site or within a one-mile radius of the site. At least 30 days before the meeting date, the Applicant shall notify the City of the desired meeting date and the City shall promptly determine whether it conflicts with any established City-sponsored meetings. Public notification shall be provided in accordance with Section 14.09.030.070, Public Notice. The Applicant shall be required to provide the following services for the Community Meeting:

a. Publish a website with project information and contact information.

b. Reception desk with sign-in sheets, flyers printed with contact information.

c. Staff to document questions from the community, prepare meeting minutes, and organize responses to the questions. The meeting shall be recorded and made available to the public.

d. Moderator with at least one representative knowledgeable about Battery Energy Storage Systems to facilitate the meeting, presentation, and questions.

e. Weeknight meetings shall occur between 6:00 p.m. and 9:00 p.m. and weekend meetings shall occur between 10:00 a.m. and 9:00 p.m.

4. Preliminary Application Letter and Formal Submittal. Within 30 days of outreach completion, the Planning Division will send to the Applicant a letter summarizing major project concerns, a description of the approval process, other issues noted during internal review, and a fee estimate. A formal project submittal will be accepted only after the Pre-Application letter has been issued. If a formal application is not submitted within one year, a new Pre-App will be required before project submittal.

B. Formal Application Process.

1. Application. Applications and fees for Battery Energy Storage Systems shall be submitted in accordance with the provisions set forth in Section 14.09.030.030, Application Forms and Fees. In addition, application shall include information demonstrating that requested entitlements conform to the required findings for approval.

2. Environmental Review. Applications for Battery Energy Storage Systems shall be evaluated in accordance with Division 14.03, Environmental Review, and the California Environmental Quality Act (CEQA). Applicants are responsible for funding the environmental analysis and corresponding technical studies necessary to disclose project-related impacts. Any unused fees will be reimbursed upon completion of the application process or withdrawal of a pending application.

3. Public Notice and Hearing. An application for a Battery Energy Storage System facility shall require noticed public hearings before the Planning Commission and City Council. Applications shall comply with the public notice and hearing requirements of Section 14.09.030.070, Public Notice.

4. Decision. The decision maker must make a determination that the application complies with the required findings under Chapter 14.09.300, Use Permits, and Chapter 14.09.290, Design Review, and any other entitlement findings that are required for the application. The decision maker shall deny

an application for a Battery Energy Storage System facility if it is unable to make a determination that the project meets the required findings for approval.

5. Submittal Checklist.

a. A preliminary emergency response plan that includes site access, equipment locations and potential hazards for responders, nearby residents, and businesses, in addition to any other requirements. The emergency response plan may be revised after land use permits are approved, with written approval from the Vacaville Fire Department. A final emergency response plan, with written approval of Vacaville Fire Department, must be submitted prior to issuance of any building permits.

b. A report documenting coordination to-date with the Vacaville Fire Department and Solano County Office of Emergency Services in developing the required emergency response plan for the project site.

c. A plan for offering site-specific training to first responders including the Vacaville Fire Department and cooperating agencies that are likely to provide mutual aid during the initial response at project site. If the fire department determines that specialized training, PPE and/or equipment are required for response to potential incidents at this location, the cost of such will be provided by the developer.

d. A hazard mitigation analyses if required by NFPA 855.

e. A comprehensive technology comparison analysis.

f. A financial assurances plan, including liability insurance that includes coverage for thermal runaway events and other hazardous incidents, pollution and other environmental damages, decommissioning bonds, a battery cell manufacturer responsibility agreement, and an agreement indemnifying the City of Vacaville and all emergency response agencies in the event of an incident associated with the BESS facility that causes environmental damage or causes injury to persons or property. Insurance shall address all phases of construction, development, and operations.

i. As part of the financial assurances, the applicant shall acknowledge that relevant and responsible agencies having jurisdiction over the site will oversee and coordinate subject matter experts to conduct a root cause analysis related to any hazardous incident, with all costs borne by the BESS facility owner.

ii. As an additional aspect of the financial assurances, the applicant shall acknowledge the responsibility and agreement to reimburse all damaged parties for an assessment of damage to the environment, agriculture, residents, and businesses conducted by one or more third-party consultants selected by the City of Vacaville and all testing, damages, and remediation conducted by responsible entities that is required to return all sites in the path of any plume caused by thermal runaway or otherwise subject to a hazardous incident to the previous site conditions.

g. A description of cybersecurity risks and mitigation measures associated with BESS modules, the Battery Management System, and active and passive fire and explosion detection systems.

h. Submitted plans and documents must be under the signature and seal of a CA Licensed design professional.

i. HMA, Fire Risk Analysis, fire suppression systems and deflagration protection analysis submittals shall be from a CA Licensed Fire Protection Engineer approved by the Vacaville Fire Department per California Fire Code (CFC) Section [A]104.7.2 as it may be amended. Submittals shall include signature and seal.

j. Fire protection system submittals such as fire suppression, pre-engineered systems, and water supply shall be provided by a licensed fire protection engineer or other approved licensed professionals as required by the CFC.

k. Fire alarm systems, fire detection, and gas detection shall include a C-10 - Electrical Contractor of record.

l. Final approval of any BESS or safety related equipment that has routine maintenance requirements according to the code or manufacturer's instructions will not receive approval until a maintenance plan has been submitted to the Vacaville Fire Department. Maintenance must comply with all NFPA Standards, title 24 and manufacturer's instructions

m. Once an application is accepted for review, any updated submittals during the period of review, installation and final inspections must either be signed and sealed by the design professional of record, or a cover letter signed and sealed by the design professional of record shall accompany the submittal, attesting that the updated information conforms to the overall design and code requirements.

n. Applicant must provide funding to the air quality district with jurisdiction over the project site to establish 10 or more permanent air monitors, at distances and elevations determined by the air quality district with jurisdiction over the project site to detect harmful constituents, hazardous to human life or wildlife, emitted as a result of thermal runaway as determined by the air quality district with jurisdiction over the project site. The number of sensors deployed will be determined by the air quality district with jurisdiction over the project site. If a thermal runaway incident occurs or air monitors detect hazardous constituents, the monitoring system and BESS operators shall notify Vacaville Police and Fire Dispatch. After an incident, related to BESS thermal runaway or otherwise, City staff will have access to the raw, unfiltered data from the air monitors.

o. BESS operator will submit a comprehensive annual report to the City of Vacaville staff as designated by the City consisting of but not limited to; the number of threats made to the site, the number of trips of the site security system, the number of hazardous incidents at the site, the number of fire and law responses to the site, soil testing on-site and the surrounding properties for hazardous chemicals existing in the battery system, air monitor results. This list can be supplemented and modified by City staff at any time.

p. The Applicant shall prepare and submit a Phase II Environmental Analysis that includes soil testing to provide the baseline condition of the site, which shall provide a benchmark reading for future measurements of potential contamination resulting from a thermal runaway event.

6. Technical Studies.

a. All technical studies, Hazard Mitigation Analysis and planning documents required by SB 38, NFPA 855 and the City of Vacaville must include both a probable scenario of limited thermal runaway and possible scenarios of simultaneous thermal runaway in all site modules at once, and shall address hazards as outlined in the "Emergency Response Plan Guidance" to the site and mitigation measures deployed.

b. Applicants must submit technical studies prepared by a third-party fire protection engineer selected by the City detailing the proposed fire safety features of the design, operation, and use of the BESS. Changes in installation configuration from the initial UL 9540A cell, module, and unit level test and the separate large scale fire testing, including internal architecture of modules and units will not be accepted unless it is demonstrated that the configuration provides equivalent results, subject to review and approval by the Vacaville Fire Department and Building Division. Fire safety features must include mechanisms for maintaining the temperature and humidity ratings of the listing.

c. Technical studies prepared by a third-party fire protection engineer, which the City has the discretion to select, must account for setback requirements and best practices from residential buildings and sensitive receptors. Technical study must include estimated impacts to property values and insurability of properties potentially impacted by a plume caused by thermal runaway.

d. Technical studies prepared by third party subject matter experts, which the City has the discretion to select, must include plume modeling and toxic gas dispersion analysis, specifically addressing impacts on missions and flight paths of Travis Air Force Base and Nut Tree Airport and freeways.

e. Technical studies prepared by third party subject matter experts selected by the City analyzing the chemical composition of BESS fire emissions and associated human, wildlife and environmental hazards, specifically at which distances emission impacts will be hazardous.

f. Technical studies prepared must analyze runoff of water and fire suppression liquid associated impacts to groundwater, wildlife, waterways, and the environment. If determined to be required by City staff, site plans must include a system for capturing runoff water, whose size requirements will be determined based on technical studies in consultation with the City of Vacaville, for water or fire suppressant liquid that may be used by first responders during thermal runaway incidents, and a geo-lined impermeable layer under all BESS modules. The retention basin must be emptied the same day if filled by rain or flood water, in accordance with applicable state laws. If thermal runaway occurs, five samples of fire suppressant liquid or water utilized must be taken by the third party subject matter expert selected by the City and mitigation measures will be taken to reduce the adverse impact by third party subject matter experts selected by the City, with the costs being paid for by the site owner. Applications shall include samples of the existing groundwater subbasin that would be affected by the BESS facilities to determine current levels of concentration.

g. BESS facilities must have active and passive fire and explosion detection systems in place, including gas detectors that meet UL 9540A, NFPA 72, and NFPA 69 standards. These systems must be able to detect explosive gases, trigger alarms, and initiate ventilation systems to mitigate risks from thermal runaway.

h. Battery Management System (BMS) must be approved and meet manufacturer's specifications. The BMS must transmit signals to an approved location, as reviewed and approved by the Vacaville Fire Department, if hazardous conditions are detected, and such signals must be monitored twenty-four hours a day seven days a week. BMS documentation must identify security risks and potential threats, along with the mitigation measures implemented to reduce each identified risk. A combustible gas concentration reduction system compliant with NFPA 855, NFPA 69, UL 9540, and CFC that has undergone UL 9540A testing will have the ability to be automatically activated.

Section 14.09.271.060 Required Findings of Economic Benefit; Public Benefit Agreement; Exempt Projects.

A. Consistent with Public Resources Code section 25545.9, and in addition to all other findings and determinations necessary for the grant of a conditional use permit, no conditional use permit for an Tier 2 or Tier 3 Battery Energy Storage System shall be granted unless the City finds that the construction and operation of the facility will have an overall net positive economic benefit to the City. For purposes of this sub-section, economic benefits may include, but are not limited to, any of the following:

1. Employment growth.

2. Housing development.

3. Infrastructure and environmental improvements.

4. Assistance to public schools and education.

5. Assistance to public safety agencies and departments.

6. Property taxes and sales and use tax revenues.

7. Contributions to City initiatives or projects that benefit the community.

B. Consistent with Public Resources Code Section 24454.10, no Conditional Use Permit for a Tier 2 or Tier 3 Battery Energy Storage System shall be granted unless the City has entered into a legally binding and enforceable agreement with, or that benefits, the City, where there is mutual benefit to the parties to the agreement. The topics and specific terms of the community benefits agreements may vary and may include funding for or providing specific community improvements or amenities such as public safety training facilities for emergency responders, park and playground equipment, urban greening, enhanced safety crossings, and paving roads and bike paths.

C. The City of Vacaville finds and declares that, where an Tier 2 or Tier 3 Battery Energy Storage System is issued a certificate pursuant to Chapter 6.2 (commencing with Section 25545) of Division 15 of the Public Resources Code, and where such certificate is in lieu of a conditional use permit or other permit, certificate, or document required by the City, a community benefit agreement in the form described in subdivision (2), above, shall satisfy the obligations on Public Resources Code section 24454.10.

D. Training, Emergency Response, and Monitoring Agreement shall be required for BESS facility operators of Tier 2 and Tier 3 facilities. Agreements shall outline the funding mechanism and procedure for obtaining equipment and providing training to emergency responders, which shall include the following:

1. Annual training with updates on BESS best practices paid for by the company and provided to the Vacaville Fire Department and cooperating agencies that are likely to provide mutual aid during the initial response, Vacaville Police Department, Utilities, and Public Works. If the best practice include new equipment or PPE this must be paid for by the company.

2. Initial training on all systems regarding their BESS for all County Haz Mat personnel throughout the county and other Fire Departments in neighboring agencies that collaborate through mutual aid agreements (e.g., Dixon Fire Department and Fairfield Fire Department).

3. Air Monitoring systems provided by and maintained by the owner of the company with remote monitoring systems accessible by the Vacaville Fire Department and Solano County Haz Mat team.

4. Gas monitors provided by and maintained by the owner of company including cost of training, maintenance and calibration.

5. Reimbursement agreements to ensure all costs associated with mitigation of events at their facility are paid by owners/operators of the BESS facility.

Section 14.09.271.070 Commissioning, Safety Standards and Certifications

A. Commissioning Plan. Prior to issuance of Building and Fire Permits for a BESS facility, Applicants shall submit a commissioning plan consistent with NFPA 855 that contains:

1. A electrical diagram detailing the Battery Energy Storage System layout, associated components, and electrical interconnection methods, with all NEC compliant disconnects and over current devices.

2. A preliminary equipment specification sheet that documents the proposed Battery Energy Storage System components (including all associated cutsheets), inverters and associated electrical equipment that are to be installed. A final equipment specification sheet shall be submitted prior to the issuance of the building permit.

3. Name, address, and contact information of proposed or potential system installer and the owner and/or operator of the battery energy storage system. Such information regarding the final system installer shall be submitted prior to the issuance of a Building Permit. The installer must have a business license with the City of Vacaville.

4. A commissioning plan, commissioning test and report meeting the requirements of NFPA 855 Sections 6.1.3, 6.1.4 6.1.5 shall be submitted prior to final inspection.

5. If plans include connection to the City of Vacaville wastewater collection system, an Industrial User Permit application must be submitted to the Utilities Department.

B. Safety Requirements. Battery Energy Storage Systems shall comply with the latest published version that is approved to be used by the CFC Chapter 80 and NFPA 855, Standard for Installation of Stationary Energy Storage Systems, at the date of the submission of the application. Prior to issuance of Building and Fire Permits, Applicants are required to:

1. Submit an emergency response plan as an appendix to the project application.

2. Submit a plan as an appendix to the project application for offering site-specific training to the Vacaville Fire Department and cooperating agencies that are likely to provide mutual aid during the initial response at the project site.

3. Conduct hazard mitigation analyses if specified by NFPA 855.

4. Equipment Certification. All batteries integrated within the battery energy storage system shall be listed under UL 1973. The battery energy storage system shall be listed in accordance with UL 9540, either from the manufacturer or by field evaluation.

5.Submit an ongoing weed abatement plan for review and approval by the Vacaville Fire Department.

C. Decommissioning

1. Decommissioning Plan. Prior to issuance of any permits related to decommissioning activities, the Applicant shall submit a Decommissioning Plan that complies with the following requirements, and is consistent with NFPA 855 and agreements reached between the Applicant and other landowners of participating properties, and that ensures the return of all participating properties to a useful condition, including removal of above-surface facilities and infrastructure that have no ongoing purpose. The decommissioning plan shall include, but is not limited to:

a. An overview of the decommissioning process developed specifically for the BESS that is to be decommissioned.

b. Roles and responsibilities for all those involved in the decommissioning of the BESS.

c. A detailed description of each activity to be conducted during the decommissioning process and who will perform that activity and at what point in time.

d. Procedures to be used in documenting the BESS and all associated operational controls and safety systems that have been decommissioned.

e. Guidelines and format for a decommissioning checklist and relevant operational testing forms and necessary decommissioning logs and progress reports.

f. A description of how any changes to the surrounding areas and other systems adjacent to the ESS facility, including, but not limited to, structural elements, building openings, means of egress, and required fire detection and suppression systems, will be protected during decommissioning and confirmed as being acceptable after the system is removed.

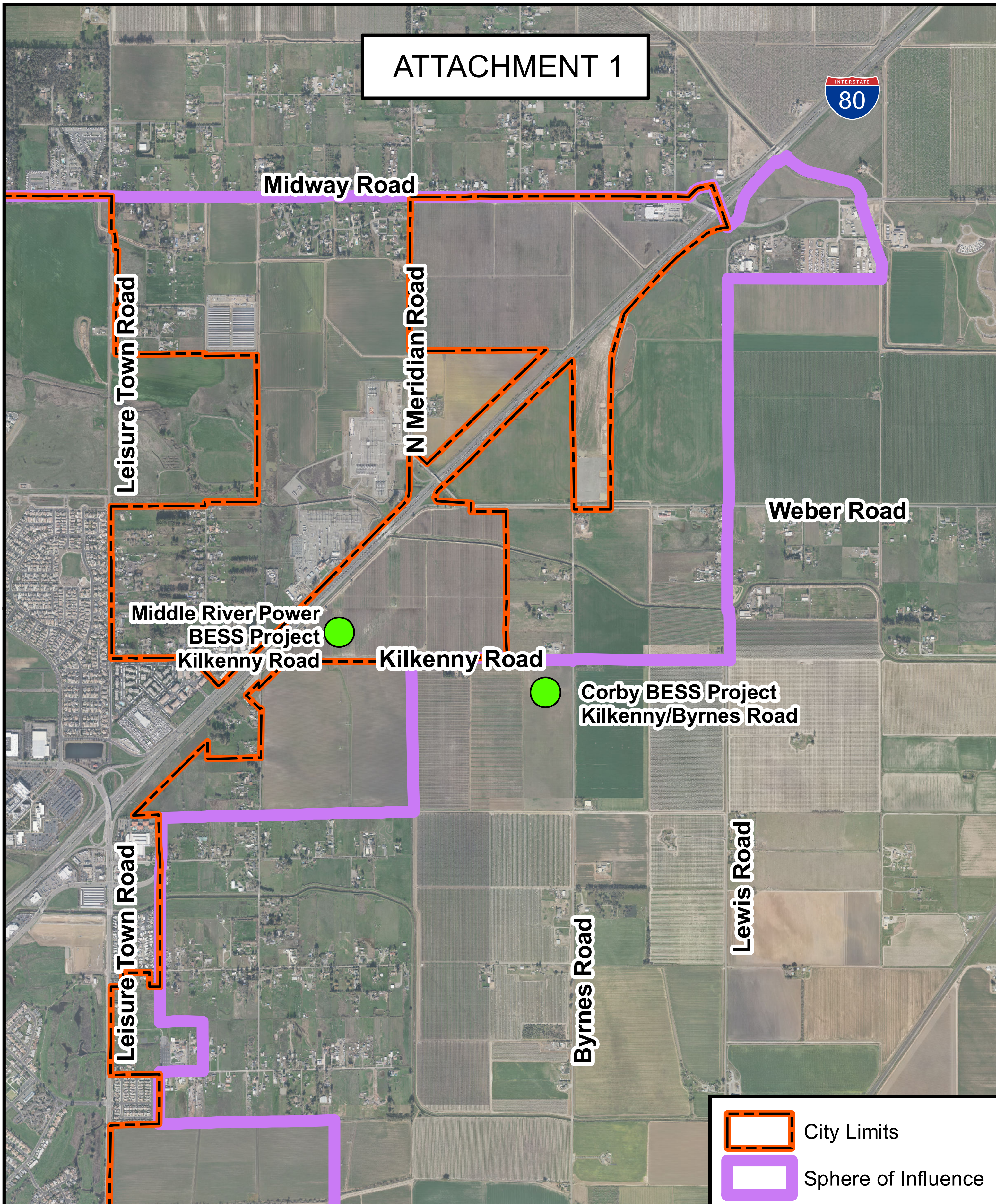
g. Estimated costs associated with decommissioning.

h. Evidence of insurance for bankruptcy in the form of a bridge policy. This includes financial assurance in the form of a bond, a parent company guarantee, or an irrevocable letter of credit, but excluding cash, to be determined by applicant. The amount of the financial assurance shall not be less than the estimated cost of decommissioning the energy facility, after deducting salvage or recycling value, as calculated by a third party with expertise in decommissioning, hired by the applicant. The entire financial assurance must be posted by the start of full commercial operation of the BESS facility.

i. Battery disposal plan and acknowledgment of the facility owner's responsibility to recover and recycle battery cells at an authorized recycling facility upon decommissioning.

E. Ownership Changes. If the owner of the Battery Energy Storage Systems facility changes or the owner of the property changes, the project approvals shall remain in effect, provided that the successor owner or operator assumes in writing all the obligations of the project, site plan approval, and Decommissioning Plan. A new owner or operator of the facility shall notify the Community Development Department of such change in ownership or operator within 30 days of the ownership change. A new owner or operator must provide such notification to the Community Development Department in writing. The project and all approvals for the facilities would be void if a new owner or operator fails to provide written notification to the Community Development Department in the required timeframe. Reinstatement of a voided project or approvals will be subject to the same review and approval processes for new applications under this chapter.

ATTACHMENT 1

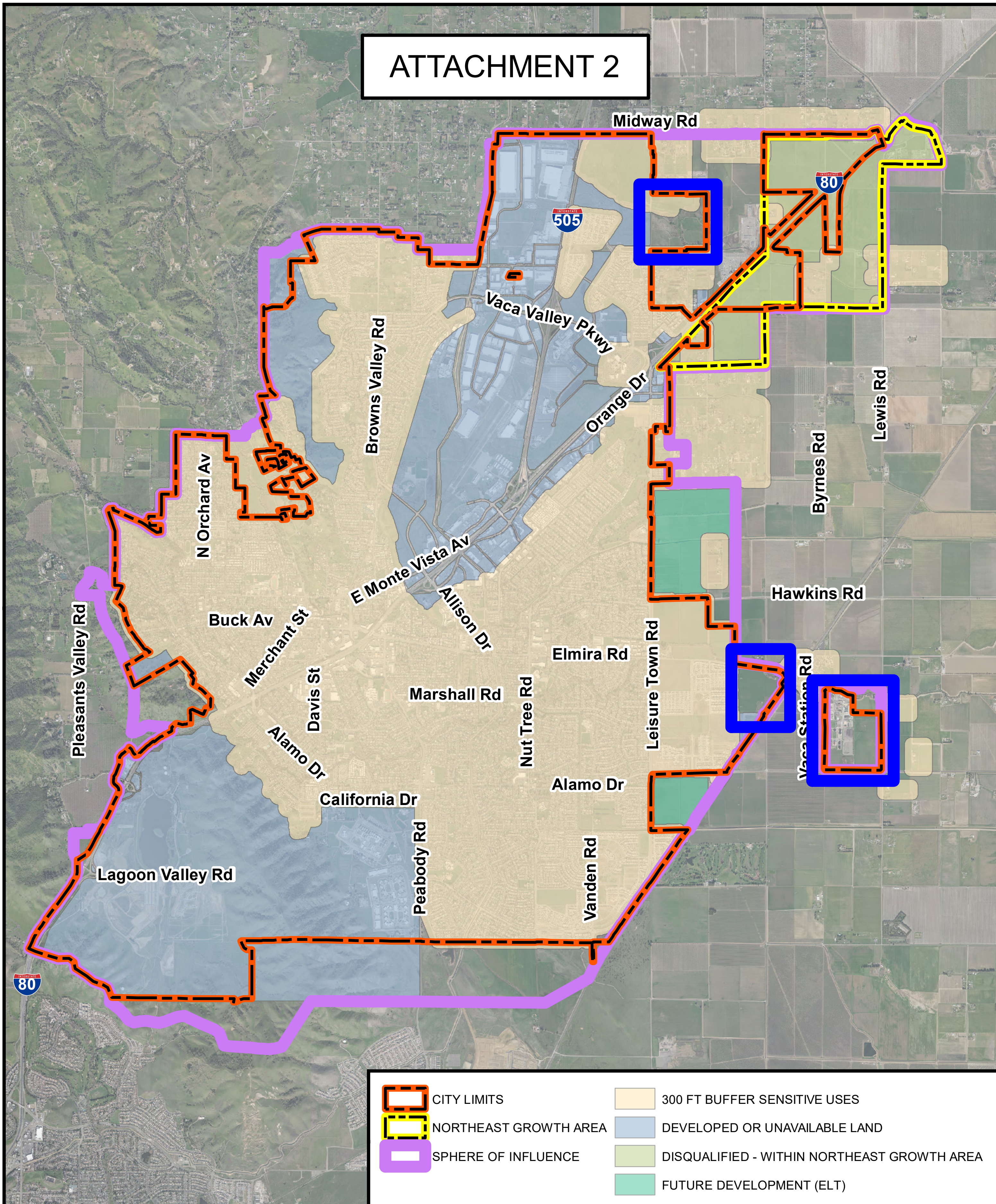


CITY OF VACAVILLE
COMMUNITY DEVELOPMENT DEPARTMENT

NORTH

CALIFORNIA ENERGY COMMISSION APPLICATIONS

BATTERY ENERGY STORAGE SYSTEMS

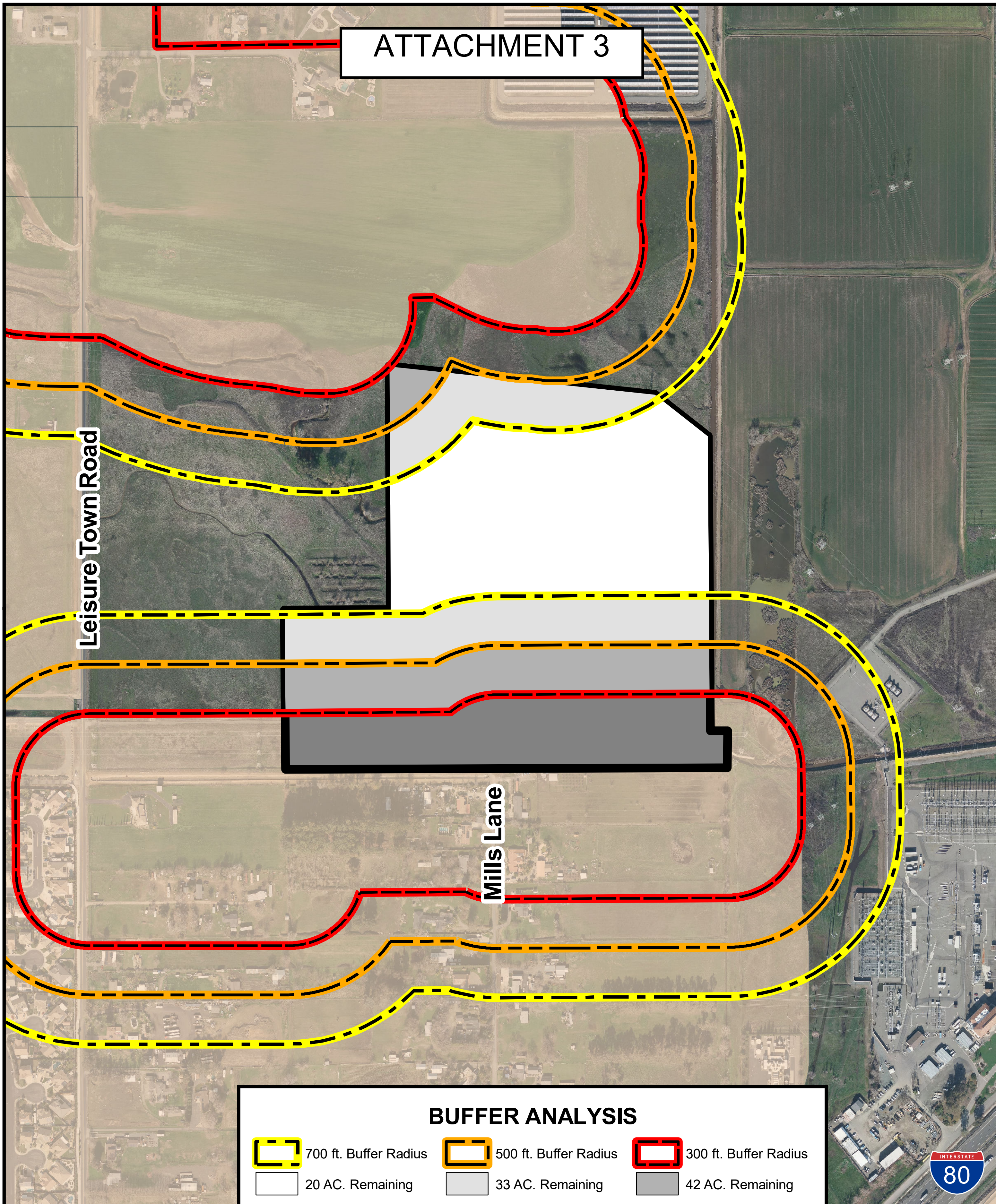


CITY OF VACAVILLE
COMMUNITY DEVELOPMENT DEPARTMENT

NORTH

SUITABILITY ANALYSIS

BATTERY ENERGY STORAGE SYSTEMS

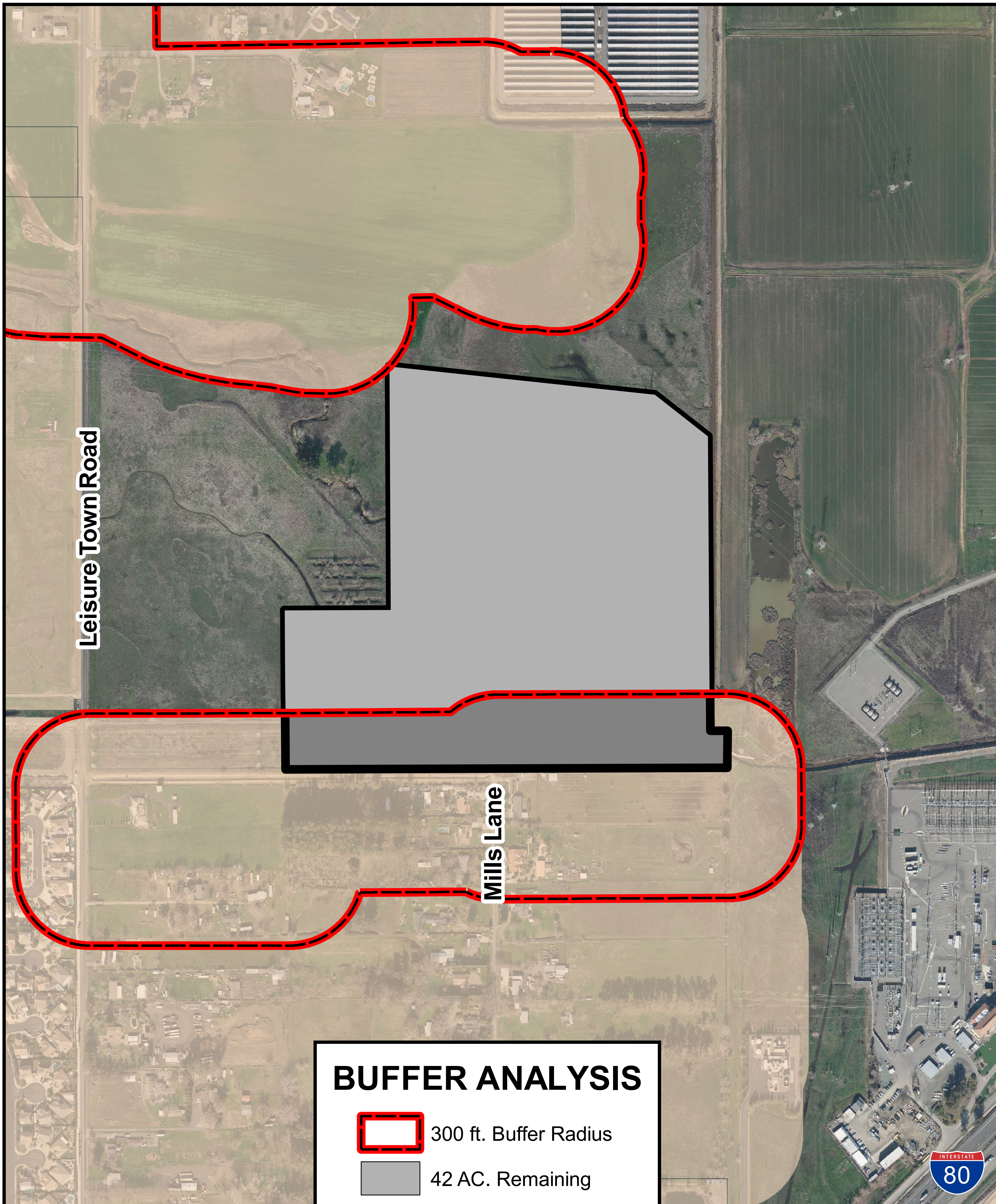


CITY OF VACAVILLE
COMMUNITY DEVELOPMENT DEPARTMENT

NORTH

REVISED SUITABILITY ANALYSIS

BATTERY ENERGY STORAGE SYSTEMS

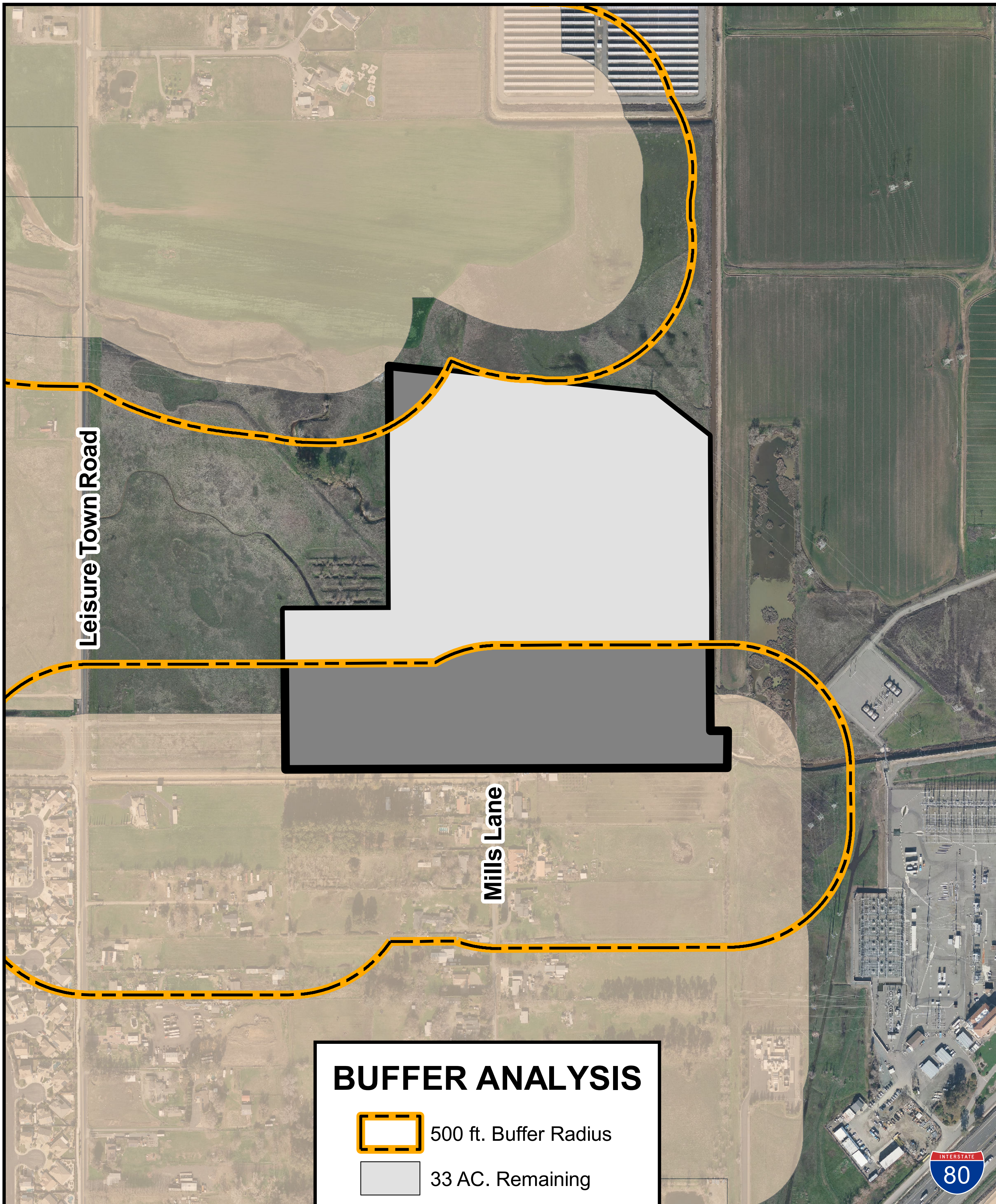


CITY OF VACAVILLE
COMMUNITY DEVELOPMENT DEPARTMENT

NORTH

REVISED SUITABILITY ANALYSIS

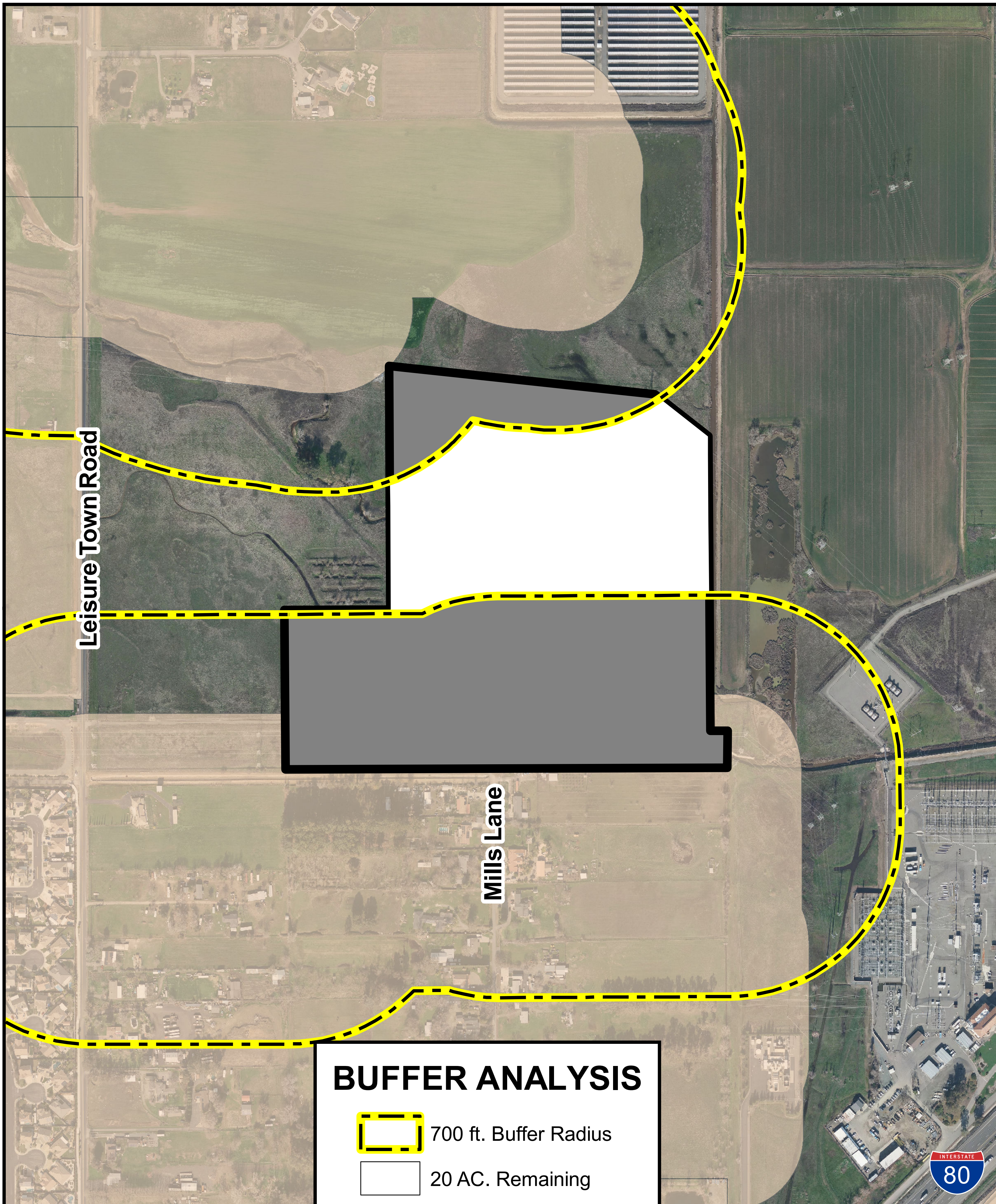
BATTERY ENERGY STORAGE SYSTEMS



CITY OF VACAVILLE
COMMUNITY DEVELOPMENT DEPARTMENT

REVISED SUITABILITY ANALYSIS

BATTERY ENERGY STORAGE SYSTEMS



CITY OF VACAVILLE
COMMUNITY DEVELOPMENT DEPARTMENT

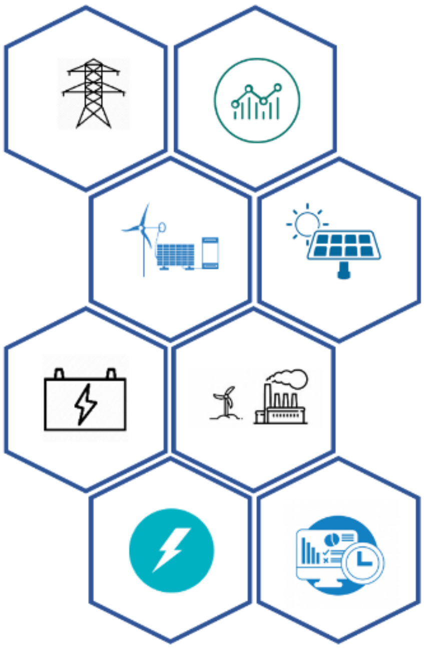
NORTH

REVISED SUITABILITY ANALYSIS

BATTERY ENERGY STORAGE SYSTEMS

ATTACHMENT 4

BESS Technology Assessment for the City of Vacaville



Client: City of Vacaville

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Rev number: R00

Executive Summary

Utility-scale Battery Energy Storage Systems (BESS) have become a critical part of modern grid planning. As utilities, municipalities, and developers navigate through BESS technology options, understanding is key to choosing the right technology:

- Chemistry
- Safety
- System lifecycle
- Commercial and regulatory readiness

This report touches on various BESS technologies but emphasizes two commercially relevant technologies for large-scale deployment:

- Lithium-Ion Batteries (LIB), mainly Lithium Iron Phosphate (LFP) batteries
- Flow Batteries, mainly Vanadium Redox Flow Batteries (VRFB) as an emerging complementary long-duration solution

This document offers a technical overview of BESS, focusing on commercially relevant technologies, safety features, and operational considerations for utility-scale deployment. Its goal is to support the City of Vacaville in making informed decisions on safe, cost-effective, and scalable BESS installations.

Technology Comparison and Safety Insights

LFP batteries are currently the most commercially mature and widely deployed BESS technology in California, offering a strong balance of cost, energy density[1], and safety. LFP's non-oxygen-releasing phosphate provides significantly higher thermal stability compared to other lithium-ion types (e.g., NMC- Lithium nickel manganese cobalt, NCA- Lithium Nickel Cobalt Aluminum Oxide, reducing the risk of thermal runaway and simplifying fire protection design.

VRFB is an emerging non-flammable, water-based chemistry alternative that eliminates thermal fire risks and provides long-duration discharge capability (8–12 hours or more). However, they introduce chemical containment, ventilation, and maintenance complexity, along with a larger land footprint (low energy density) [56] and a lack of mature regulatory and safety standards compared to Li-ion.

Comparative analysis confirms that, while flow batteries have higher manufacturing environmental impacts, they offer higher recyclability (95–97%), longer life cycles (20 plus years), and enhanced fire safety than LFP. LFP systems remain the most practical and field-proven [57] choice for utility- and industrial-scale sites today, with flow batteries as an emerging complementary technology, better suited for future long-duration, utility-scale projects.

[1] *Energy density* (expressed formally as *Wh/kg* and *Wh/L*) refers to how much energy a storage technology can hold relative to the physical space it occupies. In practical utility-scale BESS development, this translates to the acreage and enclosure volume required to achieve a *target MWh capacity*. Higher energy density means fewer containers and less land per MWh to deploy a battery (LFP trait); lower energy density means larger layouts, more civil work, and higher costs (VRFB trait).

Category	Lithium-Ion (LFP)	Flow Batteries (VRFB)
Typical Use Case	Dominant in California grid BESS; preferred for fast response, smaller footprint, and lower cost.	Increasingly used for long-duration energy storage, often in pilot or industrial projects (see Section 3.10); larger footprint requirement.
Core Chemistry	Energy stored in solid electrodes; high energy density.	Energy is stored in liquid electrolytes circulating between tanks; low energy density.
Primary Safety Risk	Thermal Risk: a self-heating chain reaction that can cause fires if not mitigated.	Chemical risk: acid leaks, gas evolution, and potentially toxic off-gases under stress.
Thermal Risk	Possible cell-to-cell propagation; mitigated in LFP by stable phosphate chemistry (non-oxygen releasing). EPRI fire study notes that LFP incidents emit less heat and fewer toxic gases than NMC or NCA systems.	Non-flammable aqueous electrolytes make sustained combustion unlikely. However, polymer and gasket materials can still burn, releasing HF, SO_2, or NO_x gases under high heat.
Chemical and Leakage Risks	LIB vents gases: CO, H_2, and organic solvent vapors during failure; modern gas detection and BMS systems (NFPA 855) reduce this risk.	VRFB and ZnBr can evolve H_2 or Br_2 during imbalance or overcharge; they require ventilation, gas sensors, and pH monitoring.
Water and Fire Suppression	Standard water deluge systems are sufficient for LFP modules, with minimal environmental impact.	Water is used primarily for cooling and containment, rather than suppression; secondary containment and corrosion-resistant design are required due to the presence of acidic liquids.
Environmental Hazard During Fire	Byproduct from LIB fires can contain metals (Ni, Co, Mn), but they are treatable and can be managed. An EPRI report found no long-term soil contamination from past incidents.	Acidic electrolyte spills may require neutralization (lime or soda ash). Bromine or chlorine gases can pose local inhalation hazards if ventilation fails.

Category	Lithium-Ion (LFP)	Flow Batteries (VRFB)
Lifecycle and Recycling	3,000 to 6,000 cycles. Established recycling infrastructure for LFP, copper, and aluminum recovery.	10,000 to 20,000 cycles. 95–97% electrolyte recyclability, since vanadium does not degrade.
Regulatory Standards	Fully codified under NFPA 855, UL 9540/9540A, and the California Energy Commission BESS fire code. There is widespread AHJ familiarity.	Still maturing, as there is no unified NFPA equivalent. More operational data will be gathered as more flow batteries are deployed in the field.
Community Implication	Proven, commercially mature, compact, and safe when designed to LFP standards with proper BMS, ventilation, and setbacks.	Safer in terms of thermal risk, but introduces corrosive liquids and maintenance complexity. It is also unsuitable for dense community sites due to the large footprint requirement. Lack of mature safety standards introduces uncertainty.

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Abbreviations and Acronyms

The following is the list of abbreviations and acronyms used in this report:

Abbreviation/Acronym	Description
AC	Alternating Current
AHJ	Authority Having Jurisdiction
APN	Assessor's Parcel Number
BESS	Battery Energy Storage System
BMS	Battery Management System
CAISO	California Independent System Operator
COD	Commercial Operation Date
DER	Distributed Energy Resource
DERMS	Distributed Energy Resource Management System
DC	Direct Current
DPR	Detailed Project Report
EMS	Energy Management System
EPC	Engineering, Procurement, and Construction
ESS	Energy Storage System
EV	Electric Vehicle
GHI	Global Horizontal Irradiance
GIS	Geographic Information System
IFC	International Fire Code
IBC	International Building Code
kV	Kilovolt
kW	Kilowatt
kWh	Kilowatt-hour
LIB	Lithium-Ion Battery
LSFT	Large-Scale Fire Testing
LFP	Lithium Iron Phosphate
Li-Ion	Lithium-Ion
MWh	Megawatt-hour
MW	Megawatt

Abbreviation/Acronym	Description
NaS	Sodium-Sulphur
NiCd	Nickel-Cadmium
NMC	Lithium Nickel Manganese Cobalt Oxide
NRTL	Nationally Recognized Testing Laboratory
PCS	Power Conversion System
PG&E	Pacific Gas and Electric
PNG	Piped Natural Gas
POI	Point of Interconnection
PPA	Power Purchase Agreement
PV	Photovoltaic
UL	Underwriters Laboratories
UPS	Uninterruptible Power Supply
W/m^2	Watts per square meter
VRFB	Vanadium Redox Flow Batteries

1 Introduction

1.1 Purpose of the Report

This report provides a focused evaluation of Battery Energy Storage System (BESS) technologies in support of the City of Vacaville's current policy deliberations around the ongoing moratorium on utility-scale BESS development.

While the report introduces a broad set of energy storage chemistries, it focuses on technologies that are technically and commercially viable for utility-scale deployment. Among these, two stand out as leading candidates based on safety, performance, and regulatory alignment:

- Lithium-Ion Batteries (LIB), particularly the Lithium Iron Phosphate (LFP) subtype
- Flow Batteries, specifically Vanadium Redox Flow Batteries (VRFB) as an emerging complementary long-duration solution

These technologies are evaluated based on their operational characteristics, safety risks (e.g., thermal runaway and flammability), discharge duration, lifecycle performance, and overall commercial readiness.

This report is intended as a technical and policy resource for city staff, officials, and community stakeholders involved in BESS-related decision-making. It aims to support the City's efforts to:

- Compare and shortlist BESS technologies that meet the scale, safety, and reliability standards required for long-duration storage and grid support
- Guide ordinance development and permitting frameworks as the City considers how to refine or lift the BESS moratorium
- Clarify tradeoffs between leading BESS technologies, especially in terms of fire risk, siting constraints, and long-term cost-effectiveness

Included in the report are:

- Summary tables of safety profiles (See Table 4), scale suitability, and duration capabilities for commercially relevant utility-scale BESS chemistries
- A comparative narrative between LFP and VRFB technologies
- Best practices and regulatory precedents from other jurisdictions with active utility-scale BESS development

By combining local regulatory context with technical evidence, this report provides a clear foundation for informed policymaking around energy storage siting and safety in the City of Vacaville.

1.2 Organization of the Report

This report is structured to move from context and definitions to technical evaluation and implementation guidance:

1. **Executive Summary**: High-level findings and key takeaways.
2. **BESS Configurations and Applications**: How BESS works with other DER technologies, including PV, hybrid PV+BESS, and natural gas systems.
3. **BESS Technology Assessment**: Types of BESS technologies, selection factors, safety considerations, and national safety standards.
4. **Comparison of Battery technology**: Comparative analysis of leading battery chemistries like the Flow battery and the Lithium-ion battery.
5. **BESS Best Practices and Implementation Guidelines**: Safety, permitting, and operational guidelines for deployment.
6. **Case Studies**: Real-world examples relevant to the context.
7. **Conclusion and Recommendations**: Summary of findings and proposed next steps.

This document is designed so that readers can first understand why BESS matters to Vacaville, then explore the technical and regulatory details that will inform ordinance development and project planning.

2 BESS Configurations and Applications

2.1 How BESS Enhances Solar and Wind for Reliable Power

BESS plays a pivotal role in renewable-centric DER systems, enabling solar-plus-storage and wind-plus-storage projects to deliver consistent, reliable power, even when the sun isn't shining or the wind isn't blowing.

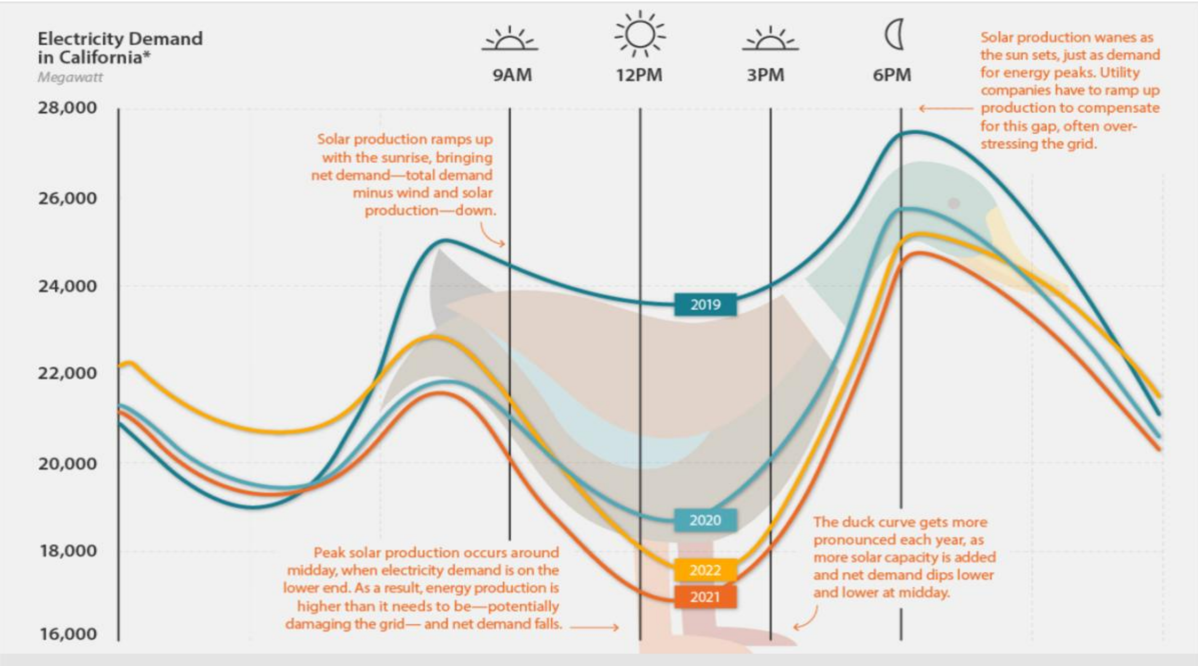

Figure 1 Duck Curve Illustrating Challenges Faced by High Solar Grids

Figure 1 illustrates "Duck Curve," which depicts the challenges faced by high-solar grids. Solar energy floods the grid with power at midday, driving net demand down (9 AM to 2 PM). Then demand spikes suddenly as the sun sets (3 PM to 6 PM), forcing other power plants (mostly natural gas) to ramp up quickly.

As solar- and wind-heavy DERs rapidly expand across the U.S., green energy consumers, policymakers, and utilities are becoming more aware of the challenges posed by the variability of renewable energy sources such as solar power. In energy systems rich in solar energy production, such as California, system operators face issues associated with too much PV in the system. One well-known example is called the "duck curve". Having a BESS directly addresses this reliability challenge by storing excess clean energy and discharging it when generation decreases.

It's important to emphasize that BESS does *not* generate power. Instead, it stores excess clean energy when renewable sources, such as solar, are producing abundantly. The BESS then releases this stored energy when generation is low, helping to smooth out variability, regulating the frequency, and ensuring the reliability of the DER system.

From a utility and more technical perspective, Battery storage is a technology that enables power system operators and utilities to store energy for later use. BESS is an electrochemical device that charges (or collects energy) from the grid or a power plant/DER and then discharges that energy later to provide electricity or other grid services when needed. Several battery chemistries are available or under investigation for grid-scale applications, including lithium-ion, lead-acid, redox flow, and molten salt [10].

2.2 What is "Hybrid" BESS

A "Hybrid" Solar + BESS system combines renewable solar generation with advanced energy storage technologies to provide a reliable, sustainable, and flexible energy solution. Solar PV panels capture and convert sunlight into electricity during the day, while the BESS stores any surplus power for later use. This integration ensures that clean solar energy can be utilized even during non-solar hours, reducing dependence on the grid and enhancing local energy resilience.

2.3 BESS Applications

Applications for BESS are shown in the Table 1 below.

Table 1 Applications for BESS

Applications	Description
Grid Reliability and Resilience	Enhances grid stability by providing backup power during outages, supports critical infrastructure such as hospitals and emergency services, and enables islanding capabilities during emergencies.
Peak Shaving and Demand Management	Reduces peak demand on distribution assets, helping to defer costly infrastructure upgrades; lowers demand charges for municipal facilities through load management.
Renewable Energy Integration	Mitigates variability in solar and wind generation; enables solar self-consumption; supports city-wide clean energy and decarbonization goals.
Lower Energy Costs	Facilitates energy arbitrage by charging during low-cost periods and discharging during peak hours, thereby reducing overall energy expenditure for city operations.
EV and Electrification Support	Supports growing electric vehicle (EV) adoption through managed charging and vehicle-to-grid (V2G) services, alleviating localized congestion from the electrification of heating and transport.
Environmental and Public Health	Reduces reliance on fossil-fueled Peaker plants, lowers greenhouse gas emissions and air pollution, and improves public health outcomes, especially in underserved communities.
Local Energy Markets and Flexibility	Enables participation in Distributed Energy Resource Management Systems (DERMS), virtual power plants (VPPs), and non-wires alternatives; enhances grid flexibility.
Data and Operational Insights	Enhances grid visibility and operational control; supports predictive maintenance, load forecasting, and integration with smart city planning tools.

2.4 Key characteristics of BESS:

BESS stores electricity when power is available and delivers it when needed. The key characteristics that determine how a BESS performs are:

- **Power Capacity:** How quickly the battery can deliver energy at a given moment (measured in kW or MW).
- **Energy Capacity:** The total amount of energy the battery can store (measured in kWh or MWh).
- **Storage Duration:** How long the battery can discharge at its rated power before running out of energy.
- **Cycle Life / Lifetime:** The total number of charge-and-discharge cycles the battery can undergo before its performance significantly degrades.
- **Self-Discharge:** The percentage of stored energy lost over time even when the battery is not being used.
- **State of Charge (SOC):** The current charge level of the battery, expressed as a percentage between 0% (empty) and 100% (full).
- **Round-Trip Efficiency:** The percentage of energy returned compared to the amount of energy used to charge the battery, accounting for internal losses.
- **Energy Density:** The amount of energy a battery can store relative to its weight or volume (measured in Wh/kg or Wh/L). Higher energy density allows for more compact systems and reduces space requirements.

Together, these characteristics determine how much power a BESS can provide, how long it can operate, how often it can be used, and how efficiently it supports the grid.

2.4.1 Key Components of BESS

The key subsystems of a BESS are depicted in *Figure 2* [10] :

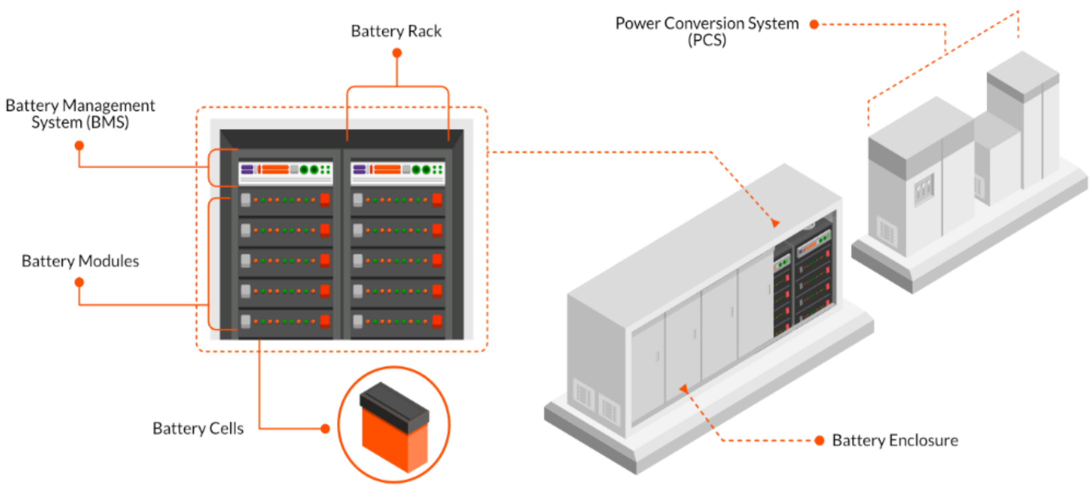

Figure 2 BESS Component-Level Diagram

In general the BESS is made up of multiple subsystems working together to ensure safe and reliable operation:

- **Battery Packs:** Battery packs hold the stored electricity that the system uses when needed.
- **Battery Management System (BMS):** Continuously monitors the battery's voltage, temperature, current, and state of charge to maintain safe and efficient operation.
- **Power Conversion System (PCS):** Allows the battery to charge from the grid and discharge back to the grid by converting AC power to DC and vice versa.
- **Thermal Management System:** Controls battery temperature using air or liquid cooling to prevent overheating and maintain performance.
- **Energy Management System (EMS):** Software that schedules charging and discharging, optimizes operation based on electricity prices or grid conditions, and coordinates with renewable energy sources.
- **Enclosures and Safety Systems:** Provide physical protection and incorporate gas detection, fire suppression, and ventilation systems to ensure safety during all operating conditions.

Combining solar PV with battery storage creates a synergistic system that addresses solar variability and enhances reliability. During sunny periods, excess solar energy charges the batteries. This stored power can then be used in the evening or during grid outages, alleviating peak demand, reducing power costs, and supporting grid stability. Advanced systems use DERMS platforms for real-time coordination, enabling smart control of energy flows and grid support. Together, PV and BESS make DERs smarter, cleaner, and more reliable—reducing grid strain, lowering energy costs, and accelerating renewable energy adoption [11].

3 BESS Technology Assessment

This section outlines the different types of BESS, compares key technologies, and offers practical guidance on selecting the right solution for specific applications [14].

3.1 About Electrical Battery

An electrical battery is an electrochemical device that stores and releases energy through reversible reactions between its anode and cathode, converting electrical energy into chemical energy during charging and converting the stored chemical energy back into electrical energy during discharging.

Figure 3 below illustrates that through these same reversible reactions, electrons flow through an external circuit to create current, while ions migrate through the electrolyte to maintain charge balance; in rechargeable batteries, applying an external voltage reverses this process and restores the original chemical state.

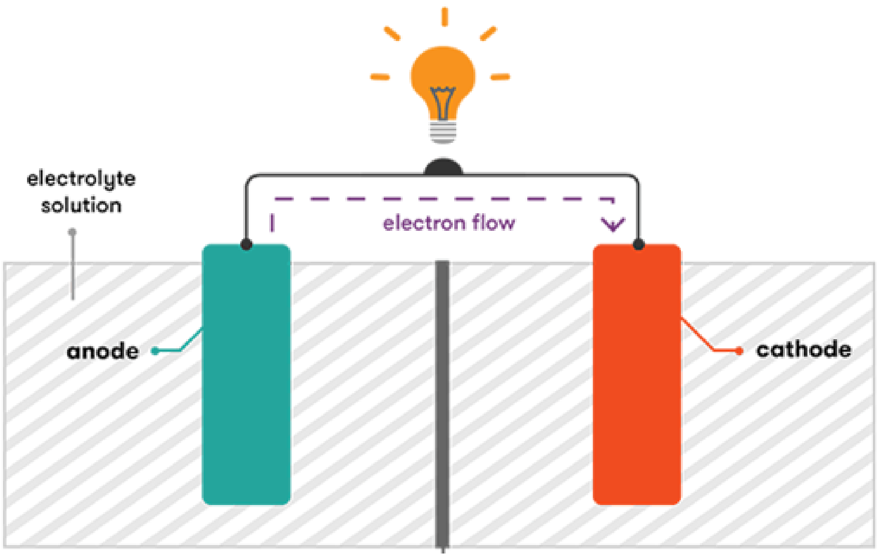

Figure 3 Working of the Battery Cell

When implemented at the community level, electrical batteries serve as the essential component of a battery storage system, often working in conjunction with variable energy sources like solar power. These batteries charge during periods of high solar energy production and discharge energy when solar production decreases in the afternoon. This fundamental capability of an electrical battery delivers clean, affordable, and resilient power, and firms up renewable-centric DER portfolios. As battery technologies continue to advance, these systems have become key enablers of local decarbonization and grid modernization efforts. Figure 4 illustrates reversible electrochemical reactions in a battery: During discharge, chemical energy at the anode and cathode is converted into electrical energy as electrons flow through the external circuit (shown by arrows); applying an external voltage reverses ion and electron flow to recharge the cell.

3.2 Types of BESS Technologies

In summary, utility-scale BESS technology requires a careful balance of cost, performance, safety, and lifespan. Currently, Lithium-ion (Li-ion) battery systems dominate the market due to their high energy density, rapid response times, and long cycle life, making them ideal for homes and small businesses.

Among the various Li-ion options, Lithium Iron Phosphate (LFP) stands out for its exceptional thermal stability and lifecycle longevity. For applications that require longer duration energy storage, flow batteries, such as vanadium redox batteries, offer higher lifecycle counts and enhanced safety. However, they come with a higher upfront cost and larger space requirements.

Emerging battery technologies, including sodium-ion and sodium-sulphur systems, show promise for robust performance in hot climates. Meanwhile, solid-state and zinc-air batteries represent the next frontier in energy density and sustainability; however, they are not yet commercially mature. Choosing the right battery technology depends on:

- battery profile alignment with local load demands
- space limitation
- budget constraints

Table 2 provides a high-level comparison across battery types, including Li-ion, used here as a benchmark but not the central focus. Notably, Solid-State Lithium-Based Batteries (SSBs) and Sodium-Ion Batteries (SIBs) are the only two technologies with energy densities and round-trip efficiencies comparable to Lithium-Ion Batteries (LIBs). However, they currently rank lower in technology readiness compared to flow batteries such as Vanadium Redox (VRFB), Iron Flow (IFB), and Zinc-Bromine (Znbr), as well as other non-flow alternatives.

Table 2 Comparison of Energy Storage Technology Characteristics

Chemistry	Li-Ion	LI SSB	IFB	Flow	Non-Flow	VRFB	SIB
Energy density (MWh/acre)	351	502	50–120	62	62	60–200	183
Discharge duration (hr)	1–10+	1–10+	5–12	2–12	3–12	5–10	4+
Round-trip efficiency, RTE (%)	90–95	90–95	55	< 80	70	65–71	91
Life (yrs)	10	10+	25	10+	20	20+	20

This battery comparison is beneficial for planning engineers or stakeholders involved in energy storage planning, procurement, or investment. It provides a clear overview of key performance indicators, such as energy density, discharge duration, round-trip efficiency, and lifespan across various battery technologies, including LFP and flow batteries.

3.2.1 Battery Types Available in the Market

Batteries are broadly classified into two types:

a) **Non-Rechargeable Batteries**: Non-rechargeable batteries, such as alkaline and lithium primary cells, are designed for single use and are commonly found in devices like remote controls, clocks, and flashlights. Once depleted, they must be replaced.
b) **Rechargeable Batteries**: Rechargeable batteries, like lithium-ion, NiMH, and lead-acid, can be used multiple times by recharging them with electricity. These are widely used in smartphones, laptops, electric vehicles, and backup power systems due to their long-term cost-effectiveness and environmental benefits.

3.2.2 Benefits of Rechargeable Batteries.

Rechargeable batteries offer several technical, economic, and environmental advantages, such as

a) **Reusability**: Rechargeable batteries can be charged and discharged thousands of times, making them highly suitable for long-term energy storage applications. This repeated usability significantly reduces the need for frequent replacements, thereby lowering operational and maintenance costs over the system's lifetime.
b) **Fast Response Time**: Rechargeable batteries can instantly supply or absorb electricity, enabling rapid response to fluctuations in power demand or supply. This swift reaction helps stabilize the grid.
c) **Renewable Energy Integration**: Rechargeable batteries play a crucial role in storing excess energy generated from renewable sources like solar and wind during periods of high generation. This stored energy can then be used during times of low or no generation, such as nighttime or cloudy days, enabling continuous and reliable use of renewable energy.
d) **Backup Power Supply**: Provides uninterrupted power during outages, ensuring reliability for homes, businesses, and critical infrastructure.

3.2.3 Types of Rechargeable Batteries

The section outlines the categories of rechargeable batteries [15]

3.2.3.1 Lithium-Ion (Li-Ion):

High energy density and long lifespan make it ideal for any use case at all scales from residential to utility-scale. Sensitive to temperature and relatively costly.

3.2.3.2 Lithium Iron Phosphate (LFP):

Safer and longer-lasting than other Li-Ion types, with slightly lower energy density. Common in solar and backup systems.

3.2.3.3 Lithium Nickel Manganese Cobalt Oxide (NMC):

Offers high energy output and efficiency but comes at a higher cost. Widely used in EVs and grid storage.

3.2.3.4 Lead-Acid (PbA):

Affordable and recyclable, suitable for backup and off-grid systems. Shorter lifespan and lower efficiency.

3.2.3.5 Flow Batteries:

Scalable and long-lasting with safe liquid electrolytes. Best for grid-scale storage, but has low energy density.

3.2.3.6 Sodium-Ion:

Cost-effective and safer alternative to Li-Ion, especially in hot climates. Still under development with lower energy density.

3.2.3.7 Solid-State:

Promises high energy density and safety with fast charging. Currently expensive and in early stages of commercialization.

3.2.3.8 Zinc-Air:

Eco-friendly with high energy density using air as a reactant. Limited cycle life and high manufacturing cost.

3.2.3.9 Nickel-Cadmium (NiCd):

Durable and reliable in extreme conditions. Environmental concerns due to cadmium toxicity.

3.2.3.10 Sodium-Sulphur (NaS):

High-temperature battery suited for large-scale grid applications. Requires heating systems and has a limited cycle life.

Table 3 provides a comparison of BESS, which helps quickly evaluate different technologies based on performance, cost, and suitability. It supports informed decision-making for selecting the right energy storage solution across residential, commercial, and utility-scale applications.[2]

Table 3 Comparison of Battery Chemistries

Battery Type	Pros	Cons	Typical Applications
Lithium-Ion (Li-Ion)	High efficiency, long lifespan, fast charging, and scalable	High upfront cost, temperature sensitivity	Residential, commercial, utility-scale
LFP (Li-Ion subtype)	Safer, longer lifespan (typically 4,000 cycles)	Lower energy density	Residential, commercial, utility-scale
NMC (Li-Ion subtype)	Higher energy density, better performance	More expensive, shorter lifecycle (typically 1,500 cycles)	EVs, commercial, utility-scale (phasing out)

[2] Amir, M., Deshmukh, R. G., Khalid, H. M., Said, Z., Raza, A., Muyeen, S. M., Nizami, A.-S., Elavarasan, R. M., Saidur, R., and Sopian, K. (2023). Energy storage technologies: An integrated survey of developments, global economical/environmental effects, optimal scheduling model, and sustainable adaption policies. *Journal of Energy Storage, 72*, 108694. https://doi.org/10.1016/j.est.2023.108694

Battery Type	Pros	Cons	Typical Applications
Lead-Acid (PbA)	Low cost, widely available, recyclable	Short lifespan, low efficiency, slow charging	Off-grid systems, UPS
Flow Batteries	Long lifespan, scalable, safe (non-flammable electrolytes)	Low energy density, high initial cost	Grid-scale, long-duration storage
Sodium-Ion	Safer, cost-effective, eco-friendly, high-temp tolerance	Lower energy density, early-stage development	Emerging markets, high-temp environments
Solid-State	High energy density, fast charging, enhanced safety	High production cost, still developing	Future EVs, advanced grid storage
Zinc-Air	High energy density, low environmental impact	Limited cycle life, expensive manufacturing	Backup power, small-scale storage
Nickel-Cadmium (NiCd)	Robust, long cycle life, performs well in extreme temperatures	Toxic materials, lower energy density, higher self-discharge rate	Industrial, remote off-grid, backup systems
Sodium-Sulphur (NaS)	High power, energy density, and high efficiency are suitable for large-scale applications	Higher manufacturing cost, requires special heating systems, and has a limited cycle life.	Utility-scale, grid load balancing

3.3 Factors to Consider When Selecting BESS Technology

The selection of an appropriate BESS technology involves a strategic assessment of multiple key parameters [16]. The following factors should be evaluated to ensure the suitability and efficiency of the system for the intended application:

3.3.1 Energy Requirements and Storage Capacity

It is essential to define the purpose of the BESS installation, whether it is intended for residential energy storage from solar PV systems or utility-scale grid support and fluctuation management. This will determine the required energy storage capacity (measured in kilowatt-hours, i.e., kWh) and power output (measured in kilowatts, i.e., kW).

3.3.2 Cost Considerations and Budget Constraints

The overall cost of a BESS is influenced by the technology employed. Among the commonly used chemistries, lithium-ion systems tend to be the most expensive, followed by flow batteries and sodium-ion technologies. Nonetheless, various financial incentives, subsidies, and rebate programs are available, particularly for residential solar-plus-storage systems, which can significantly offset the initial investment cost.

3.3.3 Environmental Impact

The environmental footprint of the chosen battery technology is a critical consideration. Li-ion batteries, for instance, generally have a higher carbon footprint compared to alternatives such as lead-acid or sodium-ion batteries. While advancements in recycling technologies are ongoing, the end-of-life disposal and recycling of batteries still pose significant environmental challenges and should be factored into the decision-making process.

3.4 BESS Technology Utility-Scale Selection Guidance

Evaluating and selecting the appropriate BESS type depends on a number of factors, primarily power and energy requirements, how often the BESS will be fully charged/discharged (cycling), response time, and cost considerations. The list below offers guidance on BESS selection.

3.4.1 Assess Energy Requirements:

Determine the average and peak power (in kW) needed, as well as the duration (in hours) required. Multiplying the average power by the duration requirement will yield energy requirements.

3.4.2 Evaluate Space Constraints:

Consider the physical space available for installation; compact systems are ideal for limited areas.

3.4.3 Review Project Finance Model and Incentives:

Factor in Project Finance Models and explore available rebates, subsidies, or tax incentives to offset costs.

3.4.4 Check for Scalability:

Ensure the system can be expanded in the future to accommodate growing energy demands.

3.4.5 Prioritize Safety Features:

Ensuring the safety and reliability of BESS is a top priority. Given the project's scale and its critical role in supporting loads, the design and selection of BESS will emphasize robust safety mechanisms over purely cost-driven considerations.

3.4.5.1 Thermal Management and Fire Protection

a) Advanced Thermal Management: High-efficiency cooling systems and thermal monitoring will prevent overheating and runaway thermal events.
b) Comprehensive Fire Protection: Integrated detection, suppression, and isolation systems will be deployed to minimize fire risks and enable rapid incident response.

3.4.5.2 Compliance with Safety Standards

All BESS systems will adhere to internationally recognized safety standards, including:

a) UL 9540 and UL 9540A for system safety and thermal runaway testing

b) NFPA 855 for fire protection in energy storage installations

c) Preference may be given to certified and field-proven solutions to ensure maximum operational reliability.

3.4.5.3 Real-Time Monitoring and Diagnostics

BESS installations will include following features as advanced monitoring systems. This ensures early fault detection and mitigates potential safety risks before escalation.

a) Tracking cell and module temperature profiles

b) Detecting anomalies in voltage or current in real time

c) Issuing predictive alerts to enable proactive maintenance

By prioritizing safety in design, compliance, monitoring, and evaluation metrics, the project ensures that BESS installations will operate reliably, protect critical loads, and meet the long-term safety expectations of the consumers and regulatory bodies.

3.4.6 Applying the BESS Technology Selection Guidance to Shortlist Utility-Scale BESS Technology Candidates

The preceding subsections 3.4.1 to 3.4.5 have outlined a structured framework for evaluating BESS technologies based on energy requirements, spatial constraints, commercial viability, scalability, and safety. These considerations are especially important for utility-scale and industrial-scale deployment, where battery systems must meet long-duration storage needs while also adhering to stringent fire, environmental, and permitting standards.

Hence, the BESS technology selection guidance shortlists the viable chemistries for utility-scale applications, excluding certain battery chemistries based on specific factors:

- Incompatibility with fire codes or high thermal risk (e.g., NMC)
- Insufficient commercial maturity or market readiness (e.g., solid-state, zinc-air)
- Low energy density requiring excessive land area (e.g., legacy lead-acid or NiCd)
- Limited cycle life or duration unsuitable for grid integration

What remains is a shortlist of commercially available technologies that are technically mature/promising and suitable for deployment at scale. Among these, two have emerged as the leading options for long-duration, utility-scale storage:

- LFP – A safer subtype of lithium-ion, widely deployed across California, as shown in Section 3.5
- VRFB – An emerging non-flammable, long-duration alternative gaining traction for grid reliability and resiliency applications as shown in Section 3.10

Table 4 summarizes the key safety features, scale suitability, and duration ranges for each BESS technology reviewed in this report. Technologies marked as not applicable are either not feasible at utility scale or fail to meet the core criteria outlined in sub-sections 3.4.1 through 3.4.5. This table serves as a practical reference for decision-makers engaged in evaluating BESS technology options.

Table 4 BESS Technologies Suitable for Utility-Scale & Industrial

Technology	Typical Duration	Utility-Scale Use	Industrial Use	Safety Profile
Lithium-ion (LFP)	2–4 hours	Yes	Yes	Fire risk is low but not zero due to more stable “safe chemistry” (reduced thermal runaway vs other Li-ion); requires fire monitoring/cooling systems.
Lithium-ion (NMC)	2–4 hours	Yes (still used in some utility projects, now shifting to LFP)	Yes	Higher fire risk – prone to thermal runaway if not managed; needs strict cooling and battery management for safety.
Vanadium Redox Flow (VRFB)	6–12+ hours	Yes - Emerging (pilots for utility-scale long-duration[3])	Emerging (less common for small sites due to size)	No fire risk – non-flammable liquid electrolyte (water-based); safe chemistry (no thermal runaway), but uses corrosive acid (requires spill containment).
Sodium–Sulfur (NaS)	6 hours (typical module)	Yes	Uncommon (high-temp system)	High operating temp (300 °C); sodium and sulfur are reactive – risk of fire if casing is breached (sodium ignites in air). Modern units have built-in insulation and fire suppression (e.g., sand).
Lead–Acid	1–4 hours (best for short backup)	Not applicable (used only in small-scale backups)	Yes (UPS, backup power in telecom/industry)	No thermal runaway, but emits hydrogen gas when charging (explosion hazard without ventilation); contains corrosive acid requiring safe handling.
Zinc-based (e.g., Zn–Br flow, Zn-ion)	4–10 hours (long-duration capable)	Yes - Emerging (pilot projects at utility scale)	Emerging (some C&I demonstrations)	No fire risk – aqueous (water-based) electrolyte; safe from thermal runaway. **Note:** Uses chemicals such as bromine (toxic if leaked), so it requires chemical safety measures.

[3] See State of the Market for Flow Batteries in Section 3.10

3.5 Dominant BESS Technologies in California: Lithium-Ion

Utility-scale BESS deployments have increased in recent years, especially between 2023 and 2024, with lithium-ion batteries dominating across all sectors. Two chemistries, LFP and NMC, make up most BESS technologies.

Based on the California Energy Commission's *"California Energy Storage System Survey,"* California is recognized as a global leader in utility-scale battery storage. As of Q1 2025, California had installed over 15,700 MW of battery storage, up from just 500 MW in 2018. Most of this capacity is utility-scale and grid-connected to provide peak power and ancillary services, as illustrated in the figure below. In 2024 alone, 4,336 MW of new utility-scale storage was added in California, raising the state's total utility-scale battery capacity to approximately 13 GW with an estimated 44.5 GWh[4] of energy (vs. 0.2 GWh of flow batteries underway in the U.S. as an emerging long-duration BESS technology as of 2024; See Section 3.10).

Statewide Energy Storage Power Capacity: **15,763 MW**

Customer Sector	Total Capacity (MW)	Installations	Average Capacity (kW)
Residential	1,829	249,340	7
Commercial	686	3,335	206
Utility	13,248	214	61,907
Total	15,763	252,889	62

Figure 4 California BESS Installed Capacity per Sector

Among the utility-scale BESS deployed, LFP and NMC are the dominant BESS chemistries used in the industry. However, California's large-scale installations have rapidly shifted toward LFP in recent years: about 67% of surveyed California battery facilities (>50 MW) use LFP, 30% use NMC, and only 3% use other blends (e.g., NMC/NCA)[5] as shown in *Figure 5*. This reflects a broader industry trend; NMC projects (many built in the late 2010s) have lost market share to LFP as newer projects favor LFP's lower cost and safety profile.

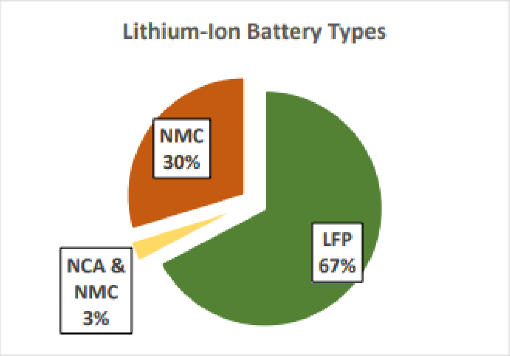

Figure 5 Dominant Lithium-Ion Battery Technologies in California are LFP and NMC, and Shifting Towards LFP due to Lower Cost and Better Safety Profile

[4] Inferred from EIA BESS data as of 2023, stating that California had 8,056 MW of BESS Capacity and 27,105 MWh of BESS Energy Capacity (ratio of 3.36 MWh/MW BESS)
[5] California Public Utilities Commission, Safety and Enforcement Division. *2025 Battery Energy Storage System Facility Survey: Fact Sheet.* July 2025

Across the U.S., a similar pattern is also observed. Most new utility-scale batteries commissioned in 2023–2024 use LFP chemistry (globally, LFP comprised roughly 88% of new 2024 battery installations by capacity). NMC chemistry, while still present in the installed base, is increasingly limited to older projects; it now likely represents well under half of U.S. utility-scale MW capacity.

The widespread shift to LFP is partly a response to safety incidents and performance data from high-profile facilities using NMC chemistry. Thermal runaway incidents, such as those at Terra-Gen's Valley Center in San Diego County, Gateway Energy in Otay Mesa, and Vistra's Moss Landing facility in Monterey County, have raised public concerns. In contrast, LFP operates at cooler temperatures and tolerates full charging, which gives stakeholders greater confidence in deploying storage solutions on the necessary scale.

3.6 BESS Technology Thermal Management

One of the most serious threats to BESS safety is thermal runaway, a chain reaction triggered by overheating within a battery cell. This can escalate into fires or explosions, posing risks to infrastructure and personnel. Without proactive thermal regulation, BESS installations are vulnerable to performance degradation and hazardous incidents.

3.6.1 Heat Generation in Batteries

Batteries naturally produce heat during operation due to several factors [17]:

a. **Internal Resistance**: Electrical resistance within the battery causes energy loss in the form of heat.
b. **Charge/Discharge Rate**: Faster energy transfer increases heat generation.
c. **Environmental Conditions**: High ambient temperatures or poor ventilation can trap heat and raise battery temperature.
d. **Battery Aging**: Over time, internal resistance increases, leading to more heat during use.

3.6.2 Dangers of Excessive Heat Buildup in BESS

Excessive heat accumulation in BESS presents significant risks to both system performance and operational safety. Prolonged exposure to elevated temperatures accelerates battery degradation, leading to reduced efficiency, shortened lifespan, and increased maintenance costs due to more frequent replacements.

Heat stress also compromises energy efficiency, as overheated batteries struggle to store and discharge energy effectively. This results in power losses and higher operational expenses, ultimately diminishing the return on investment for energy storage solutions.

The most critical consequence of poor thermal regulation is the heightened risk of thermal runaway. In this dangerous chain reaction phenomenon, overheated cells ignite adjacent ones, potentially causing fires, explosions, and complete system failure. Without robust cooling mechanisms and thermal management strategies, the impact of excessive heat can be catastrophic, endangering infrastructure, personnel, and the surrounding environment.

3.6.3 Major BESS Fire Incidents and Lessons Learned

Thermal mismanagement has been a key factor in several high-profile BESS fire incidents globally. Inadequate cooling, poor ventilation, and environmental stressors such as extreme heat and humidity have contributed to overheating and thermal runaway events.

3.6.3.1 Key Contributing Factors:

Some of the contributing factors are:

- Insufficient cooling and heat dissipation
- Environmental stress (temperature, humidity, airflow)
- Overcharging and unregulated discharge cycles

Notable incidents, including the 2019 McMicken facility fire in Arizona and the 2022 California BESS fire in Monterey County, highlight the consequences of poor thermal control—ranging from system damage to safety hazards for personnel. These events underscore the urgent need for advanced thermal management solutions to ensure safe and reliable BESS operation.

3.7 The Role of Thermal Management in Fire Prevention

3.7.1 Temperature Regulation for Battery Safety

Maintaining an optimal operating temperature, typically between 60°F and 95°F, is essential for lithium-ion battery safety and performance. Exceeding this range accelerates degradation, reduces efficiency, and increases the risk of thermal runaway. Hotspots within cells can lead to uneven performance, component damage, and higher maintenance costs [17].

3.7.2 Cooling Approaches in BESS

Some of the cooling approaches utilized in BESS are as follows:

3.7.2.1 Passive Cooling:

Utilizes natural convection, insulation, and phase change materials. Suitable for low-power systems but insufficient for large-scale BESS due to limited heat dissipation capacity.

3.7.2.2 Active Cooling:

Table 5 provides an overview of the different types of active cooling systems along with their respective advantages and disadvantages.

Table 5 Types of Active Cooling

Cooling Method	Advantages	Limitations
Air Cooling	Cost-effective, simple setup	Poor temperature uniformity across battery cells
Liquid Cooling	More efficient heat dissipation	Requires complex infrastructure and maintenance
Refrigerant Cooling	High cooling efficiency	Expensive, potential environmental concerns

3.7.2.3 Hybrid Cooling:

Combines passive and active methods to enhance thermal regulation. These systems optimize performance and safety while minimizing energy consumption, making them ideal for modern, scalable BESS deployments.

3.7.3 Thermal Runaway - Common Cause of BESS Fire

As temperatures rise due to thermal runaway, chemical reactions within the battery accelerate, producing even more heat [27]. BESS thermal runaway occurs when a damaged lithium-ion battery cell releases flammable or toxic gases, triggering a chain reaction that spreads to adjacent cells. As this process accelerates, extreme heat and pressure build up, significantly increasing the risk of fires or explosions.

3.7.3.1 Causes of Thermal Runaway

Thermal runaway can be triggered by a variety of factors, including:

a) **Overcharging:** If neither the charger nor the protection circuit stops the charging process, then more energy enters the cell. As a result, the voltage in the cell rises – this is known as overcharging. Regardless of size (cellphone or large-scale), battery overcharging poses a fire hazard to the battery cell and shortens its lifespan. It is also a safety risk for the user. Excess energy leads to heat generation, which, in the worst case, leads to thermal runaway.

b) **Deep discharging:** When a battery is drained too much, it can get damaged inside and heat up when used again. This extra heat can build up quickly, making the battery unstable. In some cases, it can get so hot that it catches fire.

c) **Manufacturing Defects***:* Sometimes batteries have hidden defects from the factory, like tiny cracks, impurities, or poor materials**.** These minor problems can cause short circuits inside the battery, making it heat up more than usual. If the heat builds up too much, it can lead to thermal runaway, where the battery gets hotter, possibly causing a fire or explosion.

d) **Physical Damage:** If a battery gets crushed, punctured, or dropped hard, it can get damaged inside. This damage can cause a short circuit in the battery, causing rapid increase of internal temperature. When the heat can't escape, it can lead to thermal runaway, where the battery keeps getting hotter and can catch fire or explode.

e) **High External Temperatures**: When a battery is left in very hot places, like direct sunlight or near a heat source, it can get too hot from the outside. This outside heat can cause the batteries' temperature to rise, leading to thermal runaway.

3.8 BESS Fire Prevention

Preventing BESS fires requires a layered, multi-faceted approach, including [28]:

3.8.1 Battery Management Systems (BMS)

A Battery Management System is the central logic component of a BESS responsible for monitoring and controlling the system. The BMS:

a) Calculates the charge remaining on the battery
b) Monitors the temperature of the battery system
c) Monitors for shorts and faulty connections
d) Maintains the charge within the cells in the optimal performance range

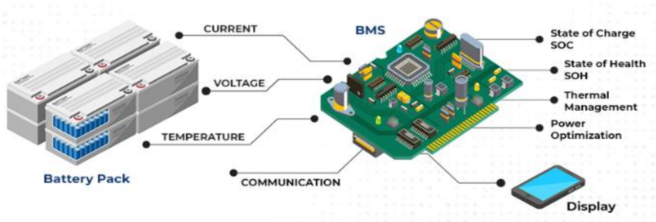

Figure 6 BMS Component-Level Diagram

The BMS monitors and implements safety measures to prevent overcharging, over-discharging, and overheating, thereby extending battery life and optimizing performance. It also diagnoses issues and logs events, providing valuable data for troubleshooting and improving system reliability. Components of BESS are given in *Figure 6***Error! Reference source not found.**.

If the BMS detects any abnormal conditions, it shuts the battery down. This protects the cells from damage.

3.8.2 Gas Detection Systems

These systems detect the release of flammable gases from a faulty battery cell. When the gas detector alerts the presence of an off-gas, it can activate several mitigating actions. Perhaps the most important thing is shutting down power to the affected cell(s). Additionally, the gas detection equipment can:

- Activate a ventilation system within the BESS enclosure to remove flammable gases and heat
- Activate local and remote alarms
- Provide an early warning for operators to take additional measures

Gas detection offers the first chance to intervene after the BMS fails. Gas detection provides far quicker notification of the problem than does a smoke, heat, or flame detector. With gas detection, this is an opportunity to mitigate the problem before it requires a response action from fire suppression equipment.

3.8.3 Fire Suppression Systems

An illustration of a typical fire suppression system is shown in *Figure 7***Error! Reference source not found.**. It is the final line of defense, meaning that all other interventions have failed. However, the way in which batteries fail, and their design make total extinguishment difficult.

Specialized fire suppression agents, such as condensed aerosol systems, can quickly suppress fires and limit thermal runaway.

Figure 7 Fire Suppression Systems

3.8.4 Thermal Barriers

Figure 8 Thermal barrier - sourced from the Tecman UK case study [62]

In BESS, Thermal Barriers are illustrated in *Figure 8* [62] can be placed in between two consecutive battery cells, modules, or trays to create physical separation that will limit the heat transfer. A thermal barrier slows down and prevents the propagation of fire to neighboring cells. This prevents a single cell's thermal runaway from triggering a chain reaction in neighboring cells.

3.9 National Blueprint for BESS Technology Safety

On March 28, 2025, the American Clean Power Association (ACP) released a comprehensive framework to ensure the safety of battery energy storage systems (BESS) in every community across the United States, informed by a new assessment of previous fire incidents at BESS facilities.

The assessment, conducted by the Fire and Risk Alliance, analyzed historical data and scientific studies on fire incidents over the last decade in the U.S. The findings indicate no impact on public health or surrounding communities from the incidents studied [29]. ACP's Battery Storage Blueprint for Safety outlines key actions and policy recommendations for state and local jurisdictions to regulate battery storage, enforce the country's most rigorous safety standards, and ensure coordination on safety and emergency response in all communities.

The assessment's key finding reveals that, in all reviewed cases of environmental sampling related to the BESS fire events, no previous incidents resulted in contaminated concentrations that would pose a public health concern or require further remediation.

A critical component of the blueprint is understanding where the industry has been successful in efforts across the country to advocate for the enforcement of the National Fire Protection Association's standard for energy storage, NFPA 855. The set of standards includes exhaustive requirements and ensures that facilities use certified batteries and equipment.

3.10 Flow Battery Technology as an Emerging Non-Flammable Long-Duration Alternative to Lithium-Ion

As discussed in Section 3.5, majority of grid-connected BESS deployed in California utilize lithium-ion chemistries, most commonly LFP. The high energy density and decreasing costs of LFP have contributed to its rapid adoption across the state. However, as outlined in Sections 3.6 to 3.9, this lithium-ion architecture, particularly NMC, delivers compactness and performance but also raises thermal management concerns. Mitigation strategies and facility setback buffers, and other thermal containment standards as per NFPA 855 and SB 38, address these issues in exchange for additional regulatory complexity and cost for the BESS developer.

Alternatively, utilities[6], municipalities[7], and regulators[8] are increasingly evaluating flow batteries for long-duration energy storage applications (typically 8-12 hours) without the thermal risk. Unlike Li-ion, flow batteries store energy in liquid electrolytes held in external tanks and circulated through electrochemical stacks during charge and discharge. This fundamental difference allows the separation of power capacity (stack size) from energy capacity (tank volume), allowing for extended discharge durations of 8 to 12 hours or more, and eliminating cell-to-cell thermal propagation (discussed in detail in Section 4.2).

State of the Market for Flow Batteries

Across the U.S. as of 2024, multiple flow battery pilot and demonstration projects are underway, with an estimated 200 MWh of capacity either already operational or slated for commissioning within the next 2–3 years.[9] These projects span a range of applications, including utility-scale pilots, military installations, microgrids, and behind-the-meter systems. Notable examples include:

- A 10 MWh VRFB integrated with a solar microgrid for the Viejas Band of the Kumeyaay Indians
- A 2 MWh VRFB microgrid project by Orcas Power and Light

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[6] In 2019, the California Independent System Operator tested a 2MW/8MWh vanadium redox flow battery pilot in coordination with SDG&E (Sumitomo Electric) to evaluate its behavior in the electricity market
[7] In 2024, SMUD announced it was awarded a $10 million state grant from the California Energy Commission (CEC) to deploy a 3.6 MW, 8-hour iron flow battery demonstration project.
[8] California, through the CEC, has allocated over $270 million to fund non-lithium long-duration energy storage (LDES) demonstrations through its LDES Program, encouraging of non-lithium LDES deployment.
[9] Aaron Hollas, Allan Tuan, Vilayanur Viswanathan, Isabella Ragazzi. *Adoption Readiness Level Assessment of Redox Flow Batteries*. PNNL-36780. Pacific Northwest National Laboratory and U.S. Department of Energy, Office of Technology Transition, September 2024.

- An 8 MWh VRFB installation supporting grid services for San Diego Gas & Electric
- A 0.1 MWh pilot system operated by Snapping Shoals EMC
- Two iron flow battery systems at Sacramento Municipal Utility District (SMUD), sized at 2.4 MWh and 29 MWh, respectively, supporting decarbonization and resiliency goals
- A 50 MWh organic flow battery project deployed by the Salt River Project for renewable energy integration and demonstration purposes

These projects reflect growing interest in non-lithium, long-duration storage solutions across a range of climates, ownership models, and technical use cases.

3.10.1 Flow Batteries are Non-Flammable but Have Inherent Safety Risks

While flow batteries are inherently non-flammable because their electrolytes are water-based, their safety risk shifts from thermal runaway to electrolyte leak hazards, necessitating safety standards for chemical containment and electrolyte management.

Regulatory standards for flow batteries are still maturing, unlike NFPA 855 and UL 9540 for Li-ion. A balanced safety assessment when considering flow batteries must acknowledge hazards identified in industry literature[10] such as (1) gas evolution under overcharge, electrolyte imbalance, or thermal stress, (2) Acidic leaks and corrosion that can damage secondary containment materials and create localized hazards, and (3) Combustion (In unlikely fire scenarios involving polymer components, small quantities of HF, SO_2, or CO/NO_x may form).

3.10.2 Flow Battery Operational and Lifecycle Value

Currently, flow batteries represent the most commercially mature non-lithium technology alternative that trades energy density and cost for safety, longevity, and long duration. The typical service life exceeds 20 years with minimal capacity fade, and electrolyte reuse or recycling can recover up to 95–97% of the active materials. For municipal applications such as the City of Vacaville, this alternative offers reduced fire-safety requirements, potential simplified permitting, and alignment with long-term resiliency and sustainability goals.

3.11 BESS Technology Recommendation:

In conclusion, both LFP and VRFBs are viable options for large-scale storage projects, with the status quo in California skewing heavily towards LFP. LFP batteries remain the preferred near-term choice due to their compactness, mature regulatory framework, and proven field safety. However, for projects that put high importance on long-duration energy storage, vanadium redox flow batteries remain the leading alternative, despite their higher upfront costs and larger land requirements. To give the client more insights on these two BESS technologies, A comprehensive comparison between lithium-ion and flow batteries is available in Section 4.

The decision on which BESS technology to select depends on the project's key economic drivers, , safety objectives, and operational priorities:

[10] Electric Power Research Institute (EPRI). Review of Environmental Life Cycle Assessments for Select Advanced Lithium and Non-Lithium Energy Storage Technologies. Palo Alto, CA: EPRI, December 2024. Report 3002030237, p.7.

3.11.1.1 Lithium-Iron Phosphate (LFP):

a) Thermal Stability and Safety: High tolerance and minimal risk of thermal runaway when installed, monitored, and maintained properly.
b) Longer Life Cycle vs. NMC: 3,000 to 6,000 cycles [37], reducing replacement frequency and lifecycle costs.
c) High Energy Density: Lower land requirement (100 MWh per acre[11]), making it suitable where available battery footprint is limited.
d) Mature Supply Chain and Cost Curve: Broad commercial availability and declining capital costs, especially when combined with solar incentives.
e) Round-Trip Efficiency: Typically, 90-95%, resulting in higher usable energy output and improved economic performance compared to flow batteries [58].
f) Supply Dependency: LFP technology relies on imported materials such as lithium and phosphate compounds, which may affect long-term cost stability and supply security [59].

3.11.1.2 Vanadium Redox Flow Batteries (VRFB):

a) Thermal Stability: Non-flammable with negligible risk of thermal runaway.
b) Marginally Longer Life Cycle: 15,000 to 20,000 cycles [38], with minimal degradation, ideal for frequent cycling.
c) Flexible and Scalable Energy Capacity: Energy capacity can be increased independently of power by enlarging electrolyte storage, suitable for multi-hour or multi-day storage.
d) Suitable for RE Integration: long-duration (8-12 hours) storage alternative to LFP for grid support that goes well with wind and solar for minimizing environmental impact. However, it requires higher upfront investment and more site area.
e) Round-Trip Efficiency: Typically, 70–80%, which is lower than LFP systems, potentially impacting overall cost economics for shorter-duration applications [60].
f) Supply Chain Advantage: Vanadium is more widely available and less import-dependent, offering a potential advantage in domestic sourcing and supply resilience, though it requires higher initial capital investment and larger site area [61].

4 Comparing Flow and Lithium-ion Batteries

As outlined in Sections 3.5 through 3.11, California's battery portfolio mainly consists of Li-ion batteries, leaning towards LFP chemistry, for energy storage because of their cost and footprint efficiency. However, recent incidents at Li-ion facilities have raised *safety concerns and regulatory scrutiny regarding the expansion of* Li-ion BESS facilities.

Alternatively, flow batteries offer a safer, non-flammable alternative with longer duration and less capacity degradation over time; however, they introduce different *operational and chemical risks*, necessitating pump management, electrolyte containment, and gas-evolution control.

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[11] To calculate this acreage requirement, storage footprint was assumed to be 0.01 acres per MWh of energy stored (Guidehouse 2020: 9). A typical grid-scale lithium-ion battery has a duration of 4 hours (CAISO 2023: 8). Therefore, a 1 MW battery with a 4-hour duration can store 4 MWh of energy. This battery will occupy 0.01 acres per MWh * 4 MWh per MW = 0.04 acres per MW.

Given these contrasting characteristics, this section introduces a comparative life-cycle assessment (LCA) framework to evaluate total environmental impact, safety performance, and long-term sustainability across both technologies.

This section begins by outlining the LCA methodology applied to quantify trade-offs between flow and lithium-ion batteries, aligning the analysis with the City's overarching goal to understand these competing BESS technologies in terms of safety, cost, and environmental impact for utility-scale deployment. The table below summarizes the comparison between flow and lithium-ion batteries in this document.

Table 6 Safety and Use Comparison Between Flow and Lithium-Ion Battery Technologies[12][13]

Category	Lithium-Ion (LFP)	Flow Batteries (VRFB)
Typical Use Case	Dominant in California grid BESS; preferred for fast response, smaller footprint, and lower cost.	Increasingly used for long-duration energy storage, often in pilot or industrial projects (see Section 3.10); larger footprint requirement.
Core Chemistry	Energy stored in solid electrodes; high energy density.	Energy is stored in liquid electrolytes circulating between tanks; low energy density.
Primary Safety Risk	Thermal Risk: a self-heating chain reaction that can cause fires if not mitigated.	Chemical risk: acid leaks, gas evolution, and potentially toxic off-gases under stress.
Thermal Risk	Possible cell-to-cell propagation; mitigated in LFP by stable phosphate chemistry (non-oxygen releasing). EPRI fire study notes that LFP incidents emit less heat and fewer toxic gases than NMC or NCA systems.	Non-flammable aqueous electrolytes make sustained combustion unlikely. However, polymer and gasket materials can still burn, releasing HF, SO_2, or NO_x gases under high heat.
Chemical and Leakage Risks	LIB vents gases: CO, H_2, and organic solvent vapors during failure; modern gas detection and BMS systems (NFPA 855) reduce this risk.	VRFB and ZnBr can evolve H_2 or Br_2 during imbalance or overcharge; they require ventilation, gas sensors, and pH monitoring.

[12] Electric Power Research Institute (EPRI). *Review of Environmental Life Cycle Assessments for Select Advanced Lithium and Non-Lithium Energy Storage Technologies.* Palo Alto, CA: EPRI, December 2024. Report 3002030237, pp. 7–12.
[13] Electric Power Research Institute (EPRI). *Global Battery Energy Storage System Fire Suppression Water Management Practices.* Palo Alto, CA: EPRI, November 2023. Report 3002031835, pp. 45–98.

Category	Lithium-Ion (LFP)	Flow Batteries (VRFB)
Water and Fire Suppression	Standard water deluge systems are sufficient for LFP modules, with minimal environmental impact.	Water is used primarily for cooling and containment, rather than suppression; secondary containment and corrosion-resistant design are required due to the presence of acidic liquids.
Environmental Hazard During Fire	Byproduct from LIB fires can contain metals (Ni, Co, Mn), but they are treatable and can be managed. An EPRI report found no long-term soil contamination from past incidents.	Acidic electrolyte spills may require neutralization (lime or soda ash). Bromine or chlorine gases can pose local inhalation hazards if ventilation fails.
Lifecycle and Recycling	3,000 to 6,000 cycles. Established recycling infrastructure for LFP, copper, and aluminum recovery.	10,000 to 20,000 cycles. 95–97% electrolyte recyclability, since vanadium does not degrade.
Regulatory Standards	Fully codified under NFPA 855, UL 9540/9540A, and the California Energy Commission BESS fire code. There is widespread AHJ familiarity.	Still maturing, as there is no unified NFPA equivalent. More operational data will be gathered as more flow batteries are deployed in the field.
Community Implication	Proven, commercially mature, compact, and safe when designed to LFP standards with proper BMS, ventilation, and setbacks.	Safer in terms of thermal risk, but introduces corrosive liquids and maintenance complexity. It is also unsuitable for dense community sites due to the large footprint requirement. Lack of mature safety standards introduces uncertainty.

4.1 Life Cycle Assessment as a Framework to Compare the Safety and Environmental Impact of Flow and Lithium-ion Batteries

Life Cycle Assessment (LCA) is a systematic method used to evaluate the environmental impacts of a product, process, or technology throughout its entire life cycle, from raw material extraction and manufacturing to transportation, usage, and end-of-life management activities, such as recycling, repurposing, or disposal.

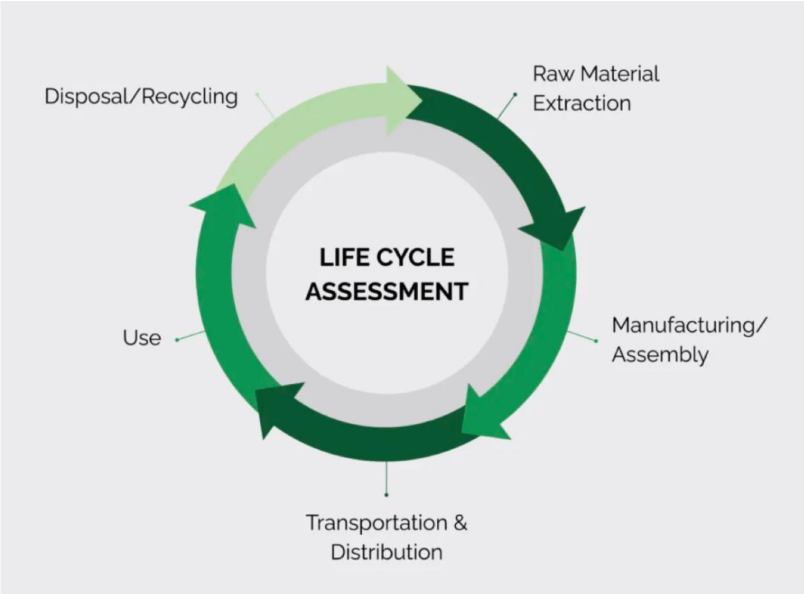


Figure 9 LCA Framework Overview. Image Reproduced from Berger Maritiem

When applied to different BESS technologies, LCA provides a structured framework for comparing technologies, such as flow and lithium-ion batteries, on an apples-to-apples basis in terms of environmental performance, safety, and sustainability. It helps identify design improvements, reduce resource use, and anticipate safety or regulatory challenges before large-scale deployment.

Forward-looking LCAs offer critical insights for comparing technological options, guiding investment and deployment decisions by highlighting trade-offs across manufacturing, policymaking, project location, operations, and maintenance.

However, LCAs have inherent limitations. Their accuracy relies on the quality and availability of input data, which is often limited, confidential, or derived from small-scale pilot projects for emerging technologies.

Additionally, differences in scope, macroenvironment, assumptions, and methodology across references can also affect how results are compared or applied to policy.

Despite these limitations, LCAs remain a valuable tool for assessing the *socio-economic and environmental trade-offs* of BESS technologies and for guiding decisions that promote their sustainable development and deployment.

4.2 Flow Batteries

Flow batteries, also known as redox flow batteries (RFBs), are often highlighted as promising alternatives to lithium-ion batteries for stationary energy storage. They stand out for being safer, easier to maintain, and capable of providing power for much more extended periods, making them a good BESS technology candidate to pair with solar and wind.

4.2.1 How Flow Batteries Work

All flow batteries work under the same concept: they store energy in liquids rather than solid materials (e.g., Li-ion). These liquids, called electrolytes, hold charged particles that move through a "stack" (the heart of the battery) separated by a thin membrane (see the green portion of the Figure 10). When charging or discharging, the two liquids are pumped through the stack, and electricity is produced as ions flow across the membrane.

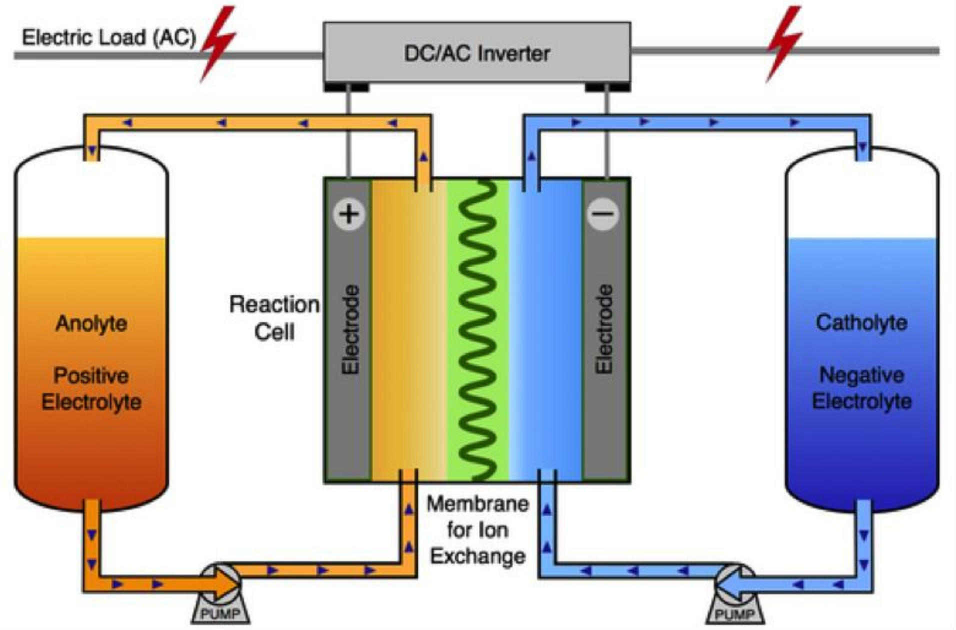


Figure 10 How Flow Batteries Work

A flow battery stores energy in two liquid electrolytes kept in separate tanks—one positive (anolyte, orange) and one negative (catholyte, blue) as shown in *Figure 10*. When the system operates, these liquids are pumped through a central reaction cell, where a membrane lets ions move between them without mixing. This ion exchange produces an electric current that can be supplied to equipment through an inverter. During charging, the reactions reverse, restoring the liquids to their original state. Because the electrolytes are reusable and stored externally in tanks, flow batteries offer long life, easy scaling, and a refillable-fuel-like operation.

Because the energy is stored in the liquid itself, the capacity of a flow battery can be increased simply by adding more liquid to its storage tanks, much like filling a fuel tank. Another advantage of flow batteries is that they can also be immediately "recharged" by replacing the spent liquids in the tank with energized liquid.

In contrast, lithium-ion batteries store energy in solid electrodes, which limits the amount of energy they can hold and makes them more susceptible to heat buildup and aging. Energy storage is the key differentiator between flow and conventional batteries.

4.2.2 Types of Flow Batteries: Vanadium Redox, Zinc-Bromine, and Iron

Flow batteries come in several types, each using different chemical liquids to store and release energy. Vanadium Redox Flow Batteries (VRFBs) are the most mature technology of those included in this review and have the largest deployed capacity, while Iron Flow Batteries (IFBs) and Zinc-Bromine (Znbr) flow batteries [40] are considered "emerging" technologies, limited to pilot or demonstration projects only.

- VRFBs and IFBs use the conventional "dual-flow" design where both positive and negative electrolytes circulate through the stack.
- ZnBr systems: Use a hybrid configuration where one side of the reaction involves a solid material instead of two liquid electrolytes.

Diagrams of these two common flow battery designs are provided in *Figure 11* for reference.

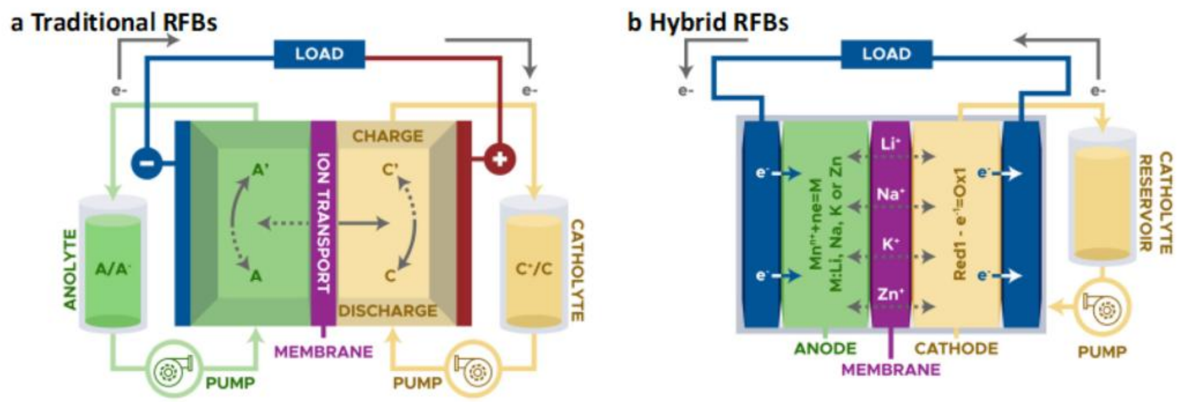


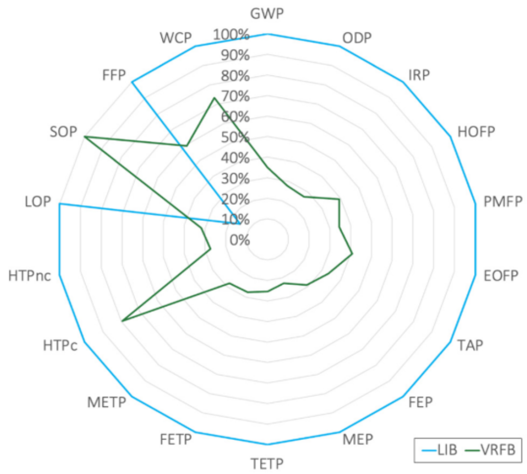
Figure 11 Two basic flow battery designs: (a) standard dual-flow system with dissolved active species, and (b) hybrid system with a solid anode active species.

4.2.3 LCA Studies and Safety Risk Comparison of LIBs and VRFBs

Recent research has compared the environmental footprint of manufacturing LIBs and VRFBs. In summary, flow batteries offer significant advantages in terms of safety, recyclability, and long-duration performance. Flow battery environmental impact studies with respect to LIB have mixed findings. Some claim that flow batteries have higher manufacturing impacts than lithium-ion systems (see *Figure 13*Error! Reference source not found.**), but they balance the emission scales during their operational phase and end-of-life, assuming they utilize substantial renewable energy systems. Another group of researchers concluded that flow batteries (specifically VRFB) produce *lower* overall manufacturing impacts compared to LIB (see** *Figure 12*Error! Reference source not found.**).**

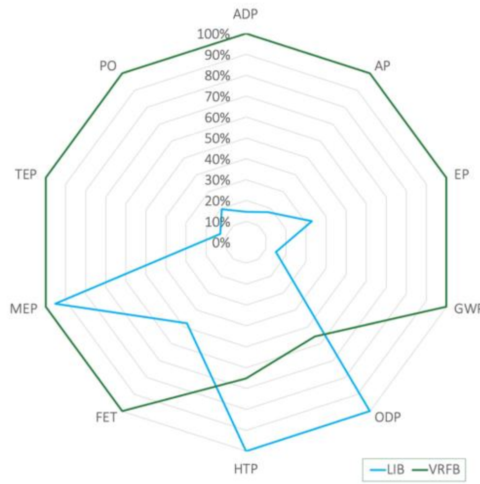
4.2.3.1 Manufacturing Phase Environmental Impact

Flow battery environmental impact studies with respect to LIB have mixed findings. A 2020 study found that manufacturing VRFBs has less battery manufacturing environmental impact than lithium-manganese-oxide (LMO) LIBs when measured per unit of stored energy, except for the 'mineral resource scarcity' category [42]. Alternatively, a 2023 study [43] reported that VRFB manufacturing has higher environmental impacts than NMC LIB production except for the 'human toxicity' and 'ozone layer depletion' categories.



Environmental Indicator	Acronym	Unit
Global Warming	GWP	kg CO_2 eq
Stratospheric Ozone Depletion	ODP	kg CFC-11 eq
Ionizing radiation	IRP	kBq Co-60 eq
Ozone formation, Human health	HOFP	kg NO_x eq
Fine particulate matter formation	PMFP	kg PM2.5 eq
Ozone formation, Terrestrial ecosystems	EOFP	kg NO_x eq
Terrestrial acidification	TAP	kg SO_2 eq
Freshwater eutrophication	FEP	kg P eq
Marine eutrophication	MEP	kg N eq
Terrestrial ecotoxicity	TETP	kg 1,4-DCB
Freshwater ecotoxicity	FETP	kg 1,4-DCB
Marine ecotoxicity	METP	kg 1,4-DCB
Human carcinogenic toxicity	HTPc	kg 1,4-DCB
Human non-carcinogenic toxicity	HTPnc	kg 1,4-DCB
Land use	LOP	m^2a crop eq
Mineral resource scarcity	SOP	kg Cu eq
Fossil resource scarcity	FFP	kg oil eq
Water consumption	WCP	m^3

Figure 12 Environmental Impact Comparison of Lithium-Ion and Vanadium Redox Flow Batteries with Associated Indicator Definitions sourced from [42]



Environmental Indicator	Acronym	Unit
Abiotic resource depletion	ADP	kg Sb eq
Acidification	AP	kg SO_2 eq
Eutrophication	EP	kg PO_4 eq
Global warming	GWP	kg CO_2 eq
Ozone layer depletion	ODP	kg CFC-11 eq
Human toxicity	HTP	kg 1,4-DB eq
Freshwater ecotoxicity	FET	kg 1,4-DB eq
Marine ecotoxicity	MEP	kg 1,4-DB eq
Terrestrial ecotoxicity	TEP	kg 1,4-DB eq
Photochemical oxidation	PO	kg C_2H_4 eq

Figure 13 Environmental Impact Comparison of Lithium-Ion and Vanadium Redox Flow Batteries with Associated Indicator Definitions sourced from [43]

Amongst flow battery chemistries, iron-flow (IFB) systems have been found to have the lowest overall manufacturing impacts, followed by zinc-bromine (ZnBr) systems, and then VRFB systems. However, it is important to note that these findings may *not* be representative of final commercial system designs, given the limited commercial deployment of these *emerging* battery chemistries.

The most significant environmental impacts highlighted in LCAs arise from the production of electrolytes, bipolar plates, membranes, electrodes, and peripheral components (such as tanks, pipes, pumps, and steel structures), as well as from the electricity mix used for charging during operation. However, these impacts can be greatly reduced through recycling, which allows recovery of metals and electrolytes in much the same way as lithium-ion battery materials.

With continued improvements in materials, design, and renewable integration, flow batteries are well-positioned to play a growing role in California's sustainable, utility- and industrial-scale energy storage landscape.

4.2.3.2 Use-Phase Environmental Impact

Beyond the manufacturing phase, flow batteries generally exhibit higher use-phase environmental impacts than lithium-ion systems due to their lower round-trip efficiency (see Table 2**Error! Reference source not found.**). However, over their full operating life, typically exceeding 20 years with minimal capacity loss, these impacts become more balanced. When charged with renewable energy, such as solar or wind, flow battery use-phase emissions and cumulative energy demand can approach or even fall below those of lithium-ion systems [44–47].

4.2.3.3 End-of-Life Environmental Impact

Studies focusing on recycling, particularly for VRFBs, show recycling's significant contribution in reducing overall life-cycle environmental impacts. Jones et al. [48] and Weber et al. [20] estimated that recycling can cut global warming impacts by 14%–75%, depending on the electricity mix and battery utilization.

Flow battery recycling is generally less complex than Li-ion systems because the liquid electrolytes do not degrade over time. Up to 95% of stack metals and 97% of vanadium electrolytes can be recovered at end-of-life [49], significantly lowering the emissions of replacement materials. Section 4.2.4 provides insights on how the industry is implementing this in practice.

However, since flow batteries still represent a smaller share of the market, a robust recycling infrastructure has not yet been established.

4.2.3.4 Primary Safety Risk for Flow Batteries

From a safety standpoint, flow batteries are non-flammable and highly resistant to thermal runaway due to their water-based electrolytes. However, they introduce different operational risks, primarily acidic leaks, gas evolution (hydrogen, bromine, or chlorine), and minor off-gases (HF, SO_2, NO_x) that may form under high-heat or poor maintenance conditions [23]. These risks can be managed through effective system design, engineering controls, including secondary containment, corrosion-resistant materials, ventilation, continuous gas monitoring, and advancements in electrode materials.

In contrast, LFP systems, while storing energy in solid electrodes that gradually degrade over time, are now considered the safest lithium-ion chemistry for stationary applications. Their stable phosphate composition prevents oxygen release, significantly reducing the risk of fire propagation. LFP systems are also covered by well-established safety standards such as NFPA 855 and UL 9540A, ensuring proven design, ventilation, and suppression protocols for utility-scale installations.

Overall, flow batteries trade thermal safety for chemical complexity, while LFP systems combine thermal stability, regulatory maturity, and compactness, making them the more practical and reliable choice for utility-scale energy storage.

4.2.4 Industry Perspective: Comparing Vanadium, Zinc-Bromine Flow Batteries to Lithium-ion

From a practical industry perspective, the environmental impact of flow batteries, particularly Vanadium Redox Flow Batteries (VRFB), primarily stems from the production of vanadium electrolytes. However, manufacturers are addressing this challenge through several strategies:

- Implementing "circular" electrolyte models (discussed further in sub-section 4.2.4.1);
- Developing reuse strategies.
- Integrating renewable energy sources; and
- Branching out to other chemistries (e.g., Zinc-Bromine).

These initiatives help establish a viable path toward commercial sustainability.

This section offers insights into the actual sustainability practices adopted by industry leaders and manufacturers, building on the life cycle impact reports discussed earlier. This section examines how companies such as Largo Inc., CellCube, EOS Energy Storage, and Gelion Technologies are minimizing environmental impacts in flow battery production through improved electrolyte management, recycling efforts, and the use of renewable energy sources.

4.2.4.1 Largo Inc - Circular Electrolyte Ownership Model to Reduce Mining Impacts

Largo Clean Energy, a subsidiary of Largo Inc., manufactures VRFBs. Largo adopts a "holding company" model, *retaining ownership* of its vanadium electrolyte to:

(1) reduce the high upfront cost of electrolytes for customers, and

(2) ensure recovery and recycling at end-of-life.

This strategy not only lowers costs for end-users but also delivers environmental benefits by avoiding new vanadium mining and processing.

Largo's sustainability report indicates that 25% of its electricity use now comes from renewable sources. The reported global warming impact of vanadium electrolyte production, estimated at 80–100 kg C02e per kWh of VRFB capacity, is consistent with independent findings. Table 7 summarizes Largo's reported GHG emissions intensity trends from 2020 to 2023, showing gradual increases linked to lower annual production volumes.

Table 7 Direct GHG Emissions Intensity of Largo Vanádio de Maracás S.A. (LVMSA) for V_2O_5 Production

GHG EMISSION INTENSITY	2020	2021	2022	2023
Direct GHG emissions (tCO2e)	78,506	77,817	82,948	93,872
Annual Production (tV2O5)	11,825	10,319	10,436	9,680
GHG emissions intensity (tCO2e/tV2O5)	6.99	8.32	8.22	9.70

4.2.4.2 CellCube - Lowering Life-Cycle Emissions through Electrolyte Reuse and Renewable Charging

In 2022, German VRFB manufacturer CellCube published a life cycle assessment (LCA) of its FB 500-2000 Rel.4.0 system [29]. The study analyzed a 4-hour system cycling daily for 20 years.

The results showed that vanadium pentoxide (V_2O_5) production was the largest contributor to global warming potential (57%), followed by power unit production (16%), energy unit production (11%), and transportation (9%). However, electrolyte reuse substantially reduced environmental impact: reusing 97.5% of the electrolyte and introducing only 2.5% new material lowered the system's global warming potential by 66%

A 2023 follow-up LCA led by Blume et al. [51], based entirely on primary operational data. The results highlighted that VRFBs charged with solar power exhibit higher emissions than those charged with wind power, regardless of location, while the transport distance of structural components had a negligible impact since the heavy electrolyte dominates transport emissions.

The study also noted that onsite electrolyte production, as being explored by manufacturers such as Largo Clean Energy, can further reduce both the financial and environmental burdens associated with transporting electrolyte materials.

In summary, CellCube's analyses confirm that *vanadium production* and *electrolyte management* have the most environmental impacts in VRFB systems. Electrolyte reuse and renewable-based charging are the most effective strategies to minimize life-cycle emissions and improve the long-term sustainability of flow battery technology.

4.2.4.3 EOS Energy Storage and Gelion Technologies - Early Zinc-Bromine Flow Battery Designs Show Strong Economic and Environmental Performance

Zinc-bromine flow batteries (ZBFBs) remain in early commercial development stages but show potential for safe and sustainable stationary storage. While Redflow was one of the first major manufacturers of ZBFB, other companies, such as EOS Energy Storage and Gelion Technologies, have published independent Climate Impact Reports assessing the environmental performance of their batteries using LCA.

While many metrics are evaluated, the overall trend is clear:

- **Lower greenhouse-gas and energy intensity:** Both EOS and Gelion batteries use *less energy* and produce *fewer lifecycle emissions* per kWh than typical lithium-ion systems.
- **Reduced water use:** Their water-based electrolytes and simpler manufacturing processes minimize water demand and volatile-organic-compound (VOC) emissions.
- **Shorter carbon payback time:** The batteries offset their production-phase emissions more quickly, meaning they achieve net climate benefits sooner in operation.

These results indicate that zinc-bromine batteries combine strong environmental performance with the inherent safety of non-flammable, water-based chemistries. Although still maturing commercially, they demonstrate how alternative flow and hybrid chemistries can contribute to the long-term sustainability of the stationary storage market.

In summary, EOS and Gelion's climate impact studies show that zinc-bromine batteries perform well environmentally compared to lithium-ion. They use less energy and water over their lifetime, emit fewer greenhouse gases, and pay back their carbon footprint faster. Their results also demonstrate how non-flammable, water-based chemistries can reduce both environmental and safety risks for stationary energy storage.

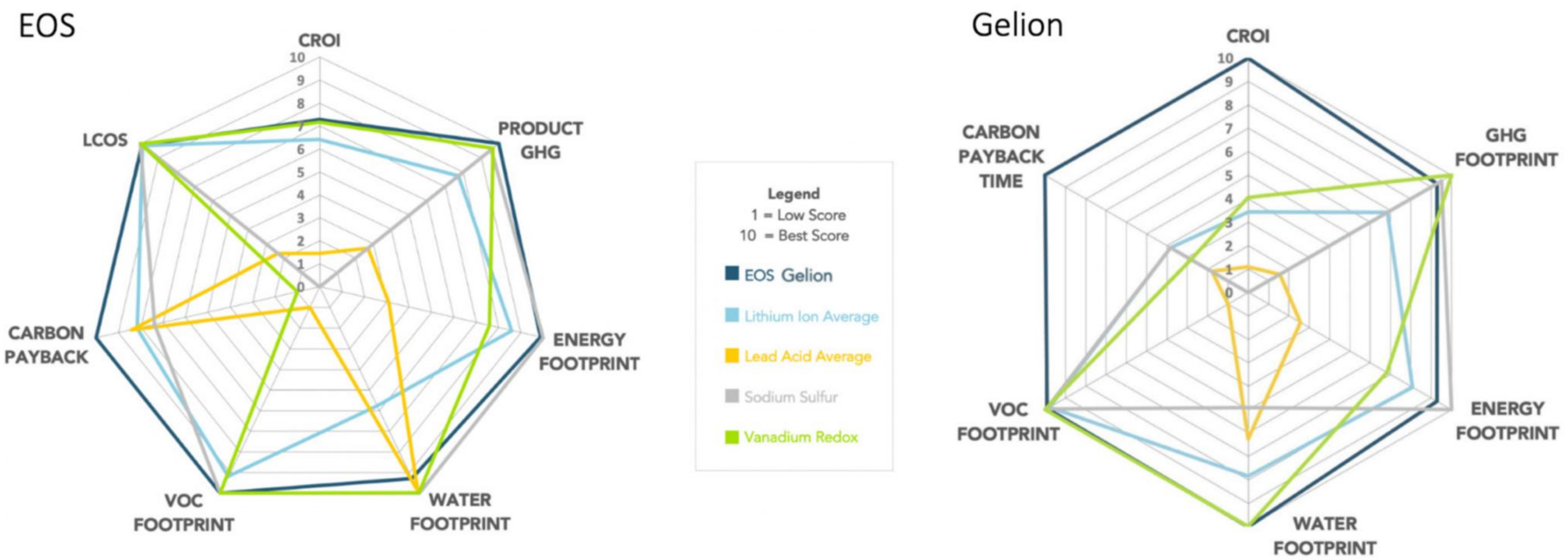


Figure 14 Summary results from the Climate Impact Profiles for EOS (Left) and Gelion (Right), showing strong performance across GHG, energy, water, and VOC metrics.[14]

[14] Image reproduced from EPRI. *Review of Environmental Life Cycle Assessments for Select Advanced Lithium and Non-Lithium Energy Storage Technologies*. Palo Alto, CA: EPRI, December 2024. Report 3002030237

Table 8 Description of Metrics Used for Comparing VRFB, EOS, Gelion, and Li-ion BESS Technologies[15]

ENVIRONMENTAL KEY PERFORMANCE INDICATOR (EKPI)	UNIT OF MEASURE	DESCRIPTION
Energy Intensity	MJ/kWh · lifetime	A measure of the energy input per kWh of stored energy during the lifetime of the battery.
GHG Intensity	$kgCO_2e$/kWh · lifetime	A measure of the greenhouse gas impact per kWh of stored energy during the lifetime of the battery.
Levelized Cost of Production/ Levelized Cost of Storage (LCOS)	$/kWh	The levelized unit-cost of battery production in terms of storage capacity.
Water Footprint	Gallons/kWh · lifetime	A measure of the water use per kWh of stored energy during the lifetime of the battery.
Solvent/VOC Footprint	mg/kWh	A measure of the VOC avoided by using water-based manufacturing, measured per kWh of stored energy.
Carbon Return on Investment (CROI)	$kgCO_2e$ saved/$1M investment	A measure of the climate impact (positive or negative) of each $M dollars (USD) investment.
Carbon Payback Time	Years	A measure of the time that it takes for a product's use to offset the GHG of its production.
Carbon Return on Purchase	$kgCO_2e$/kWh installed	A measure of the greenhouse gases avoided by customers per kWh of customer energy storage.

Table 9 Comparative environmental scores for EOS, Gelion, Li-Ion, and VRFB from manufacturing to use phase

Metric	EOS	Gelion	Li-Ion Avg	VRFB Avg
CROI (Carbon Return on Investment)	7	10	5	5.5
GHG Footprint	10	9.5	7.5	9.5
Energy Footprint	10	9	8.5	7
Water Footprint	9	10	8	10
VOC Footprint	10	10	9.5	10
Carbon Payback Time	10	10	6	2
LCOS / Product Cost Efficiency	10	N/A	10	10

Overall, emerging zinc-bromine technologies demonstrate that non-flammable, water-based chemistries can deliver both safety and sustainability advantages, supporting California's transition to low-impact utility- and industrial-scale energy storage.

[15] Image reproduced from EPRI. *Review of Environmental Life Cycle Assessments for Select Advanced Lithium and Non-Lithium Energy Storage Technologies.* Palo Alto, CA: EPRI, December 2024. Report 3002030237

4.2.5 Key Takeaways on Flow Battery and Li-ion: Maturity, Comparative Outlook, and Path Forward

Flow batteries represent one of the most promising emerging alternatives to lithium-ion for long-duration and utility-scale energy storage with little to no thermal safety concerns. Their non-flammable, water-based electrolyte characteristics nearly eliminate the thermal runaway risks inherent even in the safest lithium-ion chemistries. In addition, their independent scaling of energy and power, along with a 20- to 30-year design life, enable predictable long-term operation.

Finally, while it might take VRFB longer than LFP to offset their greenhouse gas emissions during manufacturing, their high recyclability, combined with renewable energy integration and electrolyte management, allows them to have a smaller overall environmental impact vs. LFP over their full life cycle.

Among all flow battery chemistries, VRFB remains the most commercially mature option. They benefit from standardized stack designs, electrolyte chemistry, and growing recycling pathways that recover up to 97% of vanadium content. However, their up-front cost, land footprint, and dependence on mined vanadium continue to constrain near-term competitiveness against LFP systems for projects below multi-megawatt scale.

Iron-Flow Batteries and Zinc-Bromine Flow Batteries address some of these material and cost barriers by replacing vanadium with more abundant elements. IFBs offer potential cost advantages and lower embodied energy, though they are still limited by prototype-scale demonstrations and uncertain stack durability. ZBFBs, on the other hand, show strong environmental performance and safety in early-stage analyses (e.g., EOS and Gelion studies), but have yet to prove long-term reliability and scalability.

When compared with LFPs, flow batteries trade compactness and round-trip efficiency for thermal safety, durability, and recyclability. LFP remains the most practical choice for dense community sites and short-duration applications. At the same time, flow batteries, especially VRFBs, are better suited for multi-hour storage supporting renewable integration, grid-support functions, and remote microgrids.

In summary, flow batteries complement rather than replace lithium-ion technology. They fill a distinct market niche where safety, longevity, and environmental stewardship outweigh footprint and efficiency. As material innovations and circular-electrolyte business models mature, VRFBs, and eventually IFBs and ZBFBs, are poised to play a central role in California's transition to safe, sustainable, long-duration energy storage.

5

5 Development Guidelines

This section provides BESS safety practices and standards, and development guidelines with a focus on thermal safety, UL/NFPA compliance, and local permitting requirements. These guidelines ensure that battery storage projects are designed, certified, and implemented to meet industry standards while addressing safety, regulatory, and community concerns.

5.1 Introduction

5.1.1 Case Study: McMicken, AZ Battery Fire Incident

On April 19, 2019, a significant incident occurred at a 2 MW / 2 MWh lithium-ion BESS facility located in McMicken, Arizona, operated by Arizona Public Service (APS). The system used lithium Nickel Manganese Cobalt Oxide (NMC) battery cells housed within a single containerized unit.

A thermal runaway was triggered by a battery cell failure, likely caused by a manufacturing defect or electrical fault. This led to overheating and the release of flammable gases inside the battery container. Although gas detectors were installed, the system did not activate ventilation quickly enough to prevent gas buildup. When first responders opened the container door without full awareness of the explosive environment, oxygen entered and caused an explosion, injuring four firefighters, two of whom suffered serious injuries.

5.1.2 Impact, Lessons Learned, and Industry Response:

The McMicken incident became a landmark event for the energy storage industry, prompting:

a) Strengthened adoption and enforcement of NFPA 855 and related fire safety standards.
b) Mandatory UL 9540A testing for thermal runaway and fire propagation risks.
c) Improved training for first responders and revised emergency response protocols for BESS sites.
d) Design improvements such as module isolation, gas monitoring, blast venting, and automatic ventilation triggers.

5.1.3 Summary

In summary, the McMicken incident demonstrated that even small failures in design, detection, or emergency response can escalate into large-scale safety events. To prevent such outcomes, the industry adopted:

a) BESS safety practices by requiring BESS technology certifications, testing frameworks, and
b) Development guidelines through regulatory compliance, permitting, and local standards.

Sections 5.2 (BESS Fire and Thermal Safety Practices and Standards) and Section 5.3 (UL Certification) build on the safety lessons of 5.1 by showing how system-level certification (UL 9540) and fire-propagation testing (UL 9540A) provide independent validation that a BESS can contain, suppress, and manage thermal runaway risks under real-world conditions. This ensures that failures like McMicken are anticipated and designed against before projects are deployed.

Section 5.4 (Local Permitting and Compliance Requirements) complements certification by addressing the regulatory and siting safeguards that must be in place for BESS projects. From detailed project reports and grid impact studies to spacing, fire protection plans, farmland mitigation, and LSFT testing, these requirements ensure projects are not only technically safe but also acceptable to communities, utilities, and permitting agencies.

Together, Sections 5.2, 5.3, and 5.4 provide the standards and governance framework that translate the lessons of past incidents (See Section 6) into practical, enforceable guidelines for safe BESS development.

5.2 BESS Fire Safety Practices and Standards - NFPA 855

5.2.1 Overview of NFPA 855

NFPA 855, Standard for the Installation of Stationary Energy Storage Systems, provides critical guidance for minimizing risks and ensuring safe and compliant installation of ESS, with a strong emphasis on life safety. The standard outlines detailed requirements for fire protection based on factors such as the specific ESS technology, installation environment, system size, separation distances, and the implementation of fire suppression and control systems [33].

Additionally, NFPA 855 addresses key safety aspects, including fire detection and suppression systems, explosion mitigation, exhaust ventilation, gas detection mechanisms, and the management of thermal runaway events.

5.2.2 Applicability and Scope

NFPA 855 applies to a broad range of ESS technologies, including electrochemical, chemical, mechanical, and thermal systems. The standard specifies requirements based on factors such as system size, technology type, installation setting (indoor/outdoor), spacing, and the presence of fire protection and suppression systems.

5.2.3 Fire Protection and Explosion Control

The 2023 edition mandates fire suppression systems for all ESS installations, although the AHJ may grant exceptions under specific risk-controlled conditions [34]. The standard outlines two key approaches to managing explosion risk:

a) Deflagration Control – Implementing venting mechanisms such as blast panels, in accordance with NFPA 68, to safely direct overpressure away from critical areas.
b) Explosion Prevention – Utilizing continuous exhaust ventilation, as per NFPA 69, to prevent gas accumulation and ignition.

An integrated approach combining both methods, along with containment solutions for thermal runaway, offers enhanced protection, minimizes propagation risk, and improves firefighter safety, especially in scenarios like the McMicken, AZ incident given in above section.

5.3 UL certification

5.3.1 Overview of UL9540 and UL9540A

UL 9540 is a system-level safety standard developed by Underwriters Laboratories (UL) in 2016 to ensure the safe operation of Energy Storage Systems (ESS). It evaluates the entire system, including the battery and inverter, rather than just individual components. This standard covers a wide range of safety aspects such as electrical, mechanical, thermal, and environmental performance. It ensures that the system can operate safely under normal and fault conditions. Importantly, UL 9540 certification must be obtained through a Nationally Recognized Testing Laboratory (NRTL), and it is often required by fire and building codes such as NFPA 855, NFPA 1, the International Fire Code (IFC), and the International Building Code (IBC). While component-level certifications like UL 1973 (for batteries) and UL 1741 (for inverters) are important, they are not sufficient on their own to meet UL 9540 requirements [30].

UL 9540A, on the other hand, is not a certification but a test method designed to evaluate the fire risks associated with thermal runaway in battery systems. It provides a structured approach to assess how a fire might propagate within an ESS and how effectively it can be contained. The test is conducted at four levels: cell, module, unit, and installation. At the cell level, it examines flammability and gas emissions. The module level assesses whether thermal runaway can spread between cells. The unit level evaluates the behavior of the entire system during a fire event, and the installation level simulates real-world conditions to test fire suppression and spacing requirements. UL 9540A is particularly useful for permitting, as it provides data that can justify reduced spacing between systems or other deviations from standard fire code requirements. It is often used in conjunction with NFPA 855 to demonstrate that a system can be safely installed even in more compact configurations [30].

5.3.2 UL 9540A testing

UL 9540A is a test method shown in *Figure 15* [32] is to evaluate the fire safety hazards associated with propagating thermal runaway within battery systems. The tests establish that a storage technology is capable of reaching thermal runaway and then assess the fire and explosion hazards of that technology.

Thermal runaway occurs when a chemical reaction has gotten out of control and can no longer safely dissipate excess heat. Thermal runaway can be caused by internal short-circuits, overcharging, physical damage to cells, or high- and low-temperature environments.

The UL 9540A test method starts at the cell level and gradually builds to the installation level over four steps. If an ESS technology meets the performance criteria of any of the first three tests, there is no requirement to continue testing the subsequent levels. If not, it moves to the next level [31].

5.3.2.1 Cell-Level Tests

The UL 9540A testing process begins at the cell level, which is the smallest unit of a battery system. The objective is to determine whether a single cell can be driven into thermal runaway using multiple methods and repeated attempts. This stage sets a high benchmark for safety, as very few technologies successfully pass without exhibiting signs of failure. If no observable flaming, smoke, or gas venting occurs during these tests, the process concludes at this level, indicating strong cell-level safety performance.

5.3.2.2 Module-Level Tests

If the cell-level tests indicate potential risk, the next stage involves assembling cells into modules and retesting. The goal here is to force thermal propagation between one or more cells within the module. Observations focus on external flaming, smoke emission, and heat release. Additionally, any gases produced during the test are collected and analyzed for hazardous content. Like the cell-level tests, this stage also presents a stringent safety threshold. In most cases, systems proceed to the next level due to the complexity of containing propagation at the module level.

5.3.2.3 Unit-Level Tests

At this stage, the ESS unit is tested without any external fire suppression systems, unless such systems are integrated within the ESS itself. A variety of indoor and outdoor mounting configurations are evaluated. Performance criteria differ based on the installation type and whether the system is residential or non-residential. Residential ESS must meet strict performance standards at this level, as it cannot be assumed that homes are equipped with fire suppression systems. Non-residential systems that do not meet the criteria at this stage are advanced to the final level of testing.

5.3.2.4 Installation-Level Tests

The final stage of UL 9540A testing closely resembles the unit-level tests but includes the evaluation of fire suppression agents. The effectiveness of these agents is analyzed to determine whether they can prevent detonation, deflagration, flaming, or reignition after the initial fire event. Systems that pass this stage demonstrate robust fire safety and are deemed compliant. Those that fail must either modify their technology or revise their installation approach before undergoing retesting.

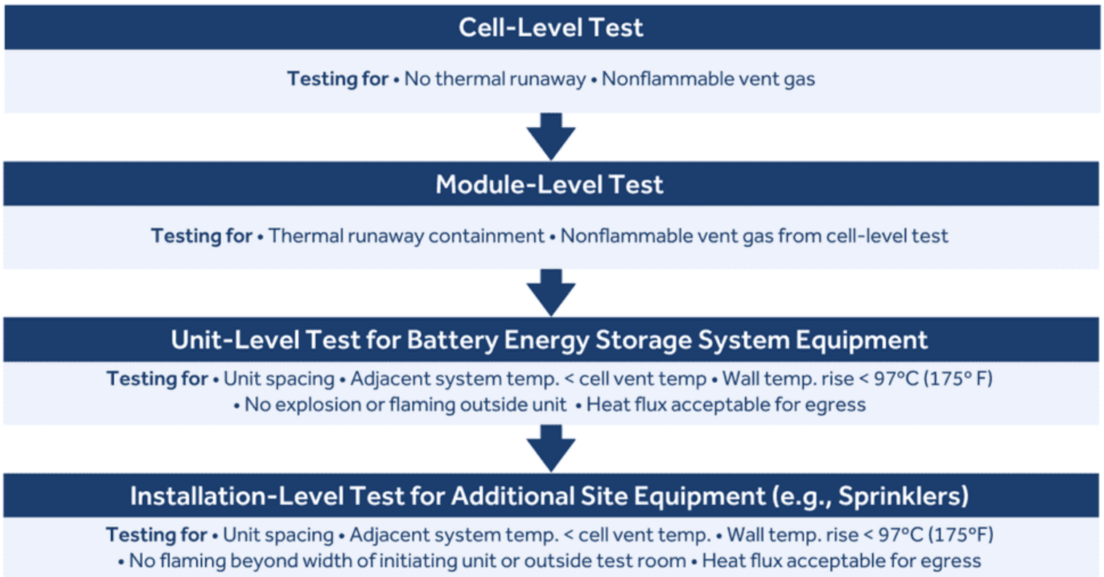


Figure 15 UL9540A Test Sequence (Image Reproduced from Mayfield Renewables)

It is the primary safety certification standard for energy storage systems, especially those using lithium-ion technology. It is essential for assessing and validating the entire BESS, including the battery modules, inverters, control systems, and associated safety features.

5.3.2.5 Ensures System-Level Safety Compliance

UL 9540 evaluates the integrated BESS as a complete system. This includes:

a) Fire and electrical safety
b) System functionality under normal and fault conditions
c) Proper interaction between components (battery, inverter, BMS, etc.)
d) Emergency shutdown and fault isolation features

This system-level testing ensures that safety is preserved even in complex, interconnected configurations.

5.3.2.6 Supports UL 9540A Testing for Thermal Runaway

UL 9540 certification is often paired with UL 9540A, which specifically tests a system's resistance to thermal runaway propagation—a key concern with lithium-ion batteries. UL 9540 ensures the system design incorporates containment, suppression, and controls that are validated by UL 9540A fire behavior data.

5.3.2.7 Reduces Fire and Explosion Risk

UL 9540 testing verifies critical safety mechanisms such as:

a) Battery Management System (BMS) functionality
b) Overvoltage, overcurrent, and thermal protection
c) Safe ventilation and shutdown controls
d) Fire containment and suppression capabilities

5.3.2.8 Enhances Market Credibility and Insurance Compliance

For developers, integrators, and utilities, having UL 9540 certification:

a) Demonstrates compliance with best practices and third-party validation
b) Facilitates smoother project approvals and interconnection processes
c) Is often required by insurers and financiers to mitigate project risk

5.3.2.9 Key players in the US market

Table 10 provides a summary of key players in the US market providing UL9540-certified BESS

Table 10 UL 9540 certified BESS vendors

Company	Product/System	Application
Tesla	Megapack	Utility-scale
Fluence Energy	Fluence Cube	Grid-scale, hybrid systems
LG Energy Solution	RESU, Rack-based modules	Residential and commercial
Powin Energy	Stack750, Centipede	Utility and commercial
Enphase Energy	IQ Battery	Residential solar + storage
Wärtsilä	GridSolv Series	Utility-scale, hybrid grids

5.4 Local Permitting and Compliance Requirements

This section highlights key factors that may influence or support the deployment of BESS, as illustrated in Figure 16.

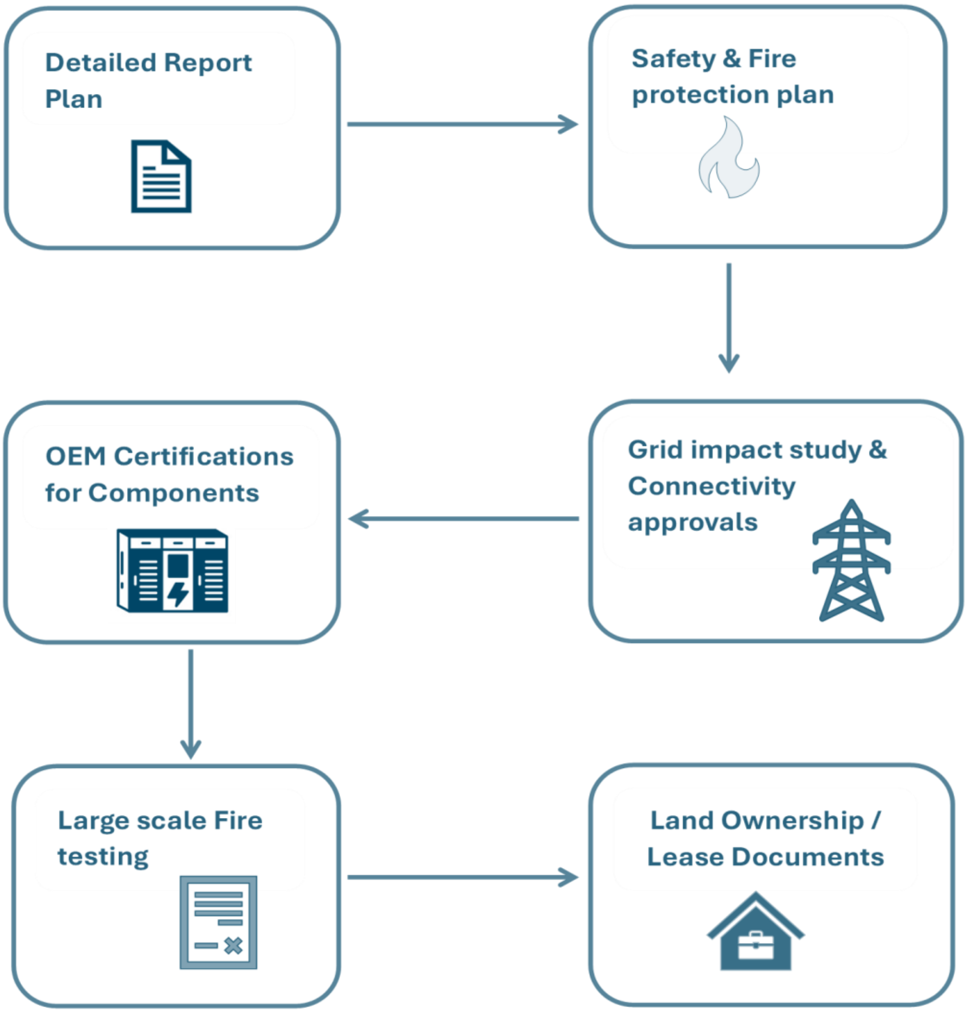


Figure 16 Key Requirements for BESS Planning in Vacaville, California

5.4.1 Detailed Project Report

Detailed project reports form the backbone of any BESS development proposal. It should provide a comprehensive overview of the system configuration, including the proposed energy and power capacity, the site layout, technical specifications of equipment, system architecture, control strategy, and the project implementation timeline. The DPR also serves as a reference for all stakeholders, including utility partners, permitting agencies, and investors.

5.4.2 Safety and Fire Protection Plan

Given the high energy density and fire risk associated with Lithium-ion batteries, developers must submit a detailed Safety and Fire Protection Plan in compliance with NFPA 855 and other applicable fire codes. This plan should include measures for fire detection, suppression systems, explosion control, and thermal runaway containment.

5.4.3 Grid Impact Study and Connectivity Approval

A Grid Impact Study must be conducted to evaluate how the proposed BESS will affect the local electrical network. This includes assessments of load flow, voltage profiles, short-circuit levels, and dynamic stability. The study should identify the Point of Interconnection (POI) and include required upgrades, protection coordination, and compliance with interconnection standards. Approval from the relevant utility or Independent System Operator (e.g., CAISO) is necessary before proceeding to construction.

5.4.4 Spacing and Safety Setback Requirements

Ensure the BESS is set back a safe distance from property lines, public roads, and especially any adjacent buildings or homes. This reduces the risk of fire spreading beyond the site and provides a buffer for heat and smoke. As a reference, San Diego County's interim BESS guidelines mandate a minimum 100-foot setback from any adjacent residences, and also a 100-foot buffer from undeveloped wildlands to comply with defensible space requirements in high fire areas.

5.4.5 Land Ownership or Lease Documents

Legal control of the project site must be established through documented land ownership or long-term lease agreements. These documents are necessary to demonstrate that the developer has the right to access, build on, and operate the proposed BESS installation. Zoning regulations and local land-use permissions must also be verified to ensure compliance with city or county development guidelines.

If a BESS is proposed on farmland, special scrutiny is needed to protect prime soils and agricultural viability. Alameda County pioneered an approach requiring 1:1 mitigation for any prime farmland converted to solar/BESS use or a demonstration that the soil will be preserved for future restoration. For example, if 10 acres of prime farmland are used for a BESS, the developer could be required to fund the permanent protection of 10 acres of farmland elsewhere or commit to restoring the site to agricultural use after decommissioning. The key is ensuring that hosting a BESS does not needlessly remove high-quality farmland from production in the long term

5.4.6 OEM Certifications for Major Components

To ensure system safety and reliability, all major BESS components must carry certifications from accredited testing bodies. The BMS should be certified under UL 991 and UL 1973, while the PCS must comply with UL 1741 and IEEE 1547. Additionally, the fully integrated system should be listed under UL 9540, which is required by fire codes such as NFPA 855 and the International Fire Code (IFC).

5.4.7 Large-Scale Fire Testing (LSFT) Reports

It is a critical safety validation process for BESS, particularly those utilizing lithium-ion technology. Conducted in accordance with CSA TS-800:24, LSFT provides a standardized method for evaluating fire hazards such as thermal runaway propagation, gas release, fire spread, and explosion risks within energy storage systems. Unlike traditional UL 9540A tests, which may not always result in a fire condition, CSA TS-800:24 simulates worst-case failure scenarios to verify that a fire originating within a fully involved ESS unit does not propagate to adjacent units or external exposures, thereby safeguarding lives and infrastructure [36]. This testing is especially vital for containerized systems, custom rack configurations, or any design that deviates from standard installation practices outlined in NFPA 855. AHJ reviews the results from LSFT to determine if additional mitigation measures such as gas ventilation, deflagration venting, or enhanced separation are necessary.

6 Case studies for BESS Incidents

6.1 Background: Moratorium on BESS in Solano County

On January 23, 2024, Solano County decided to place a two-year moratorium on the development and installation of new front-of-the-meter BESS due to increasing safety concerns following a series of major fire incidents at similar facilities across California.

According to Solano County spokesperson Matthew Davis, that moratorium will remain in effect until January 23, 2026, or until county staff can develop and adopt new regulations governing the permitting, siting, safety, and operation of such systems, whichever comes first [20] [21].

BESS thermal runaway or fire safety concerns began after a 2023 fire at the Valley Center Energy Storage Facility in San Diego County. These BESS thermal runaway events at the Terra-Gen Valley Center facility, the Gateway Energy Storage site in Otay Mesa, and SDG and E's Escondido BESS each involved lithium-ion battery containers. Additionally, they triggered evacuations, prolonged fire suppression efforts, and environmental monitoring.

6.2 Terra-Gen Facility in Valley Center BESS Thermal Event

Located in Valley Center, San Diego County, CA, the Valley Center Energy Storage Facility is a stand-alone 139MW energy storage project situated on a 7-acre property within Valley Center's commercial-industrial zone, as shown in Figure 17. The key specifications about the project and the incident are provided in Table 11.

VALLEY CENTER, CA – FEBRUARY 15, 2022: Terra-Gen, a leading operator and developer of critical renewable energy projects, announced the Valley Center Battery Storage Project is online and providing clean energy to the local power grid.

The Valley Center Energy Storage Facility produces enough electricity to power up to 140,000 homes for four hours on a single charge. It includes long-term power purchase agreements with San Diego Gas and Electric. The Project provides essential grid reliability services to the local area and helps integrate greater supplies of renewable energy in California [22].

The Project is providing about $40 million to the local area in jobs and economic activity in and around Valley Center, with about 100 direct construction jobs and other indirect jobs as workers eat, shop, and stay in Valley Center. There will also be millions of dollars in property tax benefits resulting from the Project [23]. A BESS unit in the Valley Center Energy Storage System caught fire at approximately 5:15 PM local time on 18 September 2023 [24]. The Investigation is in process.

Figure 17 Terra-Gen Facility, Valley Center

Table 11 Valley Center BESS – Specifications and Incident Timeline

Parameter	Details
Location	Valley Center, San Diego County, CA
Area	7 acres
Capacity	140 MW / 4 Hr
Power Purchase Agreement (PPA)	With San Diego Gas and Electric
Commercial Operation Date (COD)	2022
Battery Type	Lithium-ion
Date of Fire Incident	September 2023

6.3 Gateway Energy Plant in Otay Mesa BESS Thermal Event

Gateway Energy Storage is a lithium-ion energy storage facility located in Otay Mesa, CA (San Diego County). The project provides energy storage services for the wholesale energy market. Phase One provides 250 MWh capacity, while Phase Two will provide an additional 250 MWh [25].

On May 15, 2024, a fire broke out at the Gateway Energy Storage facility, with periodic flare-ups until May 28. The facility contained approximately 14,796 nickel-manganese-cobalt lithium-ion batteries, as shown in Figure 18. The key specifications about the project and the incident are provided in Table 12.

The root cause of the fire remains under investigation. EPA and local agencies will continue to oversee cleanup activities until all work is completed, and the site no longer poses a threat to public health or the environment [26].

Figure 18 Gateway Energy plant in Otay Mesa

Table 12 Otay Mesa – Specifications and Incident Timeline

Parameter	Details
Location	Otay Mesa, CA
Area	4 acres
Capacity	250 MW / 1 Hr
Power Purchase Agreement (PPA)	With San Diego Gas and Electric
Commercial Operation Date (COD)	2020
Battery Type	Lithium-ion
Date of Fire Incident	May 2024

6.4 Chandler, Arizona BESS Fire

On April 18, 2022, a large fire broke out at the Dorman battery energy storage system (BESS) in Chandler, Arizona, a 10 MW facility operated by AES for the Salt River Project (SRP). The BESS was situated in an 8,000–9,000 square foot steel building constructed in November 2019. The incident began as a smoldering fire inside the lithium-ion battery containers, triggering the facility's sprinkler systems and leading to the release of smoke and potentially hazardous gases. Due to the risk of thermal runaway and explosion, firefighters adopted a cautious strategy, using robots to open doors, ventilate the site, and measure internal conditions before sending personnel inside. Authorities ordered evacuations within a quarter-mile radius as a precaution. The fire continued to smolder for several days before being brought under control, with the Chandler Fire Department finally declaring it extinguished on May 1.

This BESS consisted of 3,600 batteries placed in a series of arrays with a total capacity of 10MW as depicted in Figure 19. The incident is believed to involve thermal runaway (a cascading failure in battery cells leading to self-heating), though the exact root cause was under investigation and not confirmed at the time of reports.

Figure 19 Interior battery rack setup of Chandler, Arizona facility

6.5 Liverpool, UK ESS Fire

A fire occurred at the Carnegie Road ESS in Liverpool, United Kingdom on September 15, 2020. This facility had an energy storage capacity of 20 MW split among three outdoor shipping-type enclosures. Firefighters used main water jets and ground monitors to fight the blaze, which burned for several hours. Nearby residents were asked to keep windows and doors closed due to heavy smoke.

The exact ignition source was never publicly confirmed, but the fire originated inside one of the 20 MW NEC-supplied lithium-ion battery containers. Reports and later analyses suggest thermal runaway in a cell or rack as the likely trigger, which then spread within the container. Like most lithium-ion ESS fires, this produced intense heat, toxic smoke, and re-ignition risks, making suppression extremely difficult.

6.6 Moss Landing BESS Overheating & Meltdown Incident

The Moss Landing Energy Storage Facility in Monterey County [63] one of the world's largest lithium-ion BESS installations—has experienced multiple safety events that significantly influenced California's energy-storage regulations. The first major incident occurred on 4 September 2021, when smoke inside the Phase-I facility triggered the water-based suppression system at a threshold lower than intended. Due to un-tested hose couplings and floor cracks, water leaked onto battery racks, causing short-circuiting and thermal damage to about 7 % of the modules, prompting highway closures and a shelter-in-place advisory.

A second, far more severe event occurred on 16 January 2025 [64], when a large-scale fire in the 300 MW system led to the evacuation of 1,200–1,500 residents. Fire crews allowed the batteries to burn out due to the difficulty of extinguishing lithium-ion fires, and subsequent environmental assessments detected heavy-metal contamination in nearby soil. The County declared a state of emergency, moved toward a moratorium on new BESS projects, and the U.S. EPA issued a CERCLA-based cleanup order requiring removal of damaged modules under federal oversight. Collectively, these incidents underscored vulnerabilities in detection, suppression, water-ingress protection, and emergency response, prompting design changes, stricter operating protocols, and renewed scrutiny of large-scale lithium-ion energy-storage safety across California.

6.7 BESS Incident Case Studies Key Takeaways

These case studies illustrate that while large-scale BESS projects such as Terra-Gen's Valley Center and Gateway Energy in Otay Mesa deliver significant economic, reliability, and clean energy benefits, high-profile thermal runaway incidents have raised public safety concerns.

Hence, the resulting moratorium in Solano County reflects a broader industry challenge: balancing the rapid deployment of storage needed for California's clean energy goals with community trust through safety, compliance, and operational standards and requirements. By aligning development with frameworks such as NFPA 855, UL 9540/9540A, and local permitting requirements, upcoming BESS projects can mitigate risks, maintain public confidence, and avoid policy setbacks that slow progress toward decarbonization.

7 Conclusion

This report provides a detailed and strategic assessment of Battery Energy Storage System deployment, integrating technical and regulatory considerations. Through a structured evaluation of DERs, including solar PV and natural gas-based systems, the report emphasizes the critical role of BESS in enhancing grid reliability, supporting renewable integration, and improving energy resilience.

The report also outlines best practices for implementation, including fire safety, permitting, and system certification, ensuring that future BESS projects are both technically sound and community aligned. Overall, the findings serve as a roadmap for transition toward a modern, flexible, and sustainable energy infrastructure.

7.1 Key Findings

a) **Technology Selection:** Vanadium Redox Flow Batteries (VRFBs) provide strong advantages for an emerging long-duration storage, including inherent safety (non-flammable electrolyte), long cycle life, and suitability for daily cycling over decades. Lithium-ion batteries offer high energy density, compact footprint, scalability, and proven performance in grid applications. Both technologies are viable depending on project priorities—it will ultimately be up to the *client* to decide whether to pursue LFP, flow batteries, or a combination of both, based on cost, duration needs, and site-specific requirements.

b) **BESS Safety and Compliance:** UL 9540 and UL 9540A certifications, along with NFPA 855 compliance, are essential for mitigating fire risks and ensuring safe deployment.

c) **Thermal Management:** Active and hybrid cooling systems are critical to prevent thermal runaway and ensure long-term reliability.

d) **Regulatory Landscape:** The current moratorium on BESS installations in Vacaville underscores the need for proactive planning, stakeholder engagement, and alignment with evolving city policies.

7.2 Call to Action for Stakeholders

To realize the full potential of DERs and BESS in Vacaville, stakeholders, including city planners, utility partners, developers, and community leaders, are encouraged to:

a) **Engage in Policy Dialogue:** Collaborate with city officials to shape regulatory frameworks that balance innovation with safety and community interests.

b) **Adopt Certified BESS Technologies:** Ensure that all deployed systems, whether Lithium-ion or Flow Batteries, comply with UL 9540, UL 9540A, and NFPA 855 standards to facilitate regulatory approvals, guarantee safety, and minimize operational risks..

c) **Require Developers to Invest in Safety Infrastructure and Practices:** Incorporate advanced thermal management, disaster response principles, fire suppression, and gas detection systems in all BESS designs.

d) **Promote Public Awareness:** Educate residents and businesses on the benefits of energy storage, including grid resilience, cost savings, and environmental impact.

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ATTACHMENT 5

Albert Enault

From:	Longman, Renee@Energy <Renee.Longman@Energy.ca.gov>
Sent:	Wednesday, January 28, 2026 12:40 PM
To:	Erin Morris; Claudia Garcia; Albert Enault; Brian Oxley; Frank Drayton; Jill Childers; Alex Nourot; Chris.Polen@cityofvacavile.com; Daniel DeCaro; Savita Chaudhary; Anne Branham; Peyman Behvand
Subject:	Local: Notice of Receipt of Opt-In Application for Vaca Dixon Power Center Project (26-OPT-01)
Attachments:	NOR-Local-VDPC-01272026.pdf

Hello,

This email serves as notification of receipt of an Opt-In Application under Public Resources Code 25519 for the proposed Vaca Dixon Power Center Project (26-OPT-01). This project is proposed in the City of Vacaville in Solano County, California. The attached letter outlines project information and the reasons under Assembly Bill 205 why we are contacting you. If you have questions, please contact me.

I appreciate your timely responses and look forward to coordinating with you as the project moves forward.

Thank you,

Renee Longman AICP, LEED AP BD+C
Project Manager
Siting and Environmental Branch
Siting, Transmission and Environmental Protection Division
1-916-937-3538

California Energy Commission
Website: www.energy.ca.gov

CALIFORNIA ENERGY COMMISSION

CALIFORNIA NATURAL RESOURCES AGENCY

January 27, 2026

Notice of Receipt of Opt-In Application for Vaca Dixon Power Center Project (26-OPT-01)

This letter serves as notification that the California Energy Commission (CEC) has received an Opt-In application for the Vaca Dixon Power Center Project (26-OPT-01). Vaca Dixon BESS LLC and Arges BESS LLC (applicant) propose to construct and operate the Vaca Dixon Power Center Project (project). The project would be located on an approximately 10-acre site (Assessor's Parcel Number [APN] 0133-060-060) within the City of Vacaville in Solano County, California. The project includes two battery energy storage system (BESS) facilities; the Vaca Dixon BESS (57 megawatts [MW], 57 megawatt-hours [MWh]), and the Arges BESS (100 MW, 400 MWh), along with associated switchyard facilities, access roads, stormwater infrastructure, fencing, and control enclosures.

The Vaca Dixon 57 MWh BESS would connect via a new 13.8-kilovolt (kV) overhead line to the existing 13.8/115 kV generator step-up transformer at the adjacent CalPeak Power Vaca Dixon Peaker Plant (VDPP), which is already tied to the adjacent Pacific Gas and Electric Company (PG&E) Vaca-Dixon Substation located north of Interstate-80 (I-80). The Arges BESS 400 MWh BESS would connect to the PG&E substation through a new approximately 2,350-foot 115 kV overhead transmission intertie (gen-tie) line. For approximately 1,500 feet, the 13.8 kV and 115 kV gen-tie circuits would be co-located on shared steel monopole structures to cross I-80 and reach the PG&E substation parcel (APN 0133-060-070). The remaining span would connect the Vaca Dixon BESS to the VDPP transformer and the Arges BESS to the PG&E Vaca-Dixon Substation.

The project would operate 24 hours per day, 7 days a week, 365 days a year, for a 35-year anticipated lifespan, with remote control via supervisory control and data acquisition system. Following construction, the project would be staffed by one to three technicians performing periodic maintenance and inspections. The Project Description (TN 268145) section of the application can be accessed directly at the following: https://efiling.energy.ca.gov/GetDocument.aspx?tn=268145&DocumentContentId=105161.

In 2022, Assembly Bill 205 established a new Opt-In Certification Program for eligible clean and renewable energy facilities to optionally seek certification through the CEC. Upon receipt of an application, the CEC has the exclusive authority to certify the site and related facility. With certain exceptions, the issuance of a certificate by the CEC is in lieu of any permit, certificate, or similar document required by any state, local, or regional agency, or federal agency to the extent permitted by federal law, and supersedes any applicable statute, ordinance, or regulation of any state, local, or regional agency, or federal agency to the extent permitted by federal law. The CEC is the lead agency under the California Environmental Quality Act and is required to prepare an environmental impact report, mitigated negative declaration, or negative declaration for any facility that elects to opt into the CEC's jurisdiction. The CEC provides the following notice pursuant to Public Resources Code section 25545.8, which states that subsections (f) and (k) of Public Resources Code section 25519 apply to an opt-in application. The relevant language from Public Resources Code section 25519 is as follows:

> (f) Upon receipt of an application, the commission shall forward the application to local governmental agencies having land use and related jurisdiction in the area of the proposed site and related facility. Those local agencies shall review the application and submit comments on, among other things, the design of the facility, architectural and aesthetic features of the facility, access to highways, landscaping and grading, public use of lands in the area of the facility, and other appropriate aspects of the design, construction, or operation of the proposed site and related facility.
>
> (k) The commission shall transmit a copy of the application to any governmental agency not specifically mentioned in this act, but which it finds has any information or interest in the proposed site and related facilities, and shall invite the comments and recommendations of each agency. The commission shall request any relevant laws, ordinances, or regulations that an agency has promulgated or administered.

Note that the CEC staff does not expect the city to develop exhaustive analysis on the application or to procure expertise to review an application. Local jurisdictions generally focus their comments on topical areas of local concern and identify local laws that the jurisdiction wants to highlight for staff such as noise ordinances, local methods of calculating vehicle miles traveled, or local architectural standards. For samples of prior comment letters from local jurisdictions, see:

- Willow Rock Energy Center, 21-AFC-02 (previously Gem Energy Storage Center) Kern County Planning and Natural Resources Department Comments - Agency Participation in Review of AFC for GEM Energy Storage Center Project, TN 243152

  https://efiling.energy.ca.gov/GetDocument.aspx?tn=243152&DocumentContentId=76834

  Kern County's Additional Comments, TN 245911

  https://efiling.energy.ca.gov/GetDocument.aspx?tn=245911&DocumentContentId=80088

- Huntington Beach Energy Project, 12-AFC-02

  City of Huntington Beach's Comment Letter Re Proposed Project, TN 68804 https://efiling.energy.ca.gov/GetDocument.aspx?tn=68804&DocumentContentId=46742

Pursuant to Title 20, section 1877(f) of the California Code of Regulations currently in effect, Opt-In applications include economic information for review and comment by local governments. While Public Resources Code section 25545.9 now establishes a rebuttable presumption of overall net positive economic benefit, staff will continue to provide the submitted information to the local government for comment consistent with section 1877(f) until the regulation is updated. The CEC webpage for the project can be found at the following link: https://www.energy.ca.gov/powerplant/battery-storage-system/vaca-dixon-power-center-project. Information about the Opt-In Certification Program can be found on the CEC website at: https://www.energy.ca.gov/programs-and-topics/topics/power-plants/opt-certification-program

The documents which comprise the Opt-In application can be found in the project docket, which is accessible via the project webpage or directly at the following link: https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=26-OPT-01. The applicant's economic information can be found in Appendix AA, Attachment A, Vaca Dixon Power Center Project California Net Economic Benefit, (TN 268173-2, https://efiling.energy.ca.gov/GetDocument.aspx?tn=268173-2&DocumentContentId=105205), Appendix J Community Benefits Plan (TN 268168-1, https://efiling.energy.ca.gov/GetDocument.aspx?tn=268168-1&DocumentContentId=105190) and Section 5-6, Socioeconomics (TN 268153, https://efiling.energy.ca.gov/GetDocument.aspx?tn=268153&DocumentContentId=105171). We look forward to receiving the City of Vacaville's comments pursuant to Public Resources Code sections 25519(f) and 25519(k).

The CEC also wishes to make the City aware that Public Resources Code section 25538 applies to an Opt-In application. The language from Public Resources Code section 25538 is as follows:

> Upon receiving the commission's request for review under subdivision (f) of Section 25519 and Section 25506, the local agency may request a fee from the commission to reimburse the local agency for the actual and added costs of this review by the local agency. The commission shall reimburse the local agency for the added costs that shall be actually incurred by the local agency in complying with the commission's request.

California Code of Regulations, title 20, section 1878.1 specifies local agency costs eligible and ineligible for reimbursement, procedures for approving reimbursement budgets and invoices, and procedures for resolving disputes. To apply for reimbursement, a local agency shall, within 21 days of receiving a request for review from the CEC, file an itemized proposed budget with the staff and the applicant estimating the actual and added costs that are likely to be incurred during such review. (Cal. Code Regs., tit. 20, § 1878.1, subd. (c)(2).)

To stay informed about this project and receive notice of upcoming public meetings, sign up to the project subscription, which can be accessed on the project webpage. Once enrolled, automatic email notifications are sent via govDelivery when documents and notices are posted to the project docket.

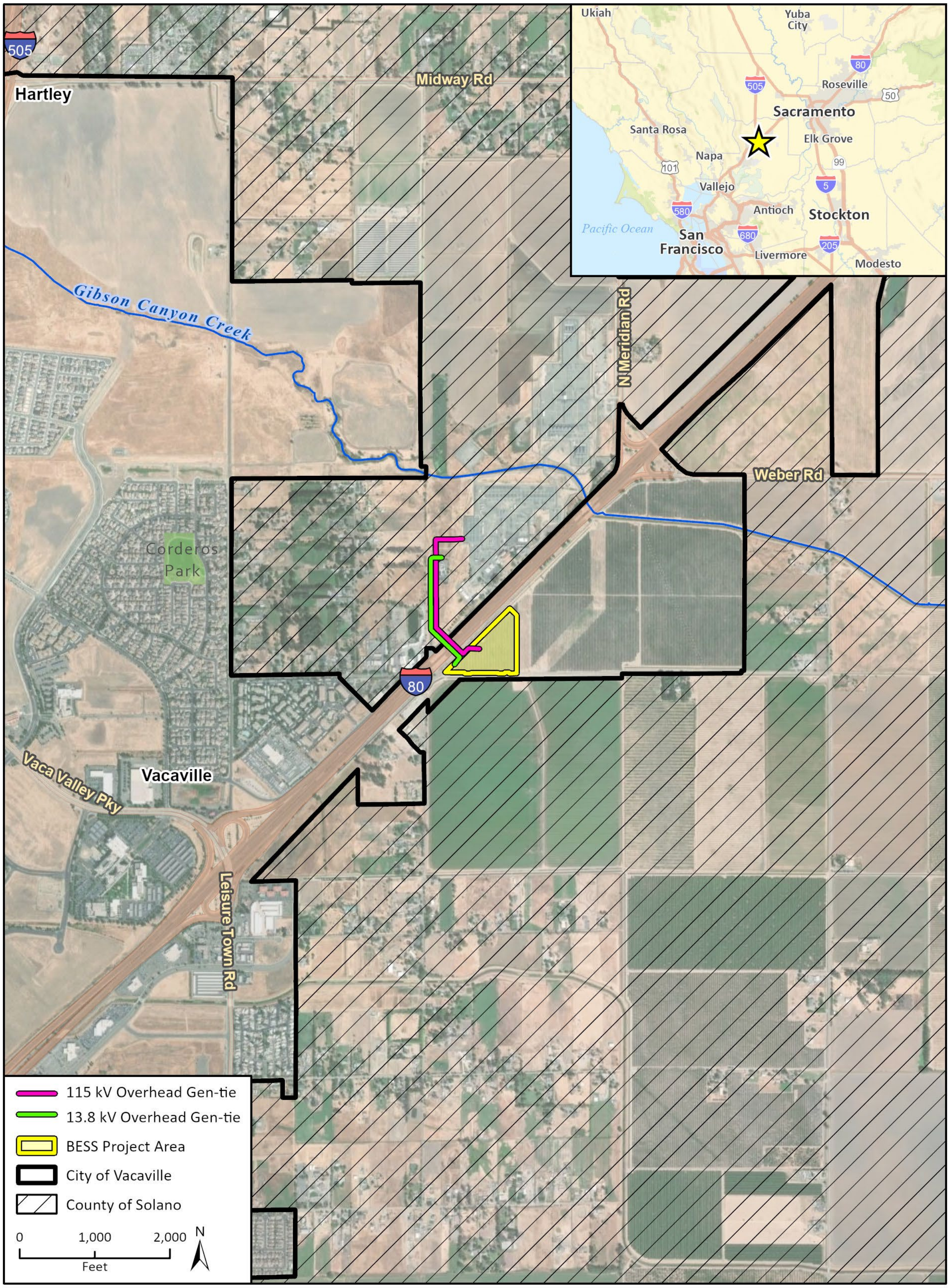
Feel free to reach out to us directly via email if you have any questions about this notice. Thank you.

Renee Longman
Project Manager
California Energy Commission

renee.longman@energy.ca.gov

Enclosures:
Figure 2-1 Regional Location (from application TN 268145)
Figure 2-2 Project Area and Components (from application TN 268145)
Figure 2-3 Project Parcels (from application TN 268145)
Figure 2-4 Vaca Dixon Power Center Project Site Plan (from application TN 268145)

Figure 2-1 Regional Location



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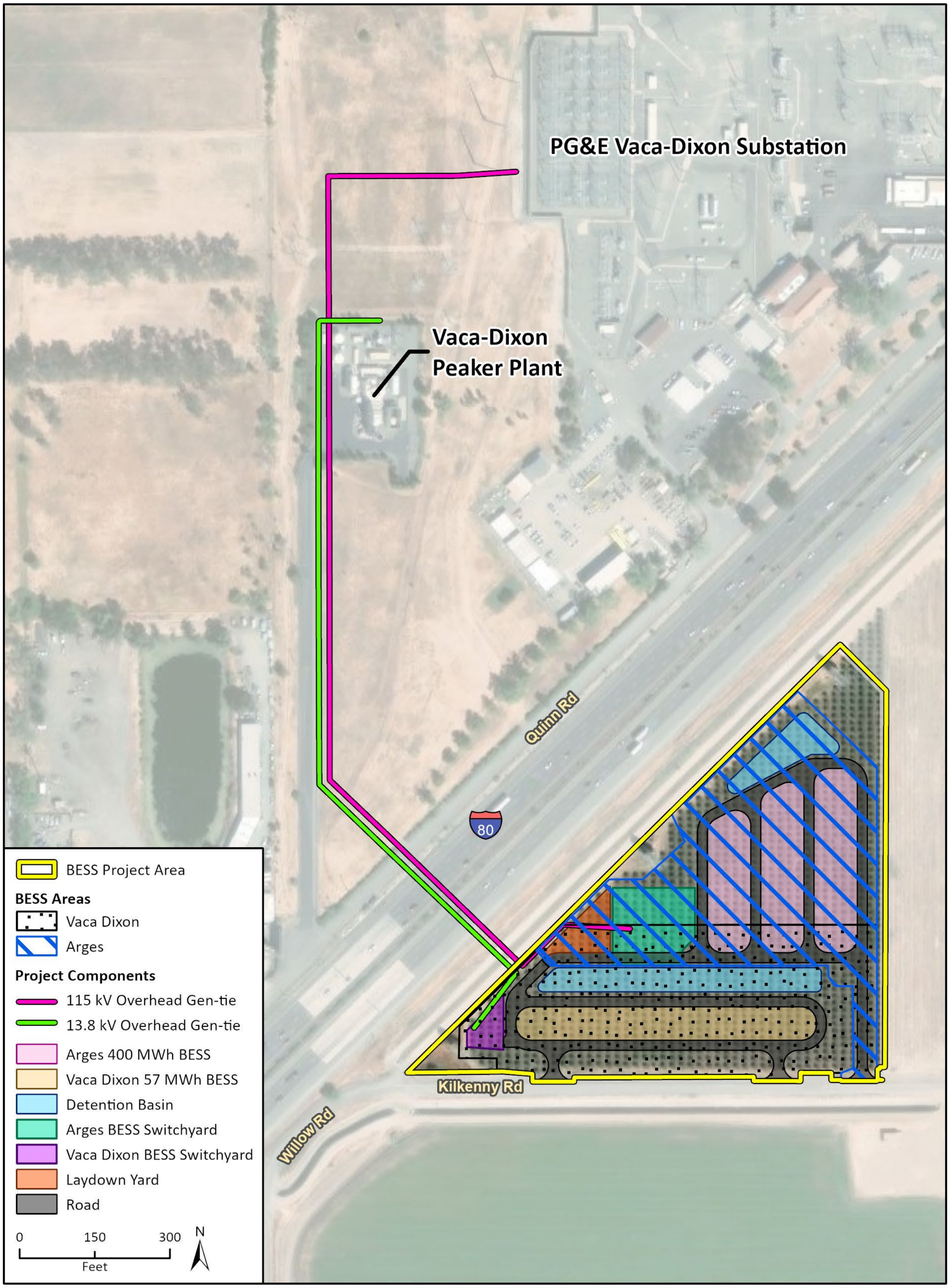
25-17851 EPS
Fig 2-1 Regional Location_Portrait

Figure 2-2 Project Area and Components



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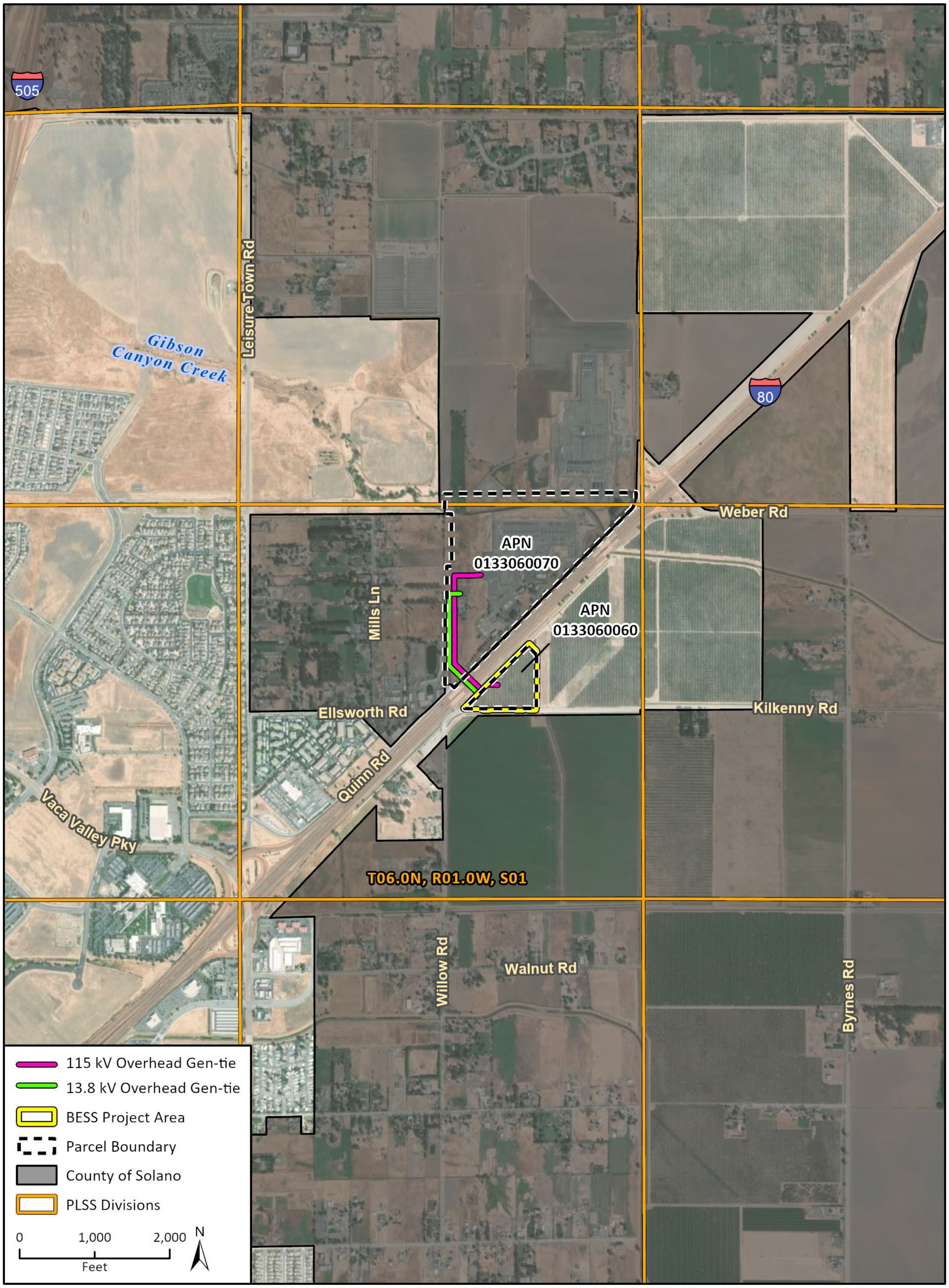
25-17851 EPS
Fig X Project Site and Components_Labels_Portrait

Figure 2-3 Project Parcels



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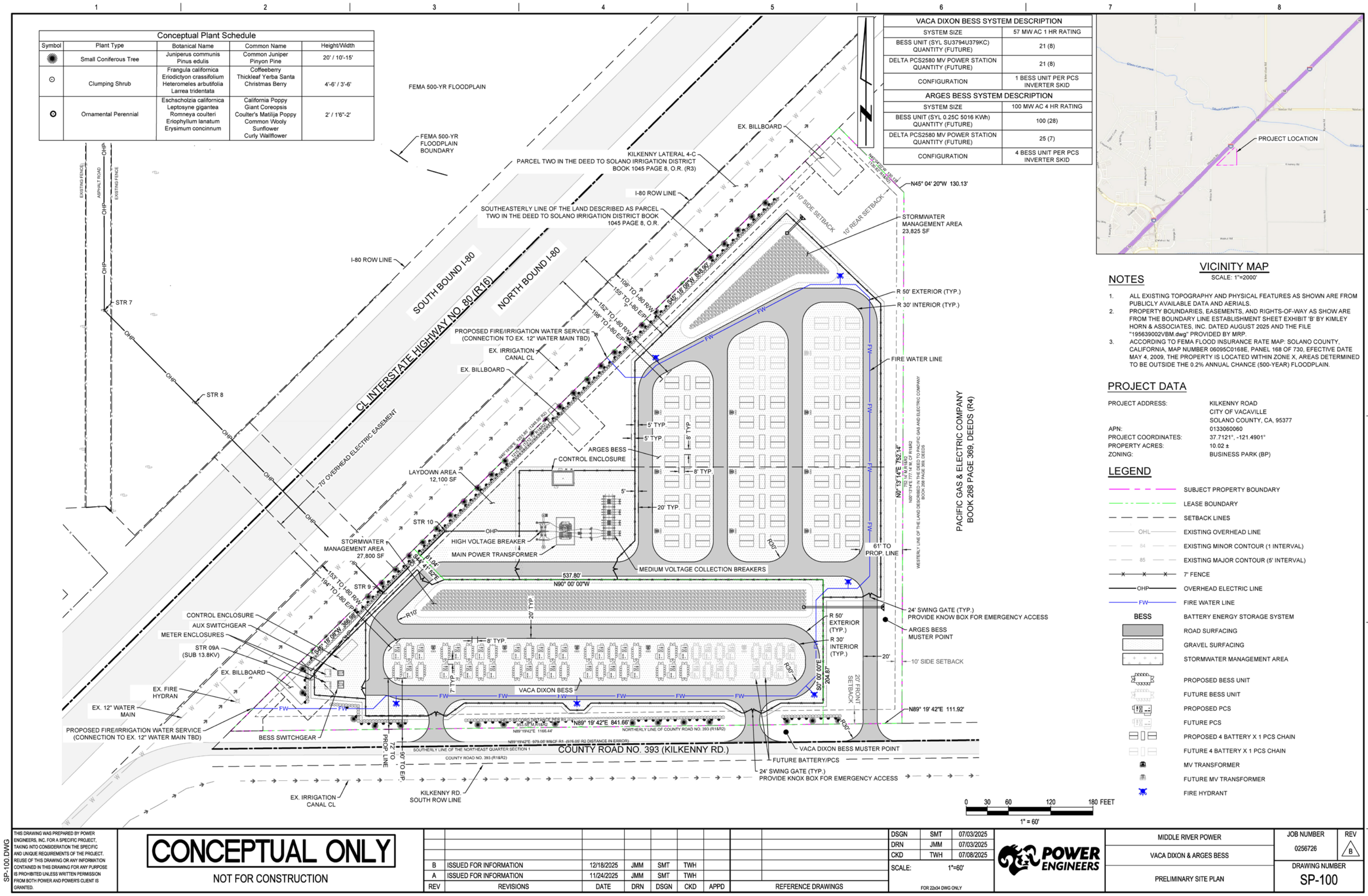
25-17851 EPS
Fig X Project Site and TRS

Figure 2-4 Vaca Dixon Power Center Project Site Plan – Full Site



Conceptual Plant Schedule

Symbol	Plant Type	Botanical Name	Common Name	Height/Width
	Small Coniferous Tree	Juniperus communis; Pinus edulis	Common Juniper; Pinyon Pine	20' / 10'-15'
	Clumping Shrub	Frangula californica; Eriodictyon crassifolium; Heteromeles arbutifolia; Larrea tridentata	Coffeeberry; Thickleaf Yerba Santa; Christmas Berry	4'-6' / 3'-6'
	Ornamental Perennial	Eschscholzia californica; Leptosyne gigantea; Romneya coulteri; Eriophyllum lanatum; Erysimum concinnum	California Poppy; Giant Coreopsis; Coulter's Matilija Poppy; Common Wooly Sunflower; Curly Wallflower	2' / 1'6"-2'

VACA DIXON BESS SYSTEM DESCRIPTION	
SYSTEM SIZE	57 MW AC 1 HR RATING
BESS UNIT (SYL SU3794U379KC) QUANTITY (FUTURE)	21 (8)
DELTA PCS2580 MV POWER STATION QUANTITY (FUTURE)	21 (8)
CONFIGURATION	1 BESS UNIT PER PCS INVERTER SKID
ARGES BESS SYSTEM DESCRIPTION	
SYSTEM SIZE	100 MW AC 4 HR RATING
BESS UNIT (SYL 0.25C 5016 KWh) QUANTITY (FUTURE)	100 (28)
DELTA PCS2580 MV POWER STATION QUANTITY (FUTURE)	25 (7)
CONFIGURATION	4 BESS UNIT PER PCS INVERTER SKID

ATTACHMENT 6

California Energy Commission
715 P Street
Sacramento, CA 95814

RE: Opposition to the Proposed Vaca Dixon Power Center Battery Energy Storage System Project (26-OPT-01)

Honorable Commissioners,

We represent a coalition of more than 1,500 residents of Vacaville and Solano County who are concerned about lithium-ion battery energy storage systems (BESS) located in inappropriate locations in our community. While we firmly support the transition to clean energy and recognize the critical role of energy storage, we are writing to formally express our opposition to the proposed Vaca Dixon Power Center. Our stance is not one of general opposition to BESS technology, but rather a firm insistence on responsible siting and safety as a priority. We believe this specific location is unsafe for a facility of this size and use of lithium-ion battery chemistry.

Our primary concern stems from the inherent risks associated with lithium-ion Battery Energy Storage Systems (BESS), specifically the threat of thermal runaway.
Our opposition is based on the following points:

Unacceptable Public Safety Risks: Unlike conventional fires, lithium-ion failures trigger chemical reactions that are nearly impossible to extinguish, burn for multiple days and emit highly toxic gases that can be harmful and deadly to breathe. The project's proximity to densely populated areas create a significant risk of toxic exposure for residents should a thermal runaway event occur. The project site is near numerous rural residential homes and just across the highway a large subdivision with thousands of homes exists. Kaiser Permanente—a Level II Trauma Center and Solano Community College are located a mile away. Adult care centers, childcare centers, schools, apartments and numerous businesses along highway 80 could also be impacted during a thermal runaway event. Thermal runaway at this location can put first responders in harm's way trying to facilitate difficult and immediate evacuations or shelter in place orders for this highly populated area.

Agricultural and Environmental Impacts: A fire at the Vaca Dixon site could not only endanger the health of residents but also impact agriculture operations. This project is sited on and near prime agricultural land, threatening the heritage and economy of Solano County. A fire incident at the project site could lead to contamination of the surrounding farms and properties due to heavy metal concentrations in the smoke plume[1]. Additionally, fire suppression efforts to cool neighboring battery packs and prevent fire spread, could lead to thousands of gallons of water runoff that become contaminated. This toxic water runoff poses a contaminant threat to nearby Solano Irrigation District canals used for farming. Additionally, there is potential for contamination of rural residential wells and the City of Vacaville well water systems that our community relies on for municipal water supply. City of Vacaville is currently constructing a new city well 1.5 miles of the project site. The project site is known to have shallow groundwater which increases potential for contamination of groundwater in the surrounding agricultural area if battery effluent leaks or water from firefighting efforts aren't contained.

Transportation and Economic Risks: The project's proximity to Interstate 80, a critical artery for California's commerce presents significant concerns. Construction related closures could force heavy traffic onto Vacaville's municipal and unincorporated roads,

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[1] **Coastal wetland deposition of cathode metals from the world's largest lithium-ion battery fire**

burdening the City with the costs of police or city-led traffic management and traffic signal reprogramming. Furthermore, these detours could cause emergency response delays within the city and obstruct access to Kaiser Permanente, our area's only Level II Trauma Center. If trucks carrying heavy loads don't stay on detours, there may be damage to city roads that aren't intended for this use. This negative impact is compounded by the potential for a lithium-ion Battery Energy Storage System (BESS) fire. A thermal runaway event could necessitate large-scale evacuations or "shelter-in-place" orders, potentially forcing an unplanned, long-term closure of I-80. In such a scenario, first responders would be stretched thin, simultaneously managing a hazardous materials crisis and a massive highway diversion. This could result in millions of dollars in lost regional commerce, damage to local roads from heavy freight rerouting, and multiple day gridlock that endangers both residents and travelers.

Strain on Community Resources: The project places a disproportionate and unfair financial strain on Vacaville's community resources. By moving forward with this project, the city is essentially forced to subsidize the risks of a private utility through the emergency preparedness and liability. As part of an emergency preparedness plan, the City of Vacaville would need special equipment, personal protective equipment, initial and annual training for first responders and mutual aid. Additionally, installation and monitoring of 10 or more gas and air monitoring devices. Thermal runaway fires are complex and resource-intensive. They are known to burn out over multiple days, an event would require a long term commitment of first responders and equipment. Such a response would unjustly drain City resources, directly inhibiting or delaying the ability to respond to emergency calls from residents Most concerning is the liability shift - the City would be left to absorb the staggering costs of emergency response, and potential environmental remediation following a thermal runaway event. Ultimately, the financial burden of such an event would fall on the local taxpayers rather than the developer.

Decline in Property Values: The project threatens the financial stability of the community by likely devaluing local real estate and introducing persistent noise pollution. Significant concerns regarding diminished property values make this project a direct threat to the surrounding neighborhood's desirability. For most residents, a home is not just a residence, but their primary investment and a cornerstone of their retirement security; any decline in equity would have a devastating ripple effect on their long-term livelihoods. Proximity to large scale industrial utility projects creates a "stigma" that leads to significant economic loss for homeowners.

A study from the University of Pennsylvania (2025) notes that similar energy projects can create a price discount of 8.8% to 15.8% for homes within a 1-km radius due to "scenic vista and nuisance stigma.[2]" The study notes that while grid-stabilization is a "positive externality," the "risk of fires for nearby properties" is a documented negative externality. In a high-density area (like the subdivision near Kaiser), this specific negative risk is amplified compared to the rural sites often used in these studies.
A BESS facility creates a similar industrial "stigma" that makes a residential area less desirable to buyers, resulting in the inability to sell their home (see real-life example here)

As insurance companies become more aware of lithium-ion fire risks (i.e. thermal runaway), they may increase premiums for homes within a certain radius of a lithium-ion BESS facility. Higher insurance costs make a home less affordable, which directly lowers the price a buyer is willing to pay. This industrialization of rural and residential adjacent land devalues the single largest investment many of our residents have made: their homes.

Negligible Local Benefit: The Vaca Dixon Power Center offers no energy discounts to our residents, as the power is intended to be sold to out-of-area providers. Furthermore, by occupying land designated for a "business park," this project displaces the potential

[2] The Impact of Utility-scale Battery Energy Storage System Projects on Property Values in California, Massachusetts, and New York

for bio-tech business offices and manufacturing centers that would provide hundreds of high-paying jobs and long-term tax revenue for Vacaville. This results in a **huge** net loss for the local economy as calculated below:

Based on Vacaville's economic development data for 2026, we can calculate the "Opportunity Cost" or net loss to the community.

1. Direct Wage Loss (35-Year Lifespan)

The most significant loss is in payroll. Vacaville is a global hub for life sciences (housing giants like Lonza and Genetech).

Business Park Potential: A 10-acre biomanufacturing site typically supports ~300 high-paying roles (based on a density of 30 employees per acre).
Average Salary: In the Vacaville biotech sector, the average annual salary is approximately $160,000.
Business Park Payroll: $160,000 × 300 jobs = **$48 Million/year**

BESS Project: The Vaca Dixon project application confirms it will be staffed by only 1–3 technicians for periodic maintenance.
BESS Payroll: $160,000 × 3 jobs = **$480,000/year**

35-Year Net Loss: Over the 35-year life of the BESS project, the community loses ***$1.66 Billion in direct wages.***

2. Economic Output & "The Multiplier"

Economists use a "multiplier" to show how one high-paying job supports other local businesses (restaurants, housing, services). For California life sciences, this multiplier is roughly 2.0.

Total Economic Impact (Business Park): $48M annual payroll × 2.0 multiplier = $96 Million/year injected into the local economy.

Total Economic Impact (BESS): The BESS project provides a one-time construction boost but near-zero ongoing local spending.

Total 35-Year Lost Economic Activity: ~$3.36 Billion.

3. Revenue vs. Risk The developer of Vaca Dixon Power Center highlights the property tax benefits to the city in their application, but the city would realize this as a net negative of ***$3.36 billion dollars*** when compared to the lost potential.

Haphazard Development and Zoning Violations: By exploiting the AB 205 "opt-in" program, the applicant is attempting to bypass local authority and ignore the zoning laws designed to protect our community. There are more appropriate locations that could be utilized for this facility outlined in the Solano County's BESS Ordinance. Additionally, there is safer technology that is commercially available that doesn't pose the thermal runaway risks[3]. The developer demonstrates a total disregard for the community's safety, economy and our local policies that would forbid this project at this location. Furthermore, in their project application they downplay the inherent risks of thermal runaway and toxic emissions that their project includes. They reference the emissions akin to a class A fire of ordinary combustibles. This is an insult to our community, who is fully engaged and well educated on this topic. This process of circumventing our city undermines our local General Plan and sets a dangerous precedent for industrial sprawl, allowing the state to force projects into areas where the community has already voiced serious safety and planning concerns. If Vaca Dixon Power Center is allowed to proceed bypassing City of Vacaville's regulations on BESS, more BESS projects may follow which would magnify and significantly increase the cumulative effects of all the above concerns listed in this letter.

---

[3] A Safer BESS

To conclude, the proposed Vaca Dixon Power Center asks the citizens of Vacaville and Solano County to bear 100% of the safety, environmental and economic risks while receiving negligible benefits. We urge the Honorable Commissioners to uphold the priority of public safety and local- land use integrity. For these reasons stated above, we respectfully request that the California Energy Commission deny the permit for the Vaca Dixon Power Center and protect the future of our community.

Sincerely,

Dee Cole
Sarah Dunn
Mike Geller
Carmen Martinez-Calderon
Keep Vacaville Safe

Albert Enault

From: Alison Harris <alisonvws@gmail.com>
Sent: Friday, January 23, 2026 8:34 PM
To: Albert Enault
Subject: No Lithium Batteries in Vacaville

CAUTION: This Email is from an EXTERNAL source. Ensure you trust this sender before clicking on any links or attachments.

Greetings Mr. Enault,

Please support No Lithium Batteries in Vacaville. Lithium Ion is terrible. There are much better options out there that will keep our air, soil and water cleaner when there is a fire.
Lithium BESS doesn't belong in the city limits because it's too densely populated. There are better, more appropriate remote locations in our county if the developers insist on lithium.
The ordinance creates a viable path for BES to exist in our city, but to do so safely.
This ordinance reflects the will of the people and the direction that our city council members have expressed and the County too.
Please approve the ordinance to keep our city of Vacaville safe!
Thank you

~ Alison
Alison Harris, REALTOR®
DRE#01420904
NavigateRE
+1 707.365.2563
AlisonHarrisHomes.com

Albert Enault

From: Laura Rakitnichan <lrakitnichan@yahoo.com>
Sent: Tuesday, January 20, 2026 6:30 PM
To: Albert Enault
Subject: Support Ban on Lithium-Ion Battery Storage Systems in Vacaville

Dear Planning Commission,
I am writing to express my support for the City of Vacaville's efforts to ban lithium-ion battery energy storage systems (BESS) within the city limits. I believe these facilities pose serious safety and environmental risks to our community and should be prohibited.

Thank you!

Michael Rakitnichan
754 Hydrangea Dr
Vacaville, CA 95687

Sent from my iPhone

Albert Enault

From: Laura Rakitnichan <rakitnichan@comcast.net>
Sent: Tuesday, January 20, 2026 6:28 PM
To: Albert Enault
Subject: Support Ban on Lithium-Ion Battery Storage Systems in Vacaville

CAUTION: This Email is from an EXTERNAL source. Ensure you trust this sender before clicking on any links or attachments.

Dear Planning Commission,
I am writing to express my support for the City of Vacaville's efforts to ban lithium-ion battery energy storage systems (BESS) within the city limits. I believe these facilities pose serious safety and environmental risks to our community and should be prohibited.

Thank you!

Laura Rakitnichan
754 Hydrangea Dr
Vacaville, CA 95687

Sent from my iPhone

Albert Enault

From: Laura Rakitnichan <rakitnichan@comcast.net>
Sent: Tuesday, January 20, 2026 6:25 PM
To: Albert Enault; Clerk@cityofvacaville.com
Subject: Support Ban on Lithium-Ion Battery Storage Systems in Vacaville

Dear Planning Commission,
I am writing to express my support for the City of Vacaville's efforts to ban lithium-ion battery energy storage systems (BESS) within the city limits. I believe these facilities pose serious safety and environmental risks to our community and should be prohibited.

Thank you!

Laura Rakitnichan
754 Hydrangea Dr
Vacaville, CA 95687

Sent from my iPhone

Albert Enault

From: Amy Yarborough <amy.m.yarborough@gmail.com>
Sent: Tuesday, January 20, 2026 5:43 PM
To: Albert Enault; Clerk@cityofvacaville.com
Subject: SAVE Vacaville BAN BESS

CAUTION: This Email is from an EXTERNAL source. Ensure you trust this sender before clicking on any links or attachments.

Dear Planning Commission,

I’m writing to show my support in banning BESS in city limits. This is not safe. Please ban this for happening. This poses serious safety an environmental concerns.

Although I’m not able to be in attendance tonight. I’m writing to say united.

Thank you,
Amy Yarborough

Albert Enault

From: Noelle <noelledemartini@gmail.com>
Sent: Tuesday, January 20, 2026 2:11 PM
To: Albert Enault
Subject: Support Banning Lithium Ion

Dear City Clerk and Mr. Enault,

I am writing to express my support for the City of Vacaville's efforts to restrict or ban lithium-ion Battery Energy Storage Systems (BESS) within city limits.

While renewable energy is important, public safety and responsible land use must come first. These facilities pose real risks that are better suited for industrial areas outside residential and commercial zones.

Thank you for prioritizing the safety and well-being of Vacaville residents.

Respectfully,
Noelle DeMartini
Vacaville, CA

Sincerely,

Noelle DeMartini

Albert Enault

From: mgneca@sbcglobal.net
Sent: Tuesday, January 20, 2026 2:02 PM
To: Albert Enault
Subject: RE: Proposed BESS Ordinance--Support

Dear Mr. Enault:

Thank you for the time and effort you and the rest of the staff have put into the proposed Battery Electric Storage Ordinance.

You have my support for the Ordinance now that lithium-ion batteries will not be utilized in the City of Vacaville.

Sincerely,

Michael Geller
5310 Kilkenny Road
Vacaville, CA 95687

From: mgneca@sbcglobal.net <mgneca@sbcglobal.net>
Sent: Monday, December 1, 2025 11:19 AM
To: 'albert.enault@cityofvacaville.gov' <albert.enault@cityofvacaville.gov>
Subject: Proposed BESS Ordinance

Albert Enault, Senior Planner
City of Vacaville
650 Merchant Street
Vacaville, CA 95688

December 1, 2025

Dear Mr. Enault:

Thank you for providing a forum for residents to comment on the structure of the proposed permanent ordinance governing Battery Energy Storage Systems proposed to be located within the city limits of Vacaville. I have several concerns that I would like to convey.

First, 300' is not a sufficient setback from an adjacent property line. I realize other jurisdictions have adopted this metric, but that in itself does not justify putting it in the ordinance. That would be exactly one football field minus the two 10 yard end zones. While that might work in an industrial area, it would not work in a residential area. I believe that the setback from nearby homes should be on the order of at least 1500' if not 2500'. The later figure would be roughly a half mile separation. You could have duel metrics addressing the two very different situations.

Second, the energy storage technology should not include the lithium-ion systems that are being promoted today. There are other technologies that are much safer and their efficiency is improving with each iteration.

Third, The technology should be further limited to technology that is not capable of a thermal runaway fire.

I will support your ordinance if it includes the measures above.

Thank you for your consideration.

Michael Geller
5310 Kilkenny Road
Vacaville, CA 95687

Albert Enault

From: Sudha Viswanathan <viswanathan3@gmail.com>
Sent: Tuesday, January 20, 2026 1:04 PM
To: Albert Enault
Subject: Lithium storage

My name is Sudha viswanathan and I live in Brighton Landing, and want to express serious concerns about the proposal to build a lithium-ion battery storage facility in Vacaville.

We only need to look at what happened recently in Moss Landing to understand the risks. That facility—the largest lithium-ion battery storage plant in the world—caught fire and burned for several days. The incident forced the evacuation of more than 1,000 residents, shut down schools, and filled surrounding neighborhoods with toxic smoke.

Residents reported headaches, sore throats, nausea, and respiratory issues almost immediately after exposure. Many described a metallic chemical odor as they fled, and some even had to relocate their families temporarily to avoid further harm. These are not theoretical risks—these are real health impacts documented in a real California community.

Lithium-ion battery fires are extremely difficult to contain. When they burn, they release hazardous chemicals such as hydrogen fluoride, cobalt, nickel, and manganese—substances linked to long-term respiratory and neurological damage. These toxins don't just disappear. They can settle on soil, homes, crops, and water sources, creating the potential for long-term environmental contamination.

In Moss Landing, weeks after the fire, officials still couldn't enter the site to fully assess the damage. That level of uncertainty is not something Vacaville residents should ever have to face.

Vacaville is a family-centered community with schools, neighborhoods, and agricultural areas nearby. Placing a lithium battery storage facility here puts all of that at risk. One fire, one malfunction, or one containment failure could endanger thousands of residents and disrupt our daily lives, just as it did in Moss Landing.

I respectfully urge the Council to reconsider the placement of this facility. The health risks, potential evacuations, environmental impacts, and long-term unknowns outweigh any projected energy benefits. Our community deserves thoughtful planning that prioritizes safety over convenience.

Thank you for your time, and I hope you will stand with the residents of Vacaville in protecting our health, our environment, and our future.

Thanks

Sudha

Albert Enault

From: Cara Case <caracase65@gmail.com>
Sent: Tuesday, January 20, 2026 12:58 PM
To: Albert Enault
Subject: Vacaville BESS ordinance draft

CAUTION: This Email is from an EXTERNAL source. Ensure you trust this sender before clicking on any links or attachments.

Hi Albert,
I'm emailing to submit a public comment for the record, in relation to the most recent city ordinance draft that was published regarding the BESS facilities proposed in the city.

I am in full support of the most recent draft that outlines stricter regulations for BESS facility development, including banning any development of flammable lithium-ion technology within city limits and only allowing less flammable technology in appropriate areas, not near homes or other commercial or residential areas.

The city council and other city officials need to do what's best for the residents of Vacaville and not bend to the demands of energy companies pushing this development in populated areas or prime ag land. There are identified industrial areas for safer battery storage technology that must be considered when reviewing or approving any of these projects.

Thank you,
Cara Eich

Albert Enault

From: Trish Ellis-Rico <trishellisrico@gmail.com>
Sent: Tuesday, January 20, 2026 12:55 PM
To: Albert Enault
Subject: Support for new Vacaville BESS ordinance

Hi Albert,

I've read the new BESS ordinance for the City of Vacaville and wanted to express my gratitude and full support.

I've lived in Vacaville for more than 20 years and I currently operate a small, in-home daycare in Brighton Landing.

Thank you for keeping our city, and my neighborhood, safe!

Sincerely,

Trish Rico

Albert Enault

From: Dee Cole <coleslah22@aol.com>
Sent: Tuesday, January 20, 2026 12:49 PM
To: clerk@cityofvacaville.com; Albert Enault
Subject: Support BESS Ordinance

CAUTION: This Email is from an EXTERNAL source. Ensure you trust this sender before clicking on any links or attachments.

Good Afternoon,

Please find this email in support of the BESS Ordinance that bans lithium BESS in the City limits.

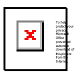
Thank you,
Deanna "Dee" Cole

Albert Enault

From: Sheena Molina <agentsmolina@gmail.com>
Sent: Tuesday, January 20, 2026 12:46 PM
To: Albert Enault; Clerk@cityofvacaville.com
Subject: BESS Ordinance

CAUTION: This Email is from an EXTERNAL source. Ensure you trust this sender before clicking on any links or attachments.

I agree with the final draft of the BESS ordinance, specifically the provision prohibiting lithium-ion battery energy storage systems within the city limits due to associated safety risks. I also support the plan to allow non-flammable battery energy storage technologies in more appropriate locations.



Albert Enault

From: Rikki Hatcher <rikkirhatcher@gmail.com>
Sent: Tuesday, January 20, 2026 12:11 PM
To: Albert Enault
Subject: Vacaville BESS ordiance

Hi Albert

My name is Rikki Hatcher and live here in Vacaville with my family. I wanted to share my support for the new revisions to the BESS ordiance. Thank you all for helping keep us safe despite corporate pressure!

Rikki Hatcher

Albert Enault

From: Jason Hatcher <jasonscotthatcher@gmail.com>
Sent: Tuesday, January 20, 2026 12:07 PM
To: Albert Enault
Subject: BESS ordinance

Good afternoon Albert,

I wanted to reach out and thank you for the work you and the planning commission has put in to the new BESS ordinance. I strongly support this and think it is the best and safest option for Vacaville. I'm the nurse that spoke out at the last meeting. My family, myself and our community are thankful for helping protect us!

Jason Hatcher

Albert Enault

From: Grace USA <graceusa2026@gmail.com>
Sent: Tuesday, January 20, 2026 10:44 AM
To: Albert Enault; Erin Morris; Nathakarn Aramvit
Cc: Sarah Chapman; John Carli
Subject: Written Comments for Jan 20, 2026 Planning Commission Mtg on draft Bess Ordinance

Written Comments for Jan 20, 2026 Planning Commission Mtg on draft Bess Ordinance

The current draft Bess Ordinance proposes the prohibition of Bess facilities that are Lithium ion based, and the elimination of two formerly-proposed areas which would have allowed the location of Bess projects, specifically the areas next to the Brighton Landing subdivision and at the Easterly Wastewater Treatment Plant. I wholeheartedly support these latest actions and thank the appointed and elected leaders in protecting the community from such irrecoverable toxic hazards. This entire Bess project inundation scenario that is happening all over the state and with the State's California Energy Commission, aka...CEC, permitting dangerous Bess projects upon local jurisdictions, shows that residents have only their local elected City Council leaders to protect them against the hazardous Bess projects being promoted by the billionaire corporate interests partnering with the State government folks and the CEC.

A toxic lithium ion Bess facility explosion in Vacaville would immediately put hundreds of adjacent homeowners into bankruptcy as homeowners insurance policies would be permanently cancelled, and the surrounding toxified land uses could not be rebuilt nor reused. This cost of clean up and loss of tax revenue would have a monumental impact on the city budget, which could lead the city into bankruptcy. As well, even the placement of a lithium ion Bess facility no doubt would cancel corporate interest in the city's proposed Biotechnic Economic Development Corridor, because what global corporation would want to spend $800 million on a biotech research center campus ....only having to abandon it soon thereafter due to a nearby permanently Bess facility explosion permanently toxifying nearby land areas. You might want to do your due diligence in interviewing the biotech research companies as to whether ANY type of Bess facility would be a no-go for them to even consider locating in Vacaville's proposed Biotechnic Economic Development Corridor. Fingers crossed, eh? 🧐 🤔

Yet, the fight is not over, don't relax yet. The next type of project coming down the line and soon to inundate local cities are AI Data Center developments. IMHO....that has always been the underlying purpose of first inundating the state with Bess facilities as they are needed first in order to later power subsequent AI Data Centers. Ergo, the State government's clamoring of the need for developing Bess facilities in order to "meet strategic green energy goals by 2030" as a purpose for Bess facilities, has been a good PR campaign to fool the masses, while the underlying purpose of the Bess facility inundation in cities is to energize AI Data centers. These AI Data center facilities suck up water and energy like nothing seen before. And given Vacaville's attraction by the global Bess corporate interests, no doubt the global corporate billionaires' next item on their list for development will be these AI Data Centers to be located en masse across the country, and locally in this Sacramento - San Francisco corridor, including Vacaville....given the regional PG&E electric substation in Vacaville. Cities across the country are fighting back against AI Data Center development, given the impact of the immense water and electrical resources that these centers require. Fortunately, a non-profit group known as the AI Now Institute, formed in 2017 to protect communities from adverse effects of AI and their facilities, has published a toolkit for local cities to use in order to protect themselves against AI Data Center developments proposed in their city. This toolkit is detailed in their article attached below, in order that your staff review it and prepare accordingly to protect Vacaville against this next wave of dangerous developments of AI Data centers.

Sincerely,

Cheryl Grace

++

https://ainowinstitute.org/publications/data-center-policy-guide

Article: **"North Star Data Center Policy Toolkit: State and Local Policy Interventions to Stop Rampant AI Data Center Expansion"**

Summary: This policy toolkit is primarily geared toward stopping, slowing, and restricting rampant data center development in the US at the local and state level. Our approach recognizes the extractive relationship between data centers and local communities: Hyperscale data centers deplete scarce natural resources, pollute local communities and increase the use of fossil fuels, raise energy costs for everyday ratepayers, pull tax dollars away from community needs, and fail to deliver on overpromised economic developments.

This toolkit is intended to help organizers and policymakers identify the strongest possible actions. Recognizing that the North Star policy may not always be feasible, we also offer scaffolded protections that put people above corporate profits.

The toolkit provides concrete policy recommendations, primarily targeted toward jurisdictions in the US that do not yet have a data center in their community, or that are working to strengthen existing legislation or regulation to account for new hyperscaler proposals. The resource is organized into local and state policy recommendations to stop and restrict data center development.

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Albert Enault

From: Wendy Breckon <wbreckon7@yahoo.com>
Sent: Monday, January 19, 2026 7:03 PM
To: Albert Enault; Peyman Behvand
Cc: Sarah Dunn; Erin Morris; Andria Borba
Subject: Comments on draft BESS Ordinance

Hi Albert and Peyman,
I hope all is well with you. Here are my questions and comments on the draft ordinance.
1. Definition BESS - I'm not sure that Lithium-Ion should be excluded from the definition of BESS. If it is not included, then the ordinance does not apply to Lithium-Ion BESS, and they can apply for a Conditional Use Permit (CUP) for Lithium-Ion BESS. If it is included in the definition, then you can prohibit Lithium-Ion BESS (as you do in the exclusion and other parts of the ordinance), and they cannot apply for a CUP.

2. Limit on BESS capacity -
The draft ordinance states in part:

> "Tier 3 (Industrial-Scale/Public Utility) battery energy storage systems have an aggregate energy capacity greater than 600 kWh, up to, <u>but not exceeding, 200 mega-watt hours (MWh)</u>, or battery energy storage systems with more than one storage battery energy technology (e.g., <u>Lithium-ion</u>, Lead-acid, Flow batteries, Nickel-based, Sodium-ion, and Solid-state batteries) is provided in a room or enclosed area. A HMA as outlined in NFPA 855 shall be required for lithium-ion ESS that exceed 600 kWh (2,160 MJ) for outdoor ESS installations, ESS installations in open parking garages and on rooftops of buildings, and mobile ESS equipment." (underlining for emphasis)

Please note: "The following types of facilities are eligible to apply to the (CEC) Opt-In Certification Program:

- . . . Energy storage systems capable of storing 200 megawatt-hours (MWh) or more" https://www.energy.ca.gov/programs-and-topics/topics/power-plants/opt-certification-program

My understanding of the draft ordinance is that you wish to permit BESS under 200 MWh. Is this because CEC certifies BESS greater than 200 MWh? If so, isn't one of the points of the ordinance to voice the City's position on the certification of arbitrary site locations for industrial-sized BESS facilities? Additionally, why is there a limit on BESS but not on battery energy storage systems with more than one storage battery energy technology? It would seem that you could have unlimited capacity if you have more than one technology. I don't remember this being an issue at the last City County meeting. If not, maybe explain the reasons for differentiating the storage limits? Finally, why is lithium-ion used as an example technology when it has been excluded?

Respectfully submitted,

Wendy Breckon

Albert Enault

From: Michelle Keem <michelle.keem@gmail.com>
Sent: Monday, January 19, 2026 3:04 PM
To: Albert Enault

Subject: BESS concern

Dear Mr. Enault,

I am a resident of Vacaville who is highly concerned about the proposed BESS facilities in/near Vacaville. I attended the Vacaville City Council meeting on December 9 and I share many community concerns that have been stated both in that meeting and in online discussions. Since that meeting, however, I've become concerned about an additional consideration that I have not heard mentioned in relation to these proposed projects or the draft ordinance.

The proposed BESS facilities are currently being discussed in relation to California's clean energy mandates and target years, which necessitate a significant amount of energy storage growth in order to fulfill requirements. However, it's important to note that BESS facilities are increasingly cropping up all over the country - not because of clean energy mandates, but due to the rapid influx of AI Data Centers. I am increasingly concerned that these projects could be pushed through via the CEC under the pretense of meeting the state's obligations under SB 100, while the companies behind them have an eye toward profiting from AI data centers. In addition to the possibility for this type of BESS use being opaque and deceptive, it is also completely contrary to the actual purpose of SB 100: mitigating the environmental impacts of climate change via carbon neutrality.

I ask that you raise additional questions, including:

1. Are AI data centers (or other AI-related uses) known or possible future customers of BESS facilities proposed for the Vacaville area?
2. Could the presence of BESS facilities in/near Vacaville potentially lead to pushes for data centers in the area?
3. Would the proposed BESS facilities be limited to supporting standard residential & commercial power demands? Can Vacaville include this in its ordinance?
4. Does the CEC require that BESS facilities prioritize fulfilling the needs of standard residential & commercial power demands? Can Vacaville include this in its ordinance?
5. Does the CEC investigate and/or take into consideration specific use(s) of BESS facilities and whether the use is contributing to state mandated targets?
6. Are the answers to any of the above permanent and/or legally binding?

Rather than helping address California's true energy demands in an environmentally-friendly way, these proposed BESS facilities could potentially encourage a significant increase in power demands - far beyond existing levels, far beyond what is environmentally responsible. We've already seen significant appetite for siphoning wealth out of our local resources (to the community's detriment) from the East Solano Plan - I urge you to ensure this doesn't become yet another instance of companies swooping in to profit at our expense.

Thank you,
Michelle Keem

Albert Enault

From: Rosie Noguera <ranrts@comcast.net>
Sent: Monday, January 19, 2026 11:59 AM
To: Albert Enault
Subject: Bess Ordinance - Jan. 20, 2026 Meeting

Good morning Mr. Enault,

I am writing to inform you that I support the proposed revision to the BESS ordinance that eliminates all lithium-ion/lithium batteries or any battery chemistry capable of thermal runaway fires within our City limits.

I also want to thank you, all of our City Council members and all other staff members who participated in the study for listening to the concerns of the people and for prioritizing the safety of our communities.

I was truly considering moving our family out of Vacaville due to the threat of these flammable batteries. This would have meant selling our forever homes and relocating three generations (total of 4 households). With this revision, I feel a huge sense of relief in knowing that I can remain in the home that I know God intended for us and that home truly is a place where I feel safe, calm and secure.

Let's show the world that our City is contributing to energy storage without putting its people in danger, without contaminating our agricultural land and without contaminating our water sources.

Let's be the example of how you can do the right thing in securing the safety of the people as well as the environment, and still achieve our goal.

Sincerely,
Rosie
(resident of 21 years)

Albert Enault

From: Anne Frey <annecfrey@att.net>
Sent: Monday, January 19, 2026 11:43 AM
To: Albert Enault
Subject: BESS

I am very pleased with the direction the City has taken regarding BESS installations in or very near Vacaville. I live on the edge of town off Cantalow, which is much too close for my comfort should a disaster happen. Frankly I have been unimpressed and offended by the companies desiring to use Vacaville and environs as sites to enrich themselves with little regard for the communities that could be affected. There is much work that is needed in the area of research before we begin populating vital farmlands with these facilities. I say wait.

Anne C Frey
7409 June Bug Lane
Vacaville 95688

Sent from my iPad

Albert Enault

From: Debra Reuter <debireuter@gmail.com>
Sent: Monday, January 19, 2026 10:55 AM
To: Albert Enault

Subject: I Support the Revision of the BESS Ordinance!

Albert,
Thank you for all your hard work on revising this ordinance, which will keep the citizens of Vacaville safe and protected.

I wholeheartedly support the revision of the BESS ordinance and look forward to its passage.

I cannot thank you enough.

Sincerely,
Debi Reuter

Debi Reuter, MA
Early Childhood Educator

"And now here is my secret, a very simple secret: It is only with the heart that one can see rightly; what is essential is invisible to the eye." ~The Little Prince

Albert Enault

From: Sam Harper <sharper@eticaag.com>
Sent: Monday, January 19, 2026 8:44 AM
To: Albert Enault
Cc: Kimberly Hidalgo
Subject: Tomorrow's BESS Ordinance Hearing: Fire + Gas Safe Option

CAUTION: This Email is from an EXTERNAL source. Ensure you trust this sender before clicking on any links or attachments.

Hi Albert,

I'm writing ahead of tomorrow's Planning Commission hearing on the draft BESS ordinance.

Energy storage can help Vacaville cut peak energy demand, improve resiliency during outages, and support local solar, all while reducing energy costs.

Developers choose lithium-ion because it delivers the best combination of performance and availability: high energy density, reliable charging and discharging, and a mature supply chain that keeps projects on schedule.

But the city is right to be concerned about safety. As you know, thermal runaway in lithium-ion cells can lead to fires and release toxic gases.

That's why EticaAG builds lithium-ion BESS with integrated fire and gas protection. Our design submerges cells in a non-toxic, high fire-point fluid, which helps prevent ignition and slows heat transfer between cells. If thermal runaway occurs, it is limited to a single cell, and our gas neutralization system converts any toxic and flammable gases into inert compounds.

Could we schedule a brief time to walk you and the City Council through this approach, so Vacaville can get the savings and reliability benefits of energy storage without the safety risks?

Best,
Sam

ETICAG

Sam Harper, *Vice President of Marketing and Branding*

sharper@eticaag.com
129 N. Pennsylvania Ave, Greensburg PA 15601
Ph: 724.348.1968 | Fx:724.838.9589
www.eticaag.com

Albert Enault

From: Nancy Abruzzo <abruzzonancy@aol.com>
Sent: Sunday, January 18, 2026 12:56 PM
To: Albert Enault
Subject: BESS Ordinance

CAUTION: This Email is from an EXTERNAL source. Ensure you trust this sender before clicking on any links or attachments.

I support the BESS ordinance 💯! We must keep our city and community safe!

Thank you 🙏,
Nancy Abruzzo

Sent from the all new AOL app for iOS

Albert Enault

From: Margaret Wimberley <peggywim4@gmail.com>
Sent: Sunday, January 18, 2026 7:53 AM
To: Albert Enault
Subject: BESS

I support the revision! Let's keep the people and the City of Vacaville safe!

Albert Enault

From: Karen McCall <klmccall65@gmail.com>
Sent: Saturday, January 17, 2026 8:37 AM
To: Albert Enault
Subject: BESS ordinance

This revision of the ordinance needs to pass for the safety of our community. I know many residents feel the same. Please do all you can to ensure the success of this ordinance.

Thank you,
Karen McCall

From: KewlEd <ememirand@gmail.com>
Sent: Friday, January 16, 2026 2:39 PM
To: Albert Enault
Subject: Oppose BESS lithium ion project near North Village

Hi Albert, I'm a resident of North Village and one of the many residents opposing the construction. Of the BESS plant near our neighborhood. If there's afire in that facility like what happened at Monterey then our homes are very close to the proximity. I do hope you would hear our voices and the entire North Village neighborhood. Ed Miranda

ATTACHMENT 7

CITY OF VACAVILLE PLANNING COMMISSION **Agenda Item No. 7.B**
STAFF REPORT **January 20, 2026**

Staff Contact:
Albert Enault
(707) 449-5364
albert.enault@cityofvacaville.gov

TITLE:	**BATTERY ENERGY STORAGE SYSTEMS (BESS) ORDINANCE**
REQUEST:	**AMEND TITLE 14 OF THE CITY OF VACAVILLE MUNICIPAL CODE BY ADDING CHAPTER 14.09.271 ENTITLED BATTERY ENERGY STORAGE SYSTEMS TO CREATE NEW POLICIES, PROCEDURES, AND STANDARDS FOR REGULATING BATTERY ENERGY STORAGE SYSTEMS IN THE CITY OF VACAVILLE.**
RECOMMENDED ACTION:	**BY SIMPLE MOTION, RECOMMEND THAT THE CITY COUNCIL:**
	ADOPT A RESOLUTION OF THE CITY OF VACAVILLE CITY COUNCIL CONCLUDING THE BATTERY ENERGY STORAGE SYSTEM ORDINANCE IS EXEMPT FROM ENVIRONMENTAL REVIEW PURSUANT TO SECTION 15061(b)(3) OF THE CALIFORNIA ENVIRONMENTAL QUALITY ACT GUIDELINES; *and*
	INTRODUCE AN ORDINANCE OF THE CITY OF VACAVILLE CITY COUNCIL AMENDING TITLE 14 OF THE CITY OF VACAVILLE MUNICIPAL CODE BY ADDING CHAPTER 14.09.271 ENTITLED BATTERY ENERGY STORAGE SYSTEMS, TO CREATE NEW POLICIES, PROCEDURES, AND STANDARDS FOR REGULATING BATTERY ENERGY STORAGE SYSTEMS IN THE CITY OF VACAVILLE.

APPLICATION INFORMATION

APPLICATIONS:	Categorical Exemption and Zoning Text Amendment
FILE NO:	24-059
APPLICANT:	City of Vacaville
PROPERTY OWNER:	Citywide

PROJECT SUMMARY

The Community Development Department is proposing to amend the City's Zoning Ordinance under Division 14.09 of the Land Use and Development Code (Title 14) to create policies, procedures, and standards for regulating Battery Energy Storage Systems (BESS) within the City of Vacaville. A BESS is an electrochemical device, with a rated capacity of equal to or greater than 1,000-kilowatt hours (1 megawatt hour), that charges or collects energy from the grid or a generation facility, stores that energy, and then discharges that energy at a later time to provide electricity or other grid services when needed. The proposed amendments will include definitions, land use and siting standards with restrictions, and will prohibit all "Lithium-Ion" battery chemistries within city limits. Pursuant to Section 15061(b)(3) of the California Environmental Quality Act (CEQA), the project is exempt from additional environmental review because there is no possibility that the addition of regulations for BESS Facilities to the Vacaville Municipal Code will have a significant effect on the environment.

PROJECT SITE INFORMATION

LOCATION:	Ordinance affects only properties in the PF, IP, and BP Zoning Districts that meet standards and regulations in the ordinance
GENERAL PLAN DESIGNATION:	Public/Institutional, Industrial Park, Business Park
ZONING:	Public Facilities (PF), Industrial Park (IP), and Business Park (BP)

PROJECT DESCRIPTION

The Community Development Department is proposing to amend the City's Zoning Ordinance under Division 14.09 of the Land Use and Development Code (Title 14) to create policies, procedures, and standards for regulating Battery Energy Storage Systems (BESS) facilities within the City of Vacaville. A BESS is an electrochemical device, with a rated capacity of equal to or greater than 1,000-kilowatt hours (1 megawatt hour), that charges or collects energy from the grid or a generation facility, stores that energy, and then discharges that energy at a later time to provide electricity or other grid services when needed. The proposed amendments will include definitions, land use and siting standards with restrictions, and will prohibit all "Lithium-Ion" battery chemistries within city limits.

PREVIOUS ACTIONS

2002
The California state legislature ("State") adopted Senate Bill (SB) 1078, which required the California Public Utilities Commission (CPUC) to develop a Renewables Portfolio Standard (RPS), with a goal for the state to have 20 percent of electricity retail sales served by renewable sources by 2017.

September 2018
The State adopted SB 100, which required CPUC to update the existing RPS to show a new goal for the State to provide 100 percent retail-sold electricity from renewable sources by 2045, and prepare a joint report that includes specified information relating to the implementation of the policy. The report concluded that the State would need to add 145 gigawatts (GW) of utility-scale capacity by 2045, including 49 GW of battery storage.

June 2022
The State adopted Assembly Bill (AB) 205, which broadened the California Energy Commission's (CEC) authority to permit certain clean and renewable energy facilities through an Opt-In Certification Program[1]. The Opt-In Certification Program provides a state-level

[1] California Energy Commission. 2025. Opt-In Certification Program Fact Sheet. URL: https://www.energy.ca.gov/sites/default/files/2024-06/Opt-In_Certification_Fact_Sheet_ada.pdf

permitting pathway for wind, solar, and BESS projects, circumventing local regulations, standards, or moratoriums.

May 2024
On May 14, 2024, the City Council adopted an interim ordinance (Ordinance No. 1933), which imposed as an urgency measure a moratorium on the application acceptance, approval, commencement, establishment, operation, relocation, or expansion of grid-scale BESS facilities within the City.

June 2024
On June 25, 2024, the City Council extended the interim ordinance moratorium to promote public health, safety, and welfare by providing City staff sufficient time to research and develop a local ordinance to address grid-scale BESS facilities.

September 2025
The State adopted SB 254, which further eroded core local land use authority for projects that utilize the Opt-In Process with the CEC, and reduced the capital investment threshold for manufacturing projects from $250 million to $100 million, meaning a wider range of projects would be eligible for the Opt-In Certification Program. For purposes of the findings, CEC is required to make as part of the Opt-In Process, SB 254 now assumes that a BESS project will have an overall net positive economic benefit.

September 2025
The CEC notified the City of Vacaville about a new Opt-In Certification application for the Middle River Power utility-scale BESS facility proposed on an approximately 10-acre site located on the north side of Kilkenny Road adjacent to Interstate 80, within Vacaville City limits and the Northeast Growth Area.

November 2025
On November 18, 2025, the Planning Commission facilitated a study session where they received staff's presentation and accepted public feedback on the draft ordinance.

December 2025
On December 9, 2025, the City Council facilitated a study session where they received staff's presentation, accepted public feedback, and directed staff to prohibit any battery chemistry involving Lithium-Ion. In addition, the City Council directed staff to conduct further evaluations on the feasibility and desirability of BESS development on three potential sites within Vacaville city limits: the Easterly Wastewater Treatment Plant, the former Gibson Canyon Wastewater Treatment Plant, and an approximately 95-acre site located south of Elmira Road and east of the Brighton Landing Subdivision.

BACKGROUND

On January 9, 2024, the City Council authorized the City Manager to enter into an agreement with Larsen & Toubro (L&T) for the preparation of a feasibility study for the development of a series of energy hubs throughout Vacaville. Following City Council's decision to impose a temporary BESS moratorium on May 14, 2024, the scope of work with L&T was amended to include a report on different battery chemistries and technologies that are technically and commercially viable for utility-scale deployment. On December 11, 2025, the City received the L&T report, which is intended as a technical and policy resource for city staff, officials, and community stakeholders involved in BESS-related decision-making. The L&T report (Attachment 6) aims to support the City's efforts to:

- Compare and shortlist BESS technologies that meet the scale, safety, and reliability standards required for long-duration storage and grid support.
- Guide ordinance development and permitting frameworks as the City considers how to refine or lift the BESS moratorium.
- Clarify tradeoffs between leading BESS technologies, especially in terms of fire risk, siting constraints, and long-term cost-effectiveness

BESS technologies were evaluated based on their operational characteristics, safety risks (e.g., thermal runaway and flammability), discharge duration, lifecycle performance, and overall commercial readiness. The L&T report identifies two leading candidates based on safety, performance, and regulatory alignment: (a) Lithium-Ion Batteries (LIB), particularly the Lithium Iron Phosphate (LFP) subtype; and (b) Flow Batteries, specifically Vanadium Redox Flow Batteries (VRFB) as an emerging complementary long-duration solution. Table 1 below is an excerpt from the report, which shows various common, uncommon, and emerging technologies.

Table 1 – BESS Technologies Suitable for Utility-Scale & Industrial

Technology	Duration	Utility-Scale Use	Industrial Use	Safety Profile
Lithium-ion (LFP)	2-4 hours	Yes	Yes	Fire Risk – Low
Lithium-ion (Nickle Manganese Cobalt, NMC)	2-4 hours	Yes	Yes	Fire Risk – High
Vanadium Redox Flow (VRFB)	6-12+ hours	Yes (Emerging)	Emerging	Fire Risk – None
Sodium-Sulfur (NaS)	6 hours	Yes	Uncommon	Fire Risk – Low
Lead-Acid	1-4 hours	No	Yes	Fire Risk – None
Zinc-based (e.g., Zn-Br flow, Zn-ion)	4-10 hours	Yes (Emerging)	Emerging	Fire Risk – None

As shown in Table 1 above, Lithium-ion battery types of the NMC varietal pose the greatest risk of fire from a thermal runaway event. Flow batteries represent one of the most promising emerging alternatives to lithium-ion for long-duration and utility-scale energy storage with little to no thermal safety concerns. Their non-flammable, water-based electrolyte characteristics nearly eliminate the thermal runaway risks inherent even in the safest lithium-ion chemistries. In addition, their independent scaling of energy and power, along with a 20- to 30-year design life, enable predictable long-term operation.

<u>City Council Direction</u>

On December 9, 2025, the Vacaville City Council held a study session on the draft ordinance, received public comments, and provided feedback to staff. During the public comment period, many commenters expressed concern about the dangers of thermal runaway from lithium-ion battery chemistry, the potential for toxic gas and fumes to affect nearby sensitive uses, insufficient buffers from residential uses, and the potential regional effects from a thermal runaway event. At the close of the public hearing, City Council deliberated and provided the following directions to staff:

A. Battery Chemistry – Council expressed a desire to prohibit any battery chemistry with high volatility and the potential for a thermal runaway event that would affect residents, businesses, and the City's public safety divisions responsible for responding to such events. As supported by the L&T report (Attachment 6), staff has updated the draft ordinance to prohibit any Lithium-ion battery chemistry within the City of Vacaville.

B. Proximity to Town of Elmira – Council expressed a desire to prohibit any BESS facilities near the Town of Elmira out of concern that such facilities would create additional hardship for the unincorporated Solano County town. Elmira contains the former Elmira wood treatment facility (APN 0142-010-130), which was identified by the California Department of Toxic Substances Control as a contaminated site.[2] In addition to concerns about existing hardship, staff conducted further research on the two potential sites near Elmira (Attachment 4).

    1. Easterly Wastewater Treatment Plant (EWWTP) – Previously, staff identified as a potential BESS site some land surrounding the City's wastewater treatment plant located at 6040 Vaca Station Road. After further evaluation, staff can confirm that this location would not be suitable due to the following:

        a. Risk – The risk of a potential closure of the EWWTP due to any type of emergency event stemming from a BESS facility located near the EWWTP facility would be unacceptable. Although the draft ordinance would prohibit volatile chemistry types, the larger utility grid-scale facilities are not flawless, and the potential still exists for an emergency event caused by calamity, such as earthquakes or flooding.
        b. Expansion – The City has observed the overall volume of sewer discharge received at the EWWTP, which has decreased because of Statewide regulations for water conservation. This decrease creates a higher concentration of solids that must be extracted from the effluent. The vacant land surrounding the EWWTP must be reserved by the City to allow for the future expansion of associated facilities that can accommodate the increase of bio-solids, such as drying beds and injection wells.
        c. Ownership – It should be noted that the vacant land surrounding the EWWTP is owned by the City, which provides an additional layer of protection from potential BESS facilities utilizing the streamlined process with the California Energy Commission, as the land could not be developed without the City's explicit approval as the owner.

    2. Brighton Landing Parcel (E95) – Located east of Brighton Landing, this vacant 95-acre parcel is located within the city limits, but outside of the City's Urban Growth Boundary, which means no development can occur until after March 2028. After engaging the property owner of this parcel, staff can confirm this location is not suitable for development because the property owner will be seeking to develop this site with future residential development that would complement the existing Brighton

[2] Toxic backyards: State dollars pay for abandoned sites. April 25, 2014. KCRA3. URL: https://www.kcra.com/article/toxic-backyards-state-dollars-pay-for-abandoned-sites/6413268#:~:text=So%20much%20contamination%20occurred%20at%20this%20site,had.%20California%20Department%20of%20Toxic%20Substances%20Control.

Landing subdivision. Development of the site would not be pursued until the Urban Growth Boundary has expired.

Revisions to Draft Ordinance

The information in the L&T report supports the City Council's direction to disallow any Lithium-ion chemistry type that has the potential for a thermal runaway event. The draft ordinance attached here has been revised to exclude any Lithium-ion battery types until such a time when the threat of thermal runaway is eliminated. In addition, staff has conducted further analysis to determine whether any sites remain suitable for potential BESS facilities, which is also described below.

PROJECT ANALYSIS

Staff is proposing amendments to the VMC by adding Chapter 14.09.271 entitled "Battery Energy Storage Systems" to create new policies, procedures, and standards for regulating BESS facilities within the City of Vacaville (Exhibit B to Attachment 2). Pursuant to VMC Chapter 14.09.020, the Planning Commission is responsible for making a recommendation on the proposed zoning text amendments, and the City Council shall have the final decision to either approve, modify, or deny the amendments. The following sections describe the ordinance framework, edits made to address City Council's comments, and additional analysis on the suitability of potential sites.

1. Draft Ordinance

The proposed ordinance is intended to implement the goals and objectives of the General Plan and to guide and manage BESS facilities within the city. Policies help protect the physical, social, and economic stability of residential, commercial, industrial, and other land uses within the city to ensure its orderly and beneficial development. Proposed standards are designed to reduce hazards to the public and emergency responders resulting from the inappropriate location, use, or design of buildings and other improvements. Included as Exhibit B to Attachment 2, the draft framework of the ordinance is outlined below:

A. Definitions and Applicability
- Describes the purpose and applicability of the ordinance
- Defines Battery Energy Storage Systems and provides definitions
- Revised to prohibit any Lithium-ion battery chemistry

B. Land Use & Siting Standards
- Conditionally Permitted in PF, IP, and BP zoning districts
- Not allowed in high or very high fire hazard severity zones
- Not allowed in Nut Tree Airport Compatibility zones
- Not allowed in the Northeast Growth Area until the Specific Plan is prepared
- Increased buffer distance from 300 to 500 feet from sensitive uses (e.g., residential, hospitals, schools)

C. Development Standards
- Lighting and Noise
- Security and Screening
- Battery Chemistry Technology
- Landscaping

D. Permitting Process
   - Preliminary Application Process
   - Formal Application Process
   - Submittal Requirements
   - Technical Studies (e.g., Plume Analysis, Hazard Mitigation Analysis)
   - Environmental Review

E. Public Benefit Agreement Criteria
   - Applicable to Tier 2 and Tier 3 (NFPA)
   - Examples could include training and equipment for emergency personnel, investments in local organizations or community projects, contributions to City initiatives, or projects that benefit the community

F. Commissioning/Decommissioning
   - Added language to require additional financial assurances at commissioning and decommissioning of BESS facility
   - Safety Requirements
   - Ownership Changes

2. Suitability Analysis

Previously, staff prepared a suitability analysis to determine whether Vacaville had any locations that could accommodate BESS facilities with the implementation of the draft ordinance. As shown by Attachment 4, the previous mapping exhibits depicted three potential sites: EWWTP, the E95 Parcel east of Brighton Landing, and the former Gibson Canyon Wastewater Treatment Plant (GCWWTP). As noted above, the EWWTP and E95 Parcel would not be suitable for potential BESS facilities, so these areas have been removed from consideration. However, staff further evaluated the GCWWTP location including potential scenarios with increased setbacks from sensitive uses with buffers at 300 feet, 500 feet, and 700 feet.

As shown by Attachment 5, the GCWWTP location contains sufficient land to accommodate larger setbacks from sensitive uses. The alternate suitability analysis is intended to show that the GCWWTP should not be outright prohibited under the ordinance because the site is large enough to include larger setbacks, earthen berms, and landscaping that can help provide sufficient screening from adjoining properties. Staff evaluated a 1,000 ft. buffer scenario but disregarded the analysis because the increased buffer would eliminate almost the entire property. Ultimately, the City retains the authority as the property owner to control any proposal seeking to develop on this location. Staff believes this location still holds the potential for a grid-scale BESS facility, while simultaneously providing larger setbacks to address community concerns.

SOLANO AIRPORT LAND USE COMMISSION

Pursuant to California Public Utilities Code (PUC) Section 21676(b) and VMC Section 14.09.110.070, any proposed amendment to the zoning ordinance that may impact airport operations must be referred to the Solano County Airport Land Use Commission (ALUC) to determine consistency with land use compatibility plans for the Nut Tree Airport and Travis Air Force Base. California PUC Section 21676(b) and VMC Section 14.09.110.070.A require that the ALUC review the proposed Zoning Text Amendments for consistency prior to action being taken by the decision maker. Pursuant to VMC Section 14.01.030.020.A.3, the City Council is the decision maker for the project. On January 8, 2026, the ALUC reviewed the amendments and found the proposed ordinance was consistent with the compatibility plans for the Nut Tree Airport and Travis Air Force Base.

PUBLIC OUTREACH

Staff provided public notification through newspaper publications, press releases and social media posts, and published information on the City's website. On October 22, 2025, the City facilitated a Community Meeting at the Ulatis Community Center from 6:00 pm to 7:30 pm to solicit community feedback about the City's efforts to draft a new ordinance. Approximately 75 people attended the meeting and 23 people provided comments. On November 18, 2025, and December 9, 2025, the City facilitated study sessions to solicit community feedback; public comments were included with each study session staff report. For this public hearing, the City published a public notice in the Vacaville Reporter on December 27, 2025, to provide a minimum 20-day notice in accordance with AB 2904. Attachment 6 includes an updated list of public comments that were received after the City Council study session on December 9, 2025.

ENVIRONMENTAL IMPACTS

The draft ordinance is exempt from the provisions of CEQA pursuant to CEQA Guidelines Section 15061 (b)(3) since there is no possibility that the addition of regulations for BESS Facilities to the VMC may have a significant effect on the environment. Proposed future BESS facilities will be reviewed in compliance with the provisions of CEQA at the time of application to determine appropriate environmental review.

RECOMMENDATION

By simple motion, recommend that the City Council:

- Adopt a Resolution of the City Council of the City of Vacaville concluding the Battery Energy Storage Systems Ordinance is exempt from environmental review pursuant to Section 15061(b)(3) of the California Environmental Quality Act Guidelines; *and*

- Introduce an Ordinance of the City Council of the City of Vacaville amending Title 14 of the city of Vacaville Municipal Code by adding Chapter 14.09.271 entitled Battery Energy Storage Systems to create new policies, procedures, and standards for regulating Battery Energy Storage Systems in the City of Vacaville.

<u>List of Attachments</u>

1. Draft Resolution adopting the CEQA determination with
    Exhibit A – Findings of Fact
2. Draft Ordinance with
    Exhibit A – Findings of Fact
    Exhibit B – Zoning Text Amendments
3. Vicinity Map
4. Previous Suitability Analysis
5. Updated Suitability Analysis
6. Larsen & Toubro Study
7. Public Comments

ATTACHMENT 1

BATTERY ENERGY STORAGE SYSTEMS ORDINANCE
CEQA Resolution
Citywide Ordinance
Categorical Exemption, Zoning Text Amendment, and Airport Area of Influence Review
File No. 24-059

RESOLUTION NO. 2026-______

RESOLUTION OF THE CITY OF VACAVILLE CITY COUNCIL CONCLUDING THE BATTERY ENERGY STORAGE SYSTEM ORDINANCE IS EXEMPT FROM ENVIRONMENTAL REVIEW PURSUANT TO SECTION 15061(b)(3) OF THE CALIFORNIA ENVIRONMENTAL QUALITY ACT GUIDELINES

WHEREAS, there is a growing demand for Battery Energy Storage Systems ("BESS") facilities in the state of California due to increased demand for renewable electricity to reach the State's clean energy goals and mechanisms to ensure reliability of the State's electric system, among other things; and

WHEREAS, there have been several recent fires at BESS facilities both in California and nationwide. BESS facilities that use lithium-ion batteries create particularly unique fire and explosion hazards. Information suggests that lithium-ion batteries are inherently safe and stable when installed properly, however certain conditions elevate the risk of fire and thermal runaways, such as impact, puncture, or mechanical damage, overcharging, overheating, and/or short circuits; and

WHEREAS, the City of Vacaville does not have land use policies or standards in place to regulate the location and operation of BESS facilities within the City of Vacaville which would address compatibility with surrounding uses and safety among other issues; and

WHEREAS, the potential for the development of new grid-scale BESS facilities within Solano County without adequate land use policies and standards in place to prevent potentially catastrophic interference with nearby communities presented an immediate threat to the public's safety and welfare, and the approval of land use entitlements for such uses would result in that threat to public safety and welfare; and

WHEREAS, on May 14, 2024, the City Council adopted, by a four-fifths affirmative vote (7-0), an interim ordinance imposing as an urgency measure a prohibition on the application acceptance, approval, commencement, establishment, operation, relocation or expansion of grid-scale BESS facilities within City limits (Ordinance No. 1993); and

WHEREAS, on June 25, 2024, the City Council adopted, by a four-fifths affirmative vote (7-0), to extend the interim ordinance pursuant to Government Code Section 65858 for an additional period of up to 22 months and 15 days, establishing a temporary moratorium until May 14, 2026 (Ordinance No. 1994); and

WHEREAS, the City of Vacaville has prepared a draft ordinance to establish policies, procedures and standards for regulating BESS facilities within city limits, and has provided opportunity for public comments during study sessions with the Vacaville City Council and Planning Commission; and

WHEREAS, pursuant to Section 15061(b)(3) of the California Environmental Quality Act (CEQA), the City of Vacaville Community Development Department has determined that the project is exempt from additional environmental review because it can be seen with certainty that there is no possibility that a project will have a significant effect on the environment; and

WHEREAS, the Planning Commission held a duly noticed public hearing on January 20, 2026, to consider the proposed BESS Ordinance where they received testimony from City staff, the Applicant, and all interested persons regarding the draft ordinance; and

WHEREAS, the Planning Commission voted __-__ to recommend that the City Council conclude the BESS Ordinance is exempt from environmental review pursuant to CEQA Section 15061(b)(3), and adopt the Zoning Text Amendments for the BESS Ordinance, based on the Findings of Fact as shown in Exhibit A; and

WHEREAS, the City Council held a duly noticed public hearing on March 10, 2026, to consider the proposed environmental determination and BESS Ordinance, where they received testimony from City staff and all interested persons regarding the proposed project, and also considered testimony and evidence submitted at the Planning Commission hearing; and

NOW, THEREFORE, BE IT RESOLVED by the City Council of the City of Vacaville as follows:

Section 1. The City Council hereby finds that the facts set forth in the recitals to this Resolution are true and correct and establish the factual basis for the City Council's adoption of this Resolution.

Section 2. The City Council has considered the BESS Ordinance and all potential impacts to the environment, and hereby concludes the Zoning Text Amendments are exempt from environmental review in accordance with CEQA Section 15061(b)(3) because it can be seen with certainty that there is no possibility that the text amendments will have a significant effect on the environment, as supported by the findings shown in Exhibit A.

Section 3. This Resolution shall take effect immediately upon its adoption.

I HEREBY CERTIFY that the foregoing resolution was introduced and passed at a regular meeting of the City Council of the City of Vacaville, held on the ____ day of ________ _____, by the following vote:

AYES:

NOES:

ABSENT:

ATTEST:

____

Michelle A. Thornbrugh, City Clerk

List of Exhibits

Exhibit A – Findings of Fact

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EXHIBIT A TO ATTACHMENT 1

BATTERY ENERGY STORAGE SYSTEMS ORDINANCE
CEQA Findings of Fact
Citywide Ordinance
Categorical Exemption, Zoning Text Amendment, and Airport Area of Influence Review
File No. 24-059

Code sections referenced below are from the Vacaville Municipal Code (VMC) or the California Environmental Quality Act (CEQA), unless otherwise specified.

SUMMARY OF EVIDENCE

The decision-maker bases its decision on the following information: (1) the project application, including attachments and related studies; (2) the staff reports, City files, records and other documents prepared for and/or submitted to the City relating to the environmental review and the project itself; (3) the evidence, facts, findings and other determinations set forth in this resolution; (4) the Vacaville General Plan, the Vacaville Land Use and Development Code and other applicable plans, codes and resolutions of the City of Vacaville; (5) all documentary and oral evidence received at public workshops, neighborhood meetings, and hearings or submitted to the City during the comment period relating to the project or the environmental review; (6) the minutes and recordings at public hearings; and (7) all other matters of common knowledge to the to the City, including, but not limited to, City, state, and federal laws, policies, rules, regulations, reports, records and projections related to development within the City and its surrounding areas.

ENVIRONMENTAL REVIEW FINDINGS

VMC Section 14.03.021.010 Exemptions

Pursuant to CEQA Section 15061(b)(3), the City of Vacaville Community Development Department has determined that the project is exempt from the provisions of CEQA because it can be seen with certainty that there is no possibility that the project will have a significant effect on the environment. The determination is supported by the following factual evidence.

A. The Vacaville City Council hereby adopts the following findings to support the decision that the project is exempt from environmental review under CEQA Section 15061(b)(3):

> *Finding: The Lead Agency has evaluated the potential for project-related impacts resulting from the draft zoning text amendments and hereby concludes that the proposed changes will not result in any foreseeable impact to the environment. This determination is supported by the following claims: (1) the ordinance does not authorize or approve entitlements to construct or make any physical change to the environment; (2) the policies, procedures, and standards provide directions for processing new development applications that will require subsequent environmental analysis; (3) the ordinance does not exempt any future project from environmental review and ensures consistency with the California Environmental Quality Act; (4) the ordinance requires the submittal of technical information that will help determine the level of environmental impacts required for any new Battery Energy Storage Systems (BESS) facility; (5) the ordinance does not authorize new uses or physical development and does not expand*

the range of allowable land uses beyond what is already permitted under existing state law; and (6) the ordinance modifies and clarifies local permitting procedures to ensure consistency with state requirements.

Environmental Review Conclusion

The City Council has concluded that no additional environmental review is required pursuant to CEQA Section 15061(b)(3) of the CEQA Guidelines.

ATTACHMENT 2

BATTERY ENERGY STORAGE SYSTEMS ORDINANCE
Zoning Text Amendments Ordinance
Citywide Ordinance
Categorical Exemption, Zoning Text Amendment, and Airport Area of Influence Review
File No. 24-059

ORDINANCE NO. _______
(First Reading)

INTRODUCE AN ORDINANCE OF THE CITY OF VACAVILLE CITY COUNCIL AMENDING TITLE 14 OF THE CITY OF VACAVILLE MUNICIPAL CODE BY ADDING CHAPTER 14.09.271 ENTITLED BATTERY ENERGY STORAGE SYSTEMS, TO CREATE NEW POLICIES, PROCEDURES, AND STANDARDS FOR REGULATING BATTERY ENERGY STORAGE SYSTEMS IN THE CITY OF VACAVILLE

WHEREAS, there is a growing demand for Battery Energy Storage Systems ("BESS") in the state of California due to increased demand for renewable electricity to reach the State's clean energy goals and mechanisms to ensure reliability of the State's electric system, among other things; and

WHEREAS, there have been several recent fires at BESS facilities both in California and nationwide. BESS facilities that use lithium-ion batteries create particularly unique fire and explosion hazards. Information suggests that lithium-ion batteries are inherently safe and stable when installed properly, however certain conditions elevate the risk of fire and thermal runaways, such as impact, puncture, or mechanical damage, overcharging, overheating, and/or short circuits; and

WHEREAS, the City of Vacaville does not have land use policies or standards in place to regulate the location and operation of BESS facilities within the City of Vacaville which would address compatibility with surrounding uses and safety among other issues; and

WHEREAS, the potential for the development of new grid-scale BESS facilities within Solano County without adequate land use policies and standards in place to prevent potentially catastrophic interference with nearby communities presented an immediate threat to the public's safety and welfare, and the approval of land use entitlements for such uses would result in that threat to public safety and welfare; and

WHEREAS, on May 14, 2024, the City Council adopted, by a four-fifths affirmative vote (7-0), an interim ordinance imposing as an urgency measure a prohibition on the application acceptance, approval, commencement, establishment, operation, relocation or expansion of grid-scale BESS facilities within City limits (Ordinance No. 1993); and

WHEREAS, on June 25, 2024, the City Council adopted, by a four-fifths affirmative vote (7-0), to extend the interim ordinance pursuant to Government Code Section 65858 for an additional period of up to 22 months and 15 days, establishing a temporary moratorium until May 14, 2026 (Ordinance No. 1994); and

WHEREAS, the City of Vacaville has prepared a draft ordinance to establish policies, procedures and standards for regulating BESS facilities within city limits, and has provided opportunity for public comments during study sessions with the Vacaville City Council and Planning Commission; and

WHEREAS, pursuant to Section 15061(b)(3) of the California Environmental Quality Act (CEQA), the City of Vacaville Community Development Department has determined that the project is exempt from additional environmental review because it can be seen with certainty that there is no possibility that a project will have a significant effect on the environment; and

WHEREAS, the Planning Commission held a duly noticed public hearing on January 20, 2026, to consider the proposed BESS Ordinance where they received testimony from City staff, the Applicant, and all interested persons regarding the draft ordinance; and

WHEREAS, the Planning Commission voted __-__ to recommend that the City Council conclude the BESS Ordinance is exempt from environmental review pursuant to CEQA Section 15061(b)(3), and adopt the Zoning Text Amendments for the BESS Ordinance, based on the Findings of Fact as shown in Exhibit A; and

WHEREAS, the City Council held a duly noticed public hearing on March 10, 2026, to consider the proposed environmental determination and BESS Ordinance, where they received testimony from City staff and all interested persons regarding the proposed project, and also considered testimony and evidence submitted at the Planning Commission hearing; and

WHEREAS, the City Council has considered the BESS Ordinance and all potential impacts to the environment, and concluded the Zoning Text Amendments are exempt from environmental review in accordance with CEQA Section 15061(b)(3) because it can be seen with certainty that there is no possibility that the text amendments will have a significant effect on the environment, which is hereby referenced as City Council Resolution No. 2026-_____.

NOW, THEREFORE, THE CITY COUNCIL OF THE CITY OF VACAVILLE DOES ORDAIN AS FOLLOWS:

SECTION 1. The City Council hereby finds that the facts set forth in the recitals to this Ordinance are true and correct and establish the factual basis for the City Council's adoption of this Ordinance.

SECTION 2. Based on the entire record for the BESS Ordinance, the City Council hereby finds that the amendment to the Vacaville Municipal Code meets the findings and supporting facts and evidence are set forth in detail in the Findings of Fact document attached hereto as Exhibit A, which is hereby incorporated by this reference into this Ordinance as if fully set forth herein.

SECTION 3: The City Council hereby approves and adopts the proposed amendments to the Vacaville Municipal Code as set forth in Exhibit B hereto, such zoning amendments being approved in accordance with Vacaville Municipal Code Chapter 14.09.020.

SECTION 4: If any section, subsection, phrase, or clause of this ordinance is for any reason held to be unconstitutional, such decision shall not affect the validity of the remaining portions of this ordinance. The City Council hereby declares that it would have passed this ordinance and each section, subsection, phrase or clause thereof irrespective of the fact that any one or more section, subsection, phrases or clauses be declared unconstitutional.

SECTION 6: This ordinance shall be published in accordance with the provisions of Government Code Section 36033, and shall become effective thirty (30) days after its passage.

I HEREBY CERTIFY that this ordinance was **INTRODUCED** at a regular meeting of the City Council of the City of Vacaville on the ____ day of ___________ 2026, by the following vote:

AYES:

NOES:

ABSENT:

ATTEST:

____
Michelle Thornbrugh, City Clerk

List of Exhibits

Exhibit A – Findings of Fact
Exhibit B – Zoning Text Amendments

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EXHIBIT A TO ATTACHMENT 2

BATTERY ENERGY STORAGE SYSTEMS ORDINANCE
Zoning Text Amendments Findings of Fact
Citywide Ordinance
Categorical Exemption, Zoning Text Amendment, and Airport Area of Influence Review
File No. 24-059

Code sections referenced below are from the Vacaville Municipal Code (VMC) or the California Environmental Quality Act (CEQA), unless otherwise specified.

SUMMARY OF EVIDENCE

The decision-maker bases its decision on the following information: (1) the project application, including attachments and related studies; (2) the staff reports, City files, records and other documents prepared for and/or submitted to the City relating to the environmental review and the project itself; (3) the evidence, facts, findings and other determinations set forth in this resolution; (4) the Vacaville General Plan, the Vacaville Land Use and Development Code and other applicable plans, codes and resolutions of the City of Vacaville; (5) all documentary and oral evidence received at public workshops, neighborhood meetings, and hearings or submitted to the City during the comment period relating to the project or the environmental review; (6) the minutes and recordings at public hearings; and (7) all other matters of common knowledge to the to the City, including, but not limited to, City, state, and federal laws, policies, rules, regulations, reports, records and projections related to development within the City and its surrounding areas.

ZONING TEXT AMENDMENT FINDINGS

VMC Section 14.04.030.040 Findings Required for Approval

In order to approve a Zoning Text Amendment, the City Council shall find that:

A. That the proposed amendment is internally consistent with the goals, objectives, and policies of the General Plan, the Zoning Ordinance, and the Land Use and Development Code;

Finding: The ordinance meet this finding, because: (1) the ordinance implements General Plan Goal LU-18 to ensure orderly, well-planned growth in the Northeast Growth Area; (2) the ordinance protects established neighborhoods from incompatible uses by prohibiting lithium-ion battery chemistry and requiring buffers from sensitive uses, as required by Policy LU-P1.4; (3) the City has provided notification and public hearings to discuss the zoning text amendments as required by Policy LU-P7.1; (4) the City used traditional and new media tools for communicating with the public, including USPS mail, emails and a separate website dedicated to providing information to the public (Policy LU-P7.2); (5) the project is consistent with the City's Zoning Ordinance because notification of public hearings has been provided to the public; and (6) the City provided adequate notification about the project in accordance with VMC Section 14.09.030.070.

B. That the proposed amendment would not be detrimental to the public health, safety, or welfare of the community;

Finding: The project meets this finding because: (1) the amendment establishes policies, procedures, and standards for regulating the construction and operation of BESS facilities in Vacaville; (2) any new development application for a BESS facility will be required to comply with the new ordinance and conduct environmental analysis to determine project-related impacts on the environment; (3) any new BESS facility will be required to comply with the California Building Code and the California Fire Code; and (4) the amendment will not conflict with the existing land use compatibility plans for the Nut Tree Airport and Travis Air Force Base.

C. That the proposed amendment would maintain an appropriate balance of land uses within the City;

Finding: The project meets this finding because: (1) the zoning text amendments establishes location requirements and development standards that would prevent the proliferation of BESS facilities throughout Vacaville; (2) the zoning text amendments will prohibit lithium-ion batteries and will require increase buffers away from sensitive land uses to protect the public health, safety, and welfare; and (3) the zoning text amendments will not displace any existing land uses and will not result in a disproportionate balance of land uses.

D. That the anticipated land uses on the subject site would be compatible with existing and future surrounding uses;

Finding: The project meets this finding because: (1) the ordinance does not authorize any new BESS facilities; (2) the policies, procedures, and standards within the draft ordinance are intended to avoid potential incompatibility issues with existing and future surrounding land uses by imposing setback standards from sensitive uses; (3) the ordinance will prohibit volatile technologies such as Lithium-Ion batteries to reduce the risk for thermal runaway events; and (4) the ordinance includes requirements for technical reports to help determine the potential impacts on existing and future surrounding uses.

E. That the potential impacts to the City's inventory of residential lands has been considered; and

Finding: The project meets this finding because: (1) the potential sites do not have the capacity to accommodate residential development, and the project will not affect any existing residential inventory; and (2) the ordinance includes development standards with setbacks to provide safe separation from residential lands and other sensitive uses.

F. That the proposed amendment is consistent with any development-related application that is processed and approved concurrently with the amendment application.

Finding: Not applicable. There are no development-related applications that are being approved concurrently with the amendment application.

<u>Zoning Text Amendment Conclusion</u>

Based on the facts and findings above, the project meets the required findings for approving the proposed Zoning Text Amendments.

ATTACHMENT 2

DRAFT ORDINANCE FOR BATTERY ENERGY STORAGE SYSTEMS
Citywide
Zoning Text Amendments
File No. 24-059

New text is shown below in underlined font, and text to be removed is shown in ~~strikethrough~~ font.

SECTION I

Division 14.09 of the Vacaville Municipal Code is amended to create Chapter 14.09.271 and add the following text to the chapter:

Chapter 14.09.271
Battery Energy Storage Systems.

Section 14.09.271.010 Purpose and Applicability

A. Purpose. The provisions of this Title are hereby established and adopted to protect and promote the public health, safety, morals, comfort, convenience, and welfare, and more particularly to:

1. Implement the goals and objectives of the general plan and guide and manage development within the city in accordance with such plan.

2. Protect the physical, social, and economic stability of residential, commercial, industrial, and other land uses within the city to assure its orderly and beneficial development.

3. Reduce hazards to the public and emergency responders resulting from the inappropriate location, use, or design of buildings/structures and other improvements.

4. Attain the physical, social, and economic advantages resulting from comprehensive and orderly land use and resource planning.

5. To prioritize public safety over exploitation of corporate profit.

B. Applicability. The requirements of this ordinance shall apply to all Tier 2 and Tier 3 front-of-the-meter Battery Energy Storage Systems that are permitted and installed in the City of Vacaville after the effective date of this ordinance. This ordinance does not extend to the general maintenance and repair of battery energy storage systems permitted, installed, or modified prior to the effective date of this ordinance. This ordinance does not apply to behind-the-meter Battery Energy Storage Systems supporting residential, commercial, agricultural, and industrial uses.

C. Exclusions. Tier 2 and Tier 3 Battery Energy Storage Systems that contain “Lithium-ion” or any technology type with documented occurrences of thermal runaway events shall not be permitted within the City of Vacaville.

Section 14.09.271.020 Definitions

"Energy Storage" means any technology that is capable of absorbing electricity, storing the electricity for a period of time, and redelivering the electricity.

"Battery Energy Storage System" (BESS) means an electrochemical device, with a rated capacity of equal to or greater than 1,000-kilowatt hours (1 megawatt hour), that charges or collects energy from the grid or a generation facility, stores that energy, and then discharges that energy at a later time to provide electricity or other grid services when needed. For the purpose of this chapter, the definition or term “BESS” shall not include any chemistry type involving “Lithium-ion” or any technology type with documented occurrences of thermal runaway events.

"Behind-the-meter (BTM) Battery Energy Storage System" refers to a Battery Energy Storage System (BESS) installed on the customer's side of the utility meter. These systems are designed to support energy use by providing backup power, demand charge management, load shifting, or renewable energy integration.

"Commissioning" means a systematic process that provides documented confirmation that a battery energy storage system functions according to the intended design criteria and complies with applicable code requirements.

"Decommissioning Plan" means a plan to retire the physical facilities of the Project, including decontamination, dismantlement, rehabilitation, landscaping and monitoring. The plan contains detailed information on the proposed decommissioning and covers the schedule, type and sequence of decommissioning activities; waste management, storage and disposal of the waste from decommissioning; the timeframe for decommissioning and site rehabilitation.

"Front-of-the-meter (FTM) Battery Energy Storage System" refers to a Battery Energy Storage System (BESS) that is directly connected to the transmission or distribution grid and primarily serves wholesale market functions such as grid support, frequency regulation, or energy arbitrage.

Hazard Mitigation Analysis (HMA) is a systematic method that considers the various hazards related to the installation, identifies potential failure modes as well as their causes and effects, and develops appropriate mitigation solutions. HMAs evaluate the consequences of thermal runaway conditions, failure of an energy storage management system, failure of a required ventilation or exhaust system, and failure of a required smoke/fire detection system, fire suppression, or gas detection system.

"IEEE" is the Institute of Electrical and Electronics Engineers is a global professional organization dedicated to advancing technology for the benefit of humanity. IEEE develops and maintains international standards in various fields of electrical and electronic engineering, computer science, and related disciplines.

"Lithium-ion" batteries refers to a battery where the negative electrode (anode) and positive electrode (cathode) materials serve as a host for the lithium ion (Li+). Lithium ions move from the anode to the cathode during discharge and are intercalated into (i.e., inserted into voids in the crystallographic structure of) the cathode. The ions reverse direction during charging. Since lithium ions are intercalated into host materials during charge or discharge, there is no free lithium metal within a lithium-ion cell and thus, even if a cell does ignite due to external flame impingement or an internal fault, metal fire suppression techniques are not appropriate for controlling the lithium-ion fire. Lithium ion is a generic term covering a number of different technologies, which can be broken down into the following three main groups that are currently commercially available:

1. Lithium metal oxide cathodes with a carbon anode [e.g., nickel cobalt aluminate (NCA) and nickel manganese cobaltate (NMC)]

2. Lithium phosphate cathode with a carbon anode [e.g., lithium iron phosphate (LFP)]

3. Lithium metal oxide cathode with a titanium oxide anode [e.g., lithium titanate (LTO)]

"National Fire Protection Association" (NFPA) is a nonprofit organization dedicated to eliminating death, injury, property, and economic loss due to fire, electrical, and related hazards. Established in 1896, the NFPA develops and publishes over 300 consensus codes and standards intended to minimize the risk and effects of fire by establishing criteria for building, processing, design, service, and installation in the United States and internationally. The NFPA's mission extends beyond code development; it also focuses on research, training, education, and advocacy to promote safety and preparedness.

"National Electric Code" (NEC), also known as NFPA 70, is a set of standards for the safe installation of electrical wiring and equipment in the United States. Its primary purpose is to ensure the safety of electrical installations by setting forth requirements to protect people and property from electrical hazards. The NEC covers the installation of electrical conductors, equipment, and raceways; signaling and communications conductors and equipment; and fiber optics. It is updated every three years to incorporate new technologies and improve safety measures.

“NFPA 855” the Standard for the Installation of Stationary Energy Storage Systems, provides comprehensive guidelines for the safe installation of stationary energy storage systems (ESS), including those using lithium batteries. These standards address various aspects of installation to mitigate fire and explosion risks associated with energy storage technologies. It covers topics such as system design, construction, operation, and maintenance to ensure safety and reliability.

“Sensitive Receptors” shall include locations with hospitals, schools, and day care centers, residential uses, and such other locations as the air district board or California Air Resources Board may determine pursuant to the California Health and Safety Code §42705.5(a)(5).

“Thermal Runaway” refers to an uncontrollable, self-sustaining exothermic chain reaction within a battery energy storage system, initiated by a failure mechanism (e.g., internal short circuit, overcharging, physical damage, or thermal exposure). This reaction results in a rapid increase in cell temperature, leading to the release of flammable electrolytes, generation of toxic gases (e.g., hydrogen fluoride, carbon monoxide), and potential cascading failures to adjacent cells. If unmitigated, thermal runaway may cause fire, explosion, or hazardous material release, posing risks to public safety, property, and the environment.

Tier 1 (Residential-Scale) battery energy storage systems have a maximum stored energy capacity less than or equal to 20 kWh and, if in a room or enclosed area, consist of only a single energy storage system technology. The aggregate rating of the ESS shall not exceed the following for each location listed:

1. 40 kWh within utility closets, basements, and storage or utility spaces.

2. 80 kWh in attached or detached garages and detached accessory structures.

3. 80 kWh where outdoor wall or ground mounted.

Tier 2 (Medium-Scale/Commercial) battery energy storage systems have an aggregate energy capacity greater than 40 kWh, up to 600 kWh.

Tier 3 (Industrial-Scale/Public Utility) battery energy storage systems have an aggregate energy capacity greater than 600 kWh, up to, but not exceeding, 200 mega-watt hours (MWh), or battery energy storage systems with more than one storage battery energy technology (e.g., Lithium-ion, Lead-acid, Flow batteries, Nickel-based, Sodium-ion, and Solid-state batteries) is provided in a room or enclosed area. A HMA as outlined in NFPA 855 shall be required for lithium-ion ESS that exceed 600 kWh (2,160 MJ) for outdoor ESS installations, ESS installations in open parking garages and on rooftops of buildings, and mobile ESS equipment.

“UL 9540” is a standard for ESS and equipment. It is designed to ensure the safety of these systems and covers their construction, performance, and testing requirements. UL 9540 certification is essential for verifying that energy storage systems, such as batteries and related equipment, meet rigorous safety standards to prevent hazards related to electrical, mechanical, and environmental conditions.

Section 14.09.271.030 Land Use and Siting Standards

A. Land Use. Table 14.09.271.A, Land Use Regulations – Energy Uses, establishes the land use regulations for specific energy uses. In cases where a specific land use or activity is not defined, the Director of Community Development shall assign the land use or activity to a classification that is substantially similar in character. Land uses not listed in the table and not substantially like the uses identified below are prohibited. Within the Northeast Growth Area, the supplemental regulations identified in Section 14.09.060.040 are applicable.

TABLE 14.09.271.A: LAND USE REGULATIONS – ENERGY USES

"P" = Permitted Use; "M" = Minor Use Permit required; "C" = Conditional Use Permit required; "–" = Use Not Allowed				
Land Use Classification	**PF**	**IP**	**BP**	**Additional Regulations**
Transportation, Communication, and Utility Uses				
Battery Energy Storage Systems	C	C	C	See Chapter 14.09.191
No Battery Energy Storage Systems are allowed within the Nut Tree Airport Compatibility Plan area.				

1. Unincorporated County. New BESS facilities proposed on unincorporated land located within Solano County that desire to annex into Vacaville city limits must be located within the city's Sphere of Influence and shall be required to amend the Vacaville General Plan and Zoning Map to ensure the subject site is designated and zoned consistently with this ordinance.

2. Tier 1 Battery Energy Storage Systems are allowed in all zoning districts, subject to the applicable requirements of the most current (or adopted per Title 24) editions of the NEC, NFPA 70, NFPA 855, and Title 24 of the California Code of Regulations, and all equipment shall be UL 9540 listed. Tier 1 systems, if installed outside a structure, shall meet all established setbacks for the zone they are within, and shall be protected by fencing and screened from view of any adjacent property and the public Right of Way.

3. Natural Disaster Zone Exclusion. A Battery Energy Storage System facility shall not be located on a parcel in the following areas that are subject to impacts from natural disasters:

a. BESS facilities are not permitted in High or Very High Fire Hazard Severity Zones as determined by Cal Fire within a State Responsibility Area or a Local Responsibility Area. Applicants must submit mapping of the proposed site demonstrating compliance with this section. If the maps listed are updated prior to permit issuance, the application must be amended to reflect most recent maps.

b. BESS facilities are not permitted within a FEMA designated floodplain unless the parcel or developed area where the BESS, including perimeter roads for emergency vehicles, is to be installed, is raised to at least two feet above the Base Flood Elevation (BFE) through engineered fill or equivalent flood protection measures. A Conditional Letter of Map Revision (CLOMR) shall be obtained from FEMA prior to site grading or fill, demonstrating that the project will not result in an increase in BFE or adverse floodplain impacts, demonstrating that the proposed project meets all applicable NFIP requirements.

c. Front-of-the-meter BESS modules will not be permitted indoors.

B. Development Standards.

1. Development Regulations. Table 14.09.271.B, Development Regulations – Energy Uses, establishes standards for new BESS facilities, which shall comply with these standards. In addition, Battery Energy Storage Systems shall comply with NFPA 855 requirements related to setbacks and buffers. In the event of a conflict between standards, the standard providing the greatest level of protection to City residents shall prevail, as determined by the Director of Community Development and Vacaville Fire Chief. An applicant may request a waiver of these requirements or submit an Alternate Means and Methods Request under California Title 24, under circumstances where an engineered solution may satisfy setback requirements outlined in NFPA 855. The Director of Community Development shall make the final determination on a requested waiver of development requirements.

TABLE 14.09.271.B: DEVELOPMENT REGULATIONS – ENERGY USES

Standard	PF	IP	BP	Additional Regulations
Setbacks (setbacks are measured from property line or back of sidewalk, whichever results in a greater setback)				
Minimum Front Setback & Corner Street Side (ft)				
Buildings/Batteries	100	100	100	
Guardhouses	75	75	75	
Perimeter Wall/Fence	50	50	50	
Minimum Interior Side (ft)				
Buildings/Batteries	50	50	50	
Perimeter Wall/Fence	30	30	30	
Minimum Rear Setback (ft)				
Buildings/Batteries	50	50	50	
Perimeter Wall/Fence	30	30	30	
Minimum Setback Adjoining Freeway (ft)	200	200	200	
Minimum Setback from Residentially Zoned Property and Parcels Developed with Sensitive Receptors (ft)	500	500	500	Setback also applies to properties in Solano County
Height Standards				
Maximum Building Height (ft)	20	20	20	Standard is applicable to structures used to enclose batteries.

2. Lighting Requirements. BESS facilities shall comply with the following City standards:

a. Interior and perimeter lighting shall be provided to ensure all areas are illuminated to an intensity between 1-to-3-foot candles. Interior lighting shall be dimmable to turn off when no motion is detected after 5 minutes.

b. Lighting poles or fixtures mounted to cabinets and perimeter walls/fences that are located on the interior of a BESS facility shall not exceed a height 20 feet above the ground. Lighting poles and fixtures located on the exterior of a BESS facility shall not exceed 8 feet, excluding street lighting located along the public right-of-way.

c. All lighting shall be directed downward and shall not shine across adjoining properties.

d. Other requirements specified in state statutes or code for electrical infrastructure that are appropriate to apply to BESS.

e. Access roads for emergency responders shall be illuminated as well as all emergency disconnects.

3. Security and Screening. BESS facilities shall comply with the following security and screening requirements:

a. The facility shall have a non-scalable and transparent perimeter fence of at least 10 feet in height. The perimeter fence shall have at minimum two entrance gates equipped with a rapid access system chosen in consultation with Vacaville Fire Department; and shall have the discretion to require more entrances. Fencing shall consist of tubular-steel, powder-coated black fence or equivalent. Click to Enter and Knox-Switches shall be required on all gates.

b. The facility shall be equipped with a security system to prevent break-ins including cameras and barbed wire that is visible from public roads. The cameras must be monitored 24 hours a day, 7 days a week, with any threats immediately reported to law enforcement.

c. The facility shall comply with NFPA 855 specifications related to barriers and buffering.

d. BESS modules shall not be visible from the public right of way and freeway.

e. Reflective Signage shall be located on BESS modules, perimeter fences and any other security barriers. Signage shall include an illuminated site map. Signage shall contain 24-hour emergency contact information, product description, site owner and hazard warnings. Signage or maps should identify isolation distances response personnel shall maintain from BESS during an emergency. Signage shall be provided for grid-interactive BESS operating in parallel with other power generating sources. Signage shall be provided indicating explosion hazard zones. Signage must be compliant with all NFPA 704 standards and must be reflective of local amendments by the City of Vacaville.

4. Noise Requirements. The average noise generated from BESS facilities, components, and associated ancillary equipment, measured at the nearest building, lot line that can be built upon, or public way, shall not exceed any noise limits established under Section 14.09.240.140, Noise.

5. Utility Lines and Electrical Circuitry. All on-site utility lines shall be placed underground to the extent feasible and as permitted by the serving utility, with the exception of the main service connection at the utility company right-of-way and any new interconnection equipment, including without limitation any poles, with new easements and right-of-way. In accordance with Chapter 14.12.050, Undergrounding of Utilities, a developer shall provide for the undergrounding of all existing and proposed utility distribution or transmission facilities, which include but are not limited to electric, natural gas, irrigation district canals, cable television, telephone and other communication facilities, within or abutting the subdivision or development.

6. Landscaping. No landscaping is required on the interior side of the screen walls, regardless of the percentage of open space landscaped. At minimum, the facility shall provide a 20-foot-wide fire access road around the perimeter of the site, which must be designed to support emergency services apparatus weighing 80,000 lbs. At the discretion of the Vacaville Fire Department, additional maintenance roads may be required. The first 30 feet of setback along a street frontage and freeway shall be landscaped and irrigated with a combination of dirt mounding a minimum of 3 feet tall.

7. Must provide a water supply that is approved by the Vacaville Fire Department.

8. Must have Click to Enter and Knox-Switches on all gates for emergency responders.

9. Tier 2 and 3 systems must be provided with fire extinguishing systems.

B. Battery Chemistry Technology

1. Best Available Technology. BESS facilities shall utilize commercially available battery technologies that minimize the risk of thermal runaway. Applicants are strongly encouraged to select technologies with no or low thermal runaway risk. All BESS applications must include third party written documentation evaluating whether the proposed battery technology poses a risk of thermal runaway.

a. If the proposed battery technology is determined by the City of Vacaville to present a thermal runaway risk, the applicant shall submit a comprehensive technology comparison analysis. This analysis must include, at a minimum: A techno-economic comparison of alternative battery technologies based on publicly available information; an assessment of hazardous chemicals involved in the event of thermal runaway, qualitative and quantitative risk analysis of thermal runaway; A thermal runaway plume modeling analysis; and any additional information deemed necessary by the Director of Community Development and/or the Fire Chief.

b. If the proposed battery technology is determined by the City of Vacaville to present no risk of thermal runaway, then the Applicant shall submit Third-party verification of system stability (e.g., material safety analysis, abusetolerance testing results) and basic chemical hazard documentation to demonstrate no risk of hazardous emissions or thermal runaway propagation.

2. Owner Responsibility for Thermal Runaway. BESS facility owners must reimburse the City of Vacaville and emergency response agencies, including fire agencies, for all costs associated with a thermal runaway event. This includes thermal runaway response costs, as tracked by the Vacaville Fire Department. In the event of thermal runaway, the BESS facility owner/operator shall provide three scopes of work for the hiring of a subject matter expert to conduct a root-cause analysis of the event, which shall be subject to review and authorization by the Vacaville Fire Department. The Vacaville Fire Department shall act as the lead coordinator is directing the preparation of the analysis, and all costs shall be funded by the BESS facility operator/owner.

The BESS facility owner must also reimburse costs of an assessment of damage to the environment, agriculture, residents, and businesses conducted by one or more third party consultants selected by the City of Vacaville and all testing, damages and remediation conducted by responsible entities that is required to return all sites in the path of the plume caused by thermal runaway to the previous condition after thermal runaway incident or other hazardous incident.

Section 14.09.271.040 Permitting and Environmental Compliance

A. Conditional Use Permits. All new applications for Tier 2 and Tier 3 Battery Energy Storage Systems shall require a Conditional Use Permit, which shall be processed in accordance with Chapter 14.09.300, Use Permits.

B. Development Agreement. All new applications for Tier 2 and Tier 3 Battery Energy Storage Systems shall require a Development Agreement in accordance with Division 14.17, Development Agreements, to strengthen the public planning process, encourage private participation in comprehensive planning by providing a greater degree of certainty in that process, to ensure that the community's safety is addressed, and to ensure that the public benefits provided by the development are appropriate.

C. Modifications. Applications for periodic augmentation to maintain the capacity of the Battery Energy Storage System or nominally increase the capacity of the system shall constitute a Modification. For applications to modify an approved use permit for a Battery Energy Storage System for which a land use or building permit has been approved (including after project completion), the Director of Community Development shall determine the level of permit modification that shall be required based on the criteria outlined under Section 14.09.030.110, Modifications to an Approved Project and/or Permit.

D. Environmental Compliance. An Applicant shall comply with, and receive the necessary permits for, relevant state and federal environmental and wildlife laws prior to commencing construction and operation of the Battery Energy Storage System.

Section 14.09.271.050 Application Submittal Procedures.

A. Preliminary Application Process.

1. Purpose. The purpose of the Preliminary Application is to allow the Planning Division to work with the applicant and coordinate an internal review of Battery Energy Storage Systems. This process is intended to provide feedback to the applicant early in the process by helping applicants understand the approval process, identifying potential issues to be addressed, and facilitating community outreach. The Preliminary Application is not intended to be a comprehensive review of the project, does not result in any approvals, and is not subject to appeal. The outcome of the Preliminary Application process is a comprehensive letter describing the approval process, summarizing major

planning concerns and issues noted during internal review and a fee estimate. The fee estimate for the project application may differ from the Pre-App estimate.

2. Applicability. A Preliminary Application for Tier 2 and Tier 3 Battery Energy Storage Systems shall be required to provide neighborhood notification and a minimum of one Planning Commission study session to discuss the proposed project and to document community concerns. The Director shall have discretion to require additional community meetings prior to the Planning Commission Study Session. The Director may require additional meetings if it is determined that additional meetings will be beneficial to the community. Preliminary Applications must include written confirmation demonstrating compliance with requirements outlined under NFPA 855.

3. Community Meeting Requirements. The applicant is responsible for arranging the community meeting venue and presenting the project to the community. Meetings shall occur at a publicly accessible venue within the City, preferably at the project site or within a one-mile radius of the site. At least 30 days before the meeting date, the Applicant shall notify the City of the desired meeting date and the City shall promptly determine whether it conflicts with any established City-sponsored meetings. Public notification shall be provided in accordance with Section 14.09.030.070, Public Notice. The Applicant shall be required to provide the following services for the Community Meeting:

a. Publish a website with project information and contact information.

b. Reception desk with sign-in sheets, flyers printed with contact information.

c. Staff to document questions from the community, prepare meeting minutes, and organize responses to the questions. The meeting shall be recorded and made available to the public.

d. Moderator with at least one representative knowledgeable about Battery Energy Storage Systems to facilitate the meeting, presentation, and questions.

e. Weeknight meetings shall occur between 6:00 p.m. and 9:00 p.m. and weekend meetings shall occur between 10:00 a.m. and 9:00 p.m.

4. Preliminary Application Letter and Formal Submittal. Within 30 days of outreach completion, the Planning Division will send to the Applicant a letter summarizing major project concerns, a description of the approval process, other issues noted during internal review, and a fee estimate. A formal project submittal will be accepted only after the Pre-Application letter has been issued. If a formal application is not submitted within one year, a new Pre-App will be required before project submittal.

B. Formal Application Process.

1. Application. Applications and fees for Battery Energy Storage Systems shall be submitted in accordance with the provisions set forth in Section 14.09.030.030, Application Forms and Fees. In addition, application shall include information demonstrating that requested entitlements conform to the required findings for approval.

2. Environmental Review. Applications for Battery Energy Storage Systems shall be evaluated in accordance with Division 14.03, Environmental Review, and the California Environmental Quality Act (CEQA). Applicants are responsible for funding the environmental analysis and corresponding technical studies necessary to disclose project-related impacts. Any unused fees will be reimbursed upon completion of the application process or withdrawal of a pending application.

3. Public Notice and Hearing. An application for a Battery Energy Storage System facility shall require noticed public hearings before the Planning Commission and City Council. Applications shall comply with the public notice and hearing requirements of Section 14.09.030.070, Public Notice.

4. Decision. The decision maker must make a determination that the application complies with the required findings under Chapter 14.09.300, Use Permits, and Chapter 14.09.290, Design Review, and any other entitlement findings that are required for the application. The decision maker shall deny an application for a Battery Energy Storage System facility if it is unable to make a determination that the project meets the required findings for approval.

5. Submittal Checklist.

a. A preliminary emergency response plan that includes site access, equipment locations and potential hazards for responders, nearby residents, and businesses, in addition to any other requirements. The emergency response plan may be revised after land use permits are approved, with written approval from the Vacaville Fire Department. A final emergency response plan, with written approval of Vacaville Fire Department, must be submitted prior to issuance of any building permits.

b. A report documenting coordination to-date with the Vacaville Fire Department and Solano County Office of Emergency Services in developing the required emergency response plan for the project site.

c. A plan for offering site-specific training to first responders including the Vacaville Fire Department and cooperating agencies that are likely to provide mutual aid during the initial response at project site. If the fire department determines that specialized training, PPE and/or equipment are required for response to potential incidents at this location, the cost of such will be provided by the developer.

d. A hazard mitigation analyses if required by NFPA 855.

e. A comprehensive technology comparison analysis.

f. A financial assurances plan, including liability insurance that includes coverage for thermal runaway events and other hazardous incidents, pollution and other environmental damages, decommissioning bonds, a battery cell manufacturer responsibility agreement, and an agreement indemnifying the City of Vacaville and all emergency response agencies in the event of an incident associated with the BESS facility that causes environmental damage or causes injury to persons or property. Insurance shall address all phases of construction, development, and operations.

i. As part of the financial assurances, the applicant shall acknowledge that relevant and responsible agencies having jurisdiction over the site will oversee and coordinate subject matter experts to conduct a root cause analysis related to any hazardous incident, with all costs borne by the BESS facility owner.

ii. As an additional aspect of the financial assurances, the applicant shall acknowledge the responsibility and agreement to reimburse all damaged parties for an assessment of damage to the environment, agriculture, residents, and businesses conducted by one or more third-party consultants selected by the City of Vacaville and all testing, damages, and remediation conducted by responsible entities that is required to return all sites in the path of any plume caused by thermal runaway or otherwise subject to a hazardous incident to the previous site conditions.

g. A description of cybersecurity risks and mitigation measures associated with BESS modules, the Battery Management System, and active and passive fire and explosion detection systems.

h. Submitted plans and documents must be under the signature and seal of a CA Licensed design professional.

i. HMA, Fire Risk Analysis, fire suppression systems and deflagration protection analysis submittals shall be from a CA Licensed Fire Protection Engineer approved by the Vacaville Fire Department per California Fire Code (CFC) Section [A]104.7.2 as it may be amended. Submittals shall include signature and seal.

j. Fire protection system submittals such as fire suppression, pre-engineered systems, and water supply shall be provided by a licensed fire protection engineer or other approved licensed professionals as required by the CFC.

k. Fire alarm systems, fire detection, and gas detection shall include a C-10 - Electrical Contractor of record.

l. Final approval of any BESS or safety related equipment that has routine maintenance requirements according to the code or manufacturer's instructions will not receive approval until a maintenance plan has been submitted to the Vacaville Fire Department. Maintenance must comply with all NFPA Standards, title 24 and manufacturer's instructions

m. Once an application is accepted for review, any updated submittals during the period of review, installation and final inspections must either be signed and sealed by the design professional of record, or a cover letter signed and sealed by the design professional of record shall accompany the submittal, attesting that the updated information conforms to the overall design and code requirements.

n. Applicant must provide funding to the air quality district with jurisdiction over the project site to establish 10 or more permanent air monitors, at distances and elevations determined by the air quality district with jurisdiction over the project site to detect harmful constituents, hazardous to human life or wildlife, emitted as a result of thermal runaway as determined by the air quality district with jurisdiction over the project site. The number of sensors deployed will be determined by the air quality district with jurisdiction over the project site. If a thermal runaway incident occurs or air monitors detect hazardous constituents, the monitoring system and BESS operators shall notify Vacaville Police and Fire Dispatch. After an incident, related to BESS thermal runaway or otherwise, City staff will have access to the raw, unfiltered data from the air monitors.

o. BESS operator will submit a comprehensive annual report to the City of Vacaville staff as designated by the City consisting of but not limited to; the number of threats made to the site, the number of trips of the site security system, the number of hazardous incidents at the site, the number of fire and law responses to the site, soil testing on-site and the surrounding properties for hazardous chemicals existing in the battery system, air monitor results. This list can be supplemented and modified by City staff at any time.

p. The Applicant shall prepare and submit a Phase II Environmental Analysis that includes soil testing to provide the baseline condition of the site, which shall provide a benchmark reading for future measurements of potential contamination resulting from a thermal runaway event.

6. Technical Studies.

a. All technical studies, Hazard Mitigation Analysis and planning documents required by SB 38, NFPA 855 and the City of Vacaville must include both a probable scenario of limited thermal runaway and possible scenarios of simultaneous thermal runaway in all site modules at once, and shall address hazards as outlined in the "Emergency Response Plan Guidance" to the site and mitigation measures deployed.

b. Applicants must submit technical studies prepared by a third-party fire protection engineer selected by the City detailing the proposed fire safety features of the design, operation, and use of the BESS. Changes in installation configuration from the initial UL 9540A cell, module, and unit level test and the separate large scale fire testing, including internal architecture of modules and units will not be accepted unless it is demonstrated that the configuration provides equivalent results, subject to review and approval by the Vacaville Fire Department and Building Division. Fire safety features must include mechanisms for maintaining the temperature and humidity ratings of the listing.

c. Technical studies prepared by a third-party fire protection engineer, which the City has the discretion to select, must account for setback requirements and best practices from residential buildings and sensitive receptors. Technical study must include estimated impacts to property values and insurability of properties potentially impacted by a plume caused by thermal runaway.

d. Technical studies prepared by third party subject matter experts, which the City has the discretion to select, must include plume modeling and toxic gas dispersion analysis, specifically addressing impacts on missions and flight paths of Travis Air Force Base and Nut Tree Airport and freeways.

e. Technical studies prepared by third party subject matter experts selected by the City analyzing the chemical composition of BESS fire emissions and associated human, wildlife and environmental hazards, specifically at which distances emission impacts will be hazardous.

f. Technical studies prepared must analyze runoff of water and fire suppression liquid associated impacts to groundwater, wildlife, waterways, and the environment. If determined to be required by City staff, site plans must include a system for capturing runoff water, whose size requirements will be determined based on technical studies in consultation with the City of Vacaville, for water or fire suppressant liquid that may be used by first responders during thermal runaway incidents, and a geo-lined impermeable layer under all BESS modules. The retention basin must be emptied the same day if filled by rain or flood water, in accordance with applicable state laws. If thermal runaway occurs, five samples of fire suppressant liquid or water utilized must be taken by the third party subject matter expert selected by the City and mitigation measures will be taken to reduce the adverse impact by third party subject matter experts selected by the City, with the costs being paid for by the site owner. Applications shall include samples of the existing groundwater subbasin that would be affected by the BESS facilities to determine current levels of concentration.

g. BESS facilities must have active and passive fire and explosion detection systems in place, including gas detectors that meet UL 9540A, NFPA 72, and NFPA 69 standards. These systems must be able to detect explosive gases, trigger alarms, and initiate ventilation systems to mitigate risks from thermal runaway.

h. Battery Management System (BMS) must be approved and meet manufacturer's specifications. The BMS must transmit signals to an approved location, as reviewed and approved by the Vacaville Fire Department, if hazardous conditions are detected, and such signals must be monitored twenty-four hours a day seven days a week. BMS documentation must identify security risks and potential threats, along with the mitigation measures implemented to reduce each identified risk. A combustible gas concentration reduction system compliant with NFPA 855, NFPA 69, UL 9540, and CFC that has undergone UL 9540A testing will have the ability to be automatically activated.

Section 14.09.271.060 Required Findings of Economic Benefit; Public Benefit Agreement; Exempt Projects.

A. Consistent with Public Resources Code section 25545.9, and in addition to all other findings and determinations necessary for the grant of a conditional use permit, no conditional use permit for an Tier 2 or Tier 3 Battery Energy Storage System shall be granted unless the City finds that the construction and operation of the facility will have an overall net positive economic benefit to the City. For purposes of this sub-section, economic benefits may include, but are not limited to, any of the following:

1. Employment growth.

2. Housing development.

3. Infrastructure and environmental improvements.

4. Assistance to public schools and education.

5. Assistance to public safety agencies and departments.

6. Property taxes and sales and use tax revenues.

7. Contributions to City initiatives or projects that benefit the community.

B. Consistent with Public Resources Code Section 24454.10, no Conditional Use Permit for a Tier 2 or Tier 3 Battery Energy Storage System shall be granted unless the City has entered into a legally binding and enforceable agreement with, or that benefits, the City, where there is mutual benefit to the parties to the agreement. The topics and specific terms of the community benefits agreements may vary and may include funding for or providing specific community improvements or amenities such as public safety training facilities for emergency responders, park and playground equipment, urban greening, enhanced safety crossings, and paving roads and bike paths.

C. The City of Vacaville finds and declares that, where an Tier 2 or Tier 3 Battery Energy Storage System is issued a certificate pursuant to Chapter 6.2 (commencing with Section 25545) of Division 15 of the Public Resources Code, and where such certificate is in lieu of a conditional use permit or other permit, certificate, or document required by the City, a community benefit agreement in the form described in subdivision (2), above, shall satisfy the obligations on Public Resources Code section 24454.10.

D. Training, Emergency Response, and Monitoring Agreement shall be required for BESS facility operators of Tier 2 and Tier 3 facilities. Agreements shall outline the funding mechanism and procedure for obtaining equipment and providing training to emergency responders, which shall include the following:

1. Annual training with updates on BESS best practices paid for by the company and provided to the Vacaville Fire Department and cooperating agencies that are likely to provide mutual aid during the initial response, Vacaville Police Department, Utilities, and Public Works. If the best practice include new equipment or PPE this must be paid for by the company.

2. Initial training on all systems regarding their BESS for all County Haz Mat personnel throughout the county and other Fire Departments in neighboring agencies that collaborate through mutual aid agreements (e.g., Dixon Fire Department and Fairfield Fire Department).

3. Air Monitoring systems provided by and maintained by the owner of the company with remote monitoring systems accessible by the Vacaville Fire Department and Solano County Haz Mat team.

4. Gas monitors provided by and maintained by the owner of company including cost of training, maintenance and calibration.

5. Reimbursement agreements to ensure all costs associated with mitigation of events at their facility are paid by owners/operators of the BESS facility.

Section 14.09.271.070 Commissioning, Safety Standards and Certifications

A. Commissioning Plan. Prior to issuance of Building and Fire Permits for a BESS facility, Applicants shall submit a commissioning plan consistent with NFPA 855 that contains:

1. A electrical diagram detailing the Battery Energy Storage System layout, associated components, and electrical interconnection methods, with all NEC compliant disconnects and over current devices.

2. A preliminary equipment specification sheet that documents the proposed Battery Energy Storage System components (including all associated cutsheets), inverters and associated electrical equipment that are to be installed. A final equipment specification sheet shall be submitted prior to the issuance of the building permit.

3. Name, address, and contact information of proposed or potential system installer and the owner and/or operator of the battery energy storage system. Such information regarding the final system installer shall be submitted prior to the issuance of a Building Permit. The installer must have a business license with the City of Vacaville.

4. A commissioning plan, commissioning test and report meeting the requirements of NFPA 855 Sections 6.1.3, 6.1.4 6.1.5 shall be submitted prior to final inspection.

5. If plans include connection to the City of Vacaville wastewater collection system, an Industrial User Permit application must be submitted to the Utilities Department.

B. Safety Requirements. Battery Energy Storage Systems shall comply with the latest published version that is approved to be used by the CFC Chapter 80 and NFPA 855, Standard for Installation of Stationary Energy Storage Systems, at the date of the submission of the application. Prior to issuance of Building and Fire Permits, Applicants are required to:

1. Submit an emergency response plan as an appendix to the project application.

2. Submit a plan as an appendix to the project application for offering site-specific training to the Vacaville Fire Department and cooperating agencies that are likely to provide mutual aid during the initial response at the project site.

3. Conduct hazard mitigation analyses if specified by NFPA 855.

4. Equipment Certification. All batteries integrated within the battery energy storage system shall be listed under UL 1973. The battery energy storage system shall be listed in accordance with UL 9540, either from the manufacturer or by field evaluation.

5.Submit an ongoing weed abatement plan for review and approval by the Vacaville Fire Department.

C. Decommissioning

1. Decommissioning Plan. Prior to issuance of any permits related to decommissioning activities, the Applicant shall submit a Decommissioning Plan that complies with the following requirements, and is consistent with NFPA 855 and agreements reached between the Applicant and other landowners of participating properties, and that ensures the return of all participating properties to a useful condition, including removal of above-surface facilities and infrastructure that have no ongoing purpose. The decommissioning plan shall include, but is not limited to:

a. An overview of the decommissioning process developed specifically for the BESS that is to be decommissioned.

b. Roles and responsibilities for all those involved in the decommissioning of the BESS.

c. A detailed description of each activity to be conducted during the decommissioning process and who will perform that activity and at what point in time.

d. Procedures to be used in documenting the BESS and all associated operational controls and safety systems that have been decommissioned.

e. Guidelines and format for a decommissioning checklist and relevant operational testing forms and necessary decommissioning logs and progress reports.

f. A description of how any changes to the surrounding areas and other systems adjacent to the ESS facility, including, but not limited to, structural elements, building openings, means of egress, and required fire detection and suppression systems, will be protected during decommissioning and confirmed as being acceptable after the system is removed.

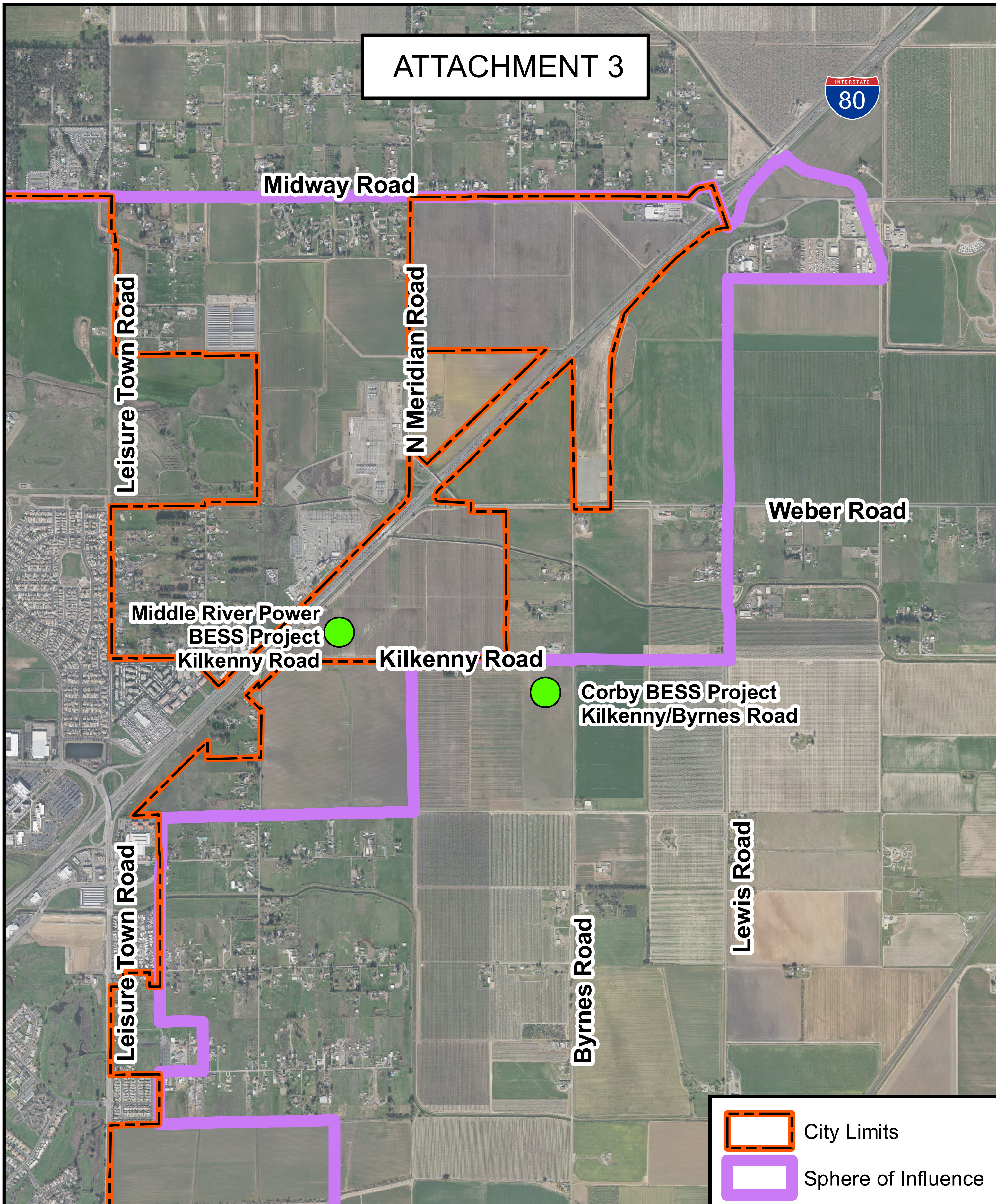
g. Estimated costs associated with decommissioning.

h. Evidence of insurance for bankruptcy in the form of a bridge policy. This includes financial assurance in the form of a bond, a parent company guarantee, or an irrevocable letter of credit, but excluding cash, to be determined by applicant. The amount of the financial assurance shall not be less than the estimated cost of decommissioning the energy facility, after deducting salvage or recycling value, as calculated by a third party with expertise in decommissioning, hired by the applicant. The entire financial assurance must be posted by the start of full commercial operation of the BESS facility.

i. Battery disposal plan and acknowledgment of the facility owner’s responsibility to recover and recycle battery cells at an authorized recycling facility upon decommissioning.

E. Ownership Changes. If the owner of the Battery Energy Storage Systems facility changes or the owner of the property changes, the project approvals shall remain in effect, provided that the successor owner or operator assumes in writing all the obligations of the project, site plan approval, and Decommissioning Plan. A new owner or operator of the facility shall notify the Community Development Department of such change in ownership or operator within 30 days of the ownership change. A new owner or operator must provide such notification to the Community Development Department in writing. The project and all approvals for the facilities would be void if a new owner or operator fails to provide written notification to the Community Development Department in the required timeframe. Reinstatement of a voided project or approvals will be subject to the same review and approval processes for new applications under this chapter.

ATTACHMENT 3



CITY OF VACAVILLE
COMMUNITY DEVELOPMENT
DEPARTMENT

CALIFORNIA ENERGY COMMISSION APPLICATIONS
BATTERY ENERGY STORAGE SYSTEMS

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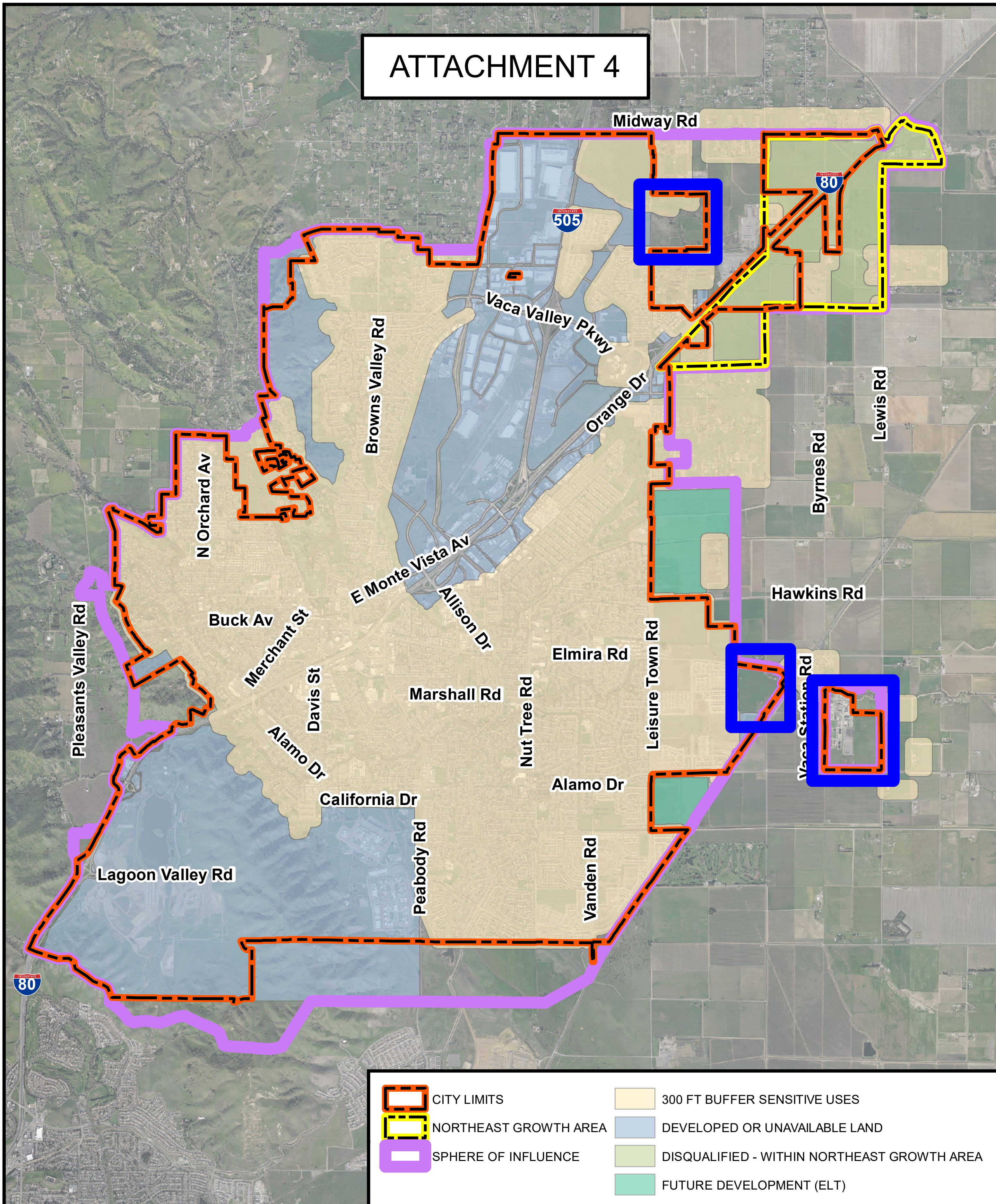

CITY OF VACAVILLE
COMMUNITY DEVELOPMENT
DEPARTMENT

NORTH

SUITABILITY ANALYSIS

BATTERY ENERGY STORAGE SYSTEMS

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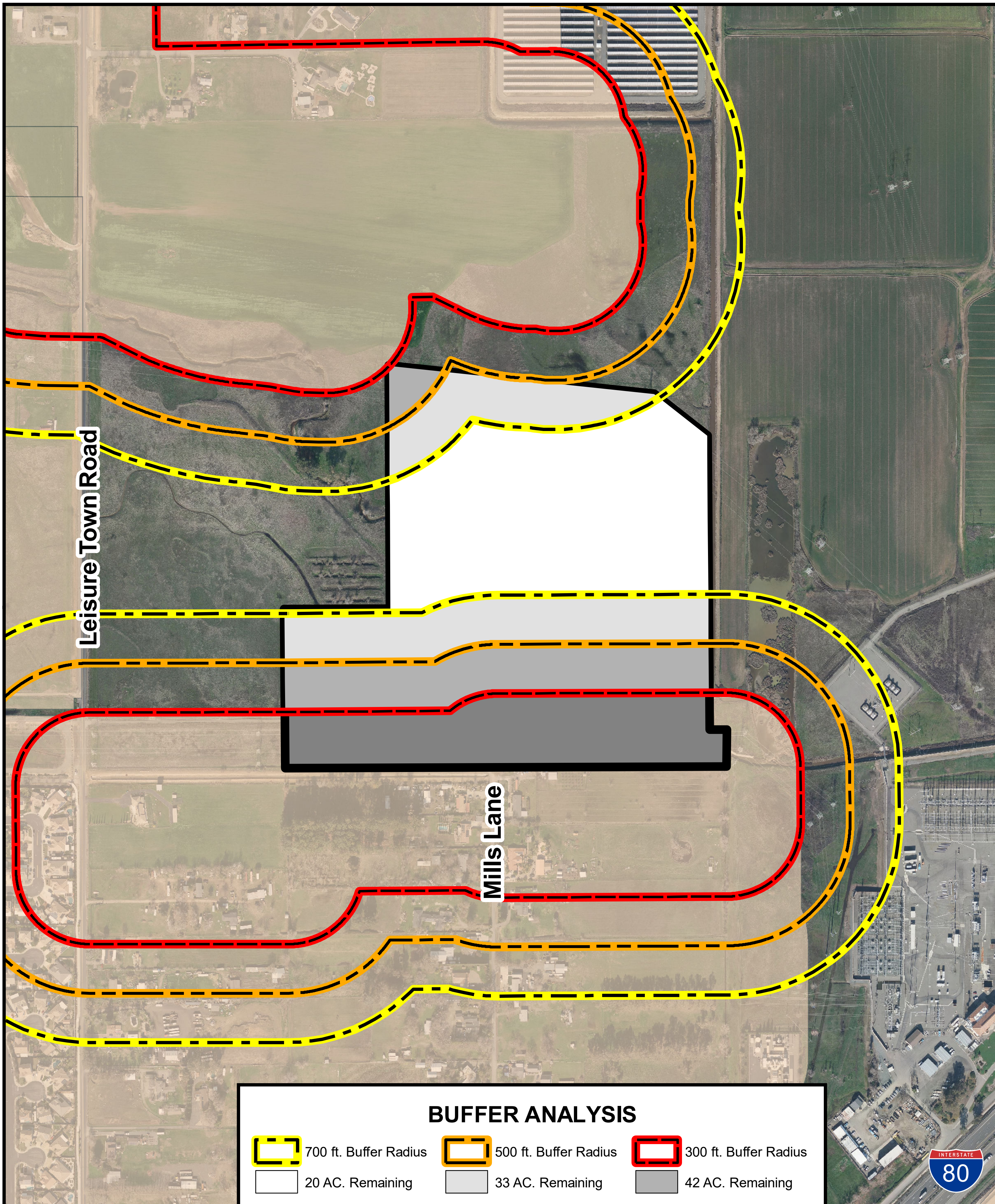
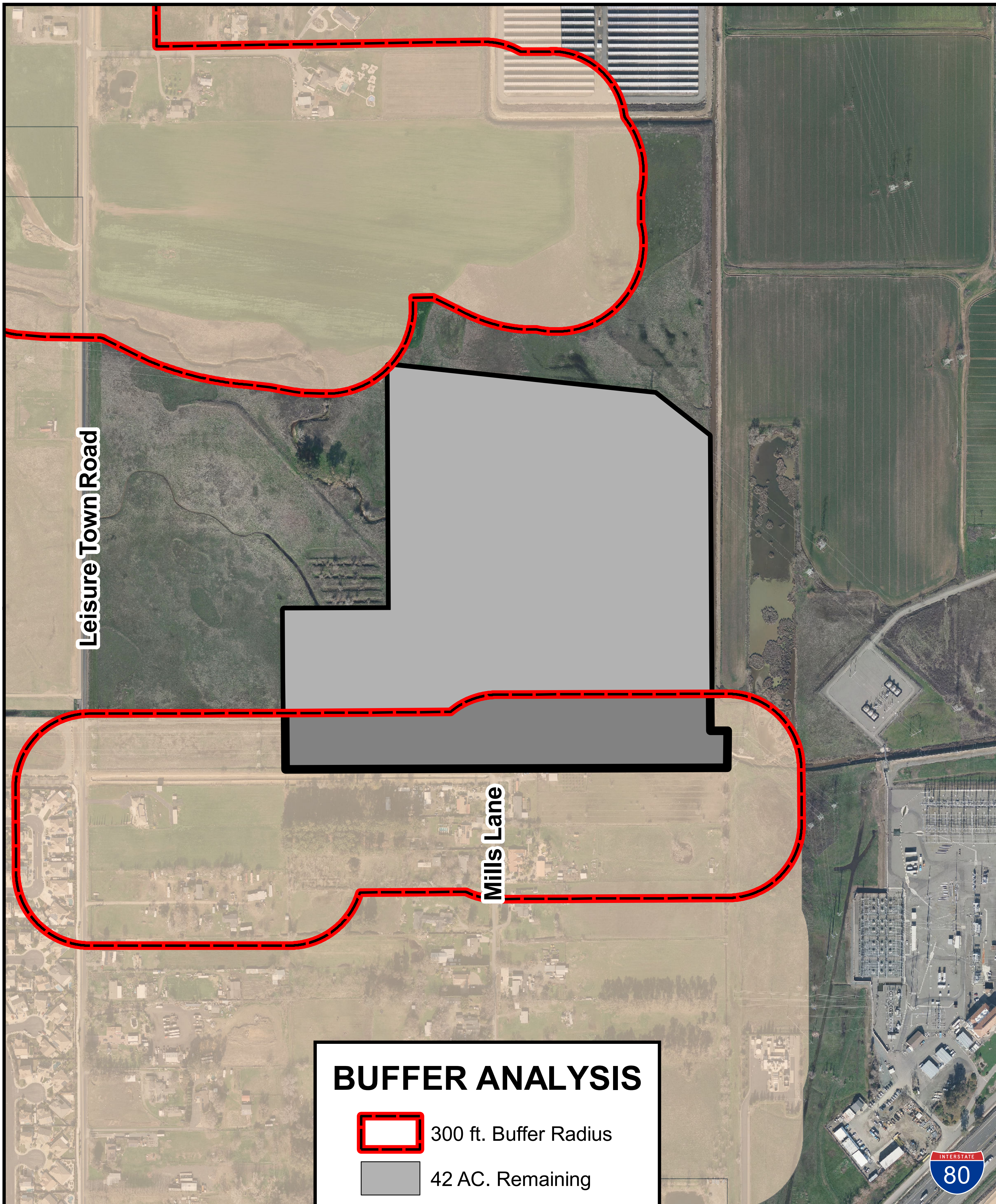


CITY OF VACAVILLE
COMMUNITY DEVELOPMENT DEPARTMENT

NORTH

REVISED SUITABILITY ANALYSIS

BATTERY ENERGY STORAGE SYSTEMS



CITY OF VACAVILLE
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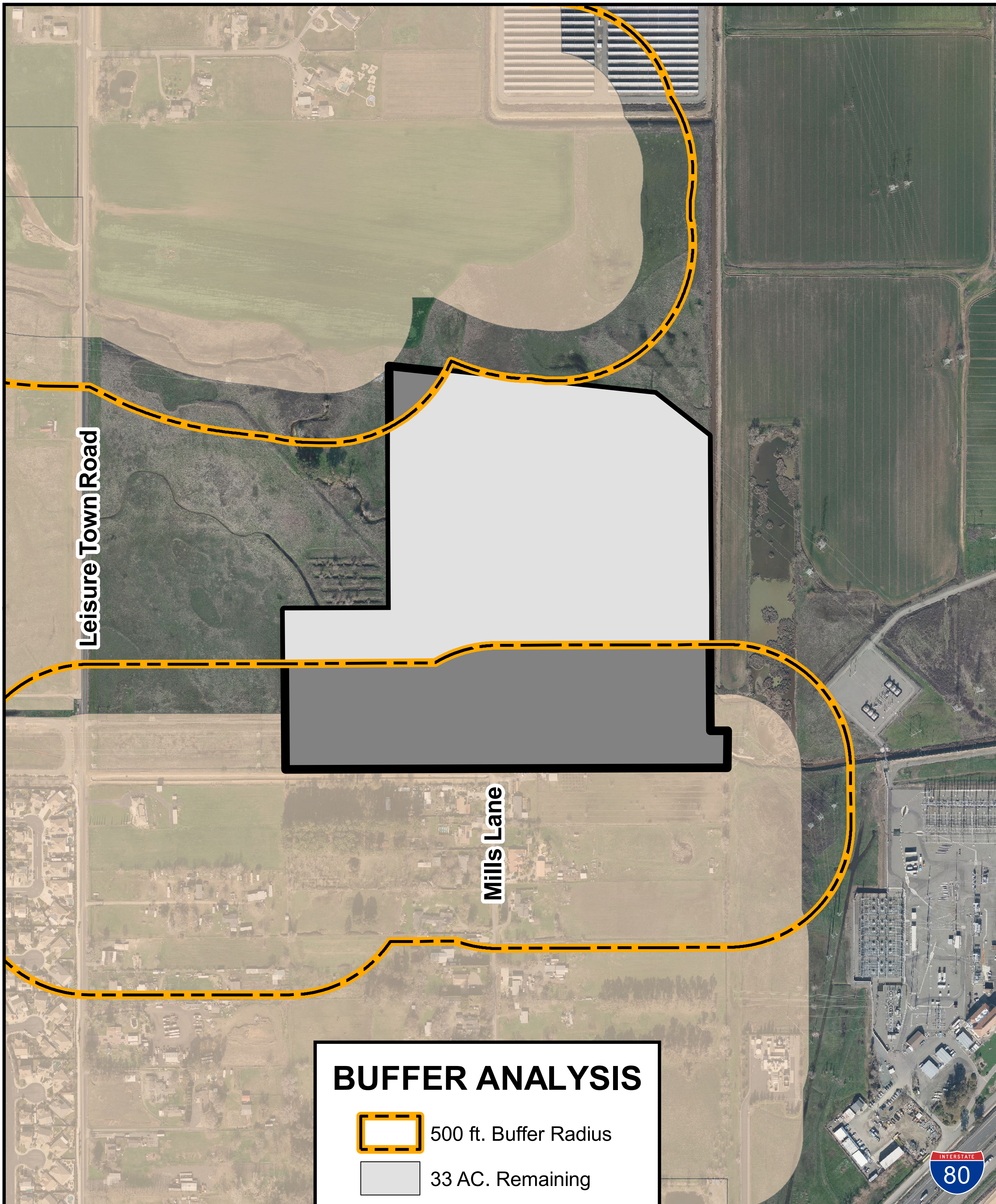
REVISED SUITABILITY ANALYSIS

BATTERY ENERGY STORAGE SYSTEMS



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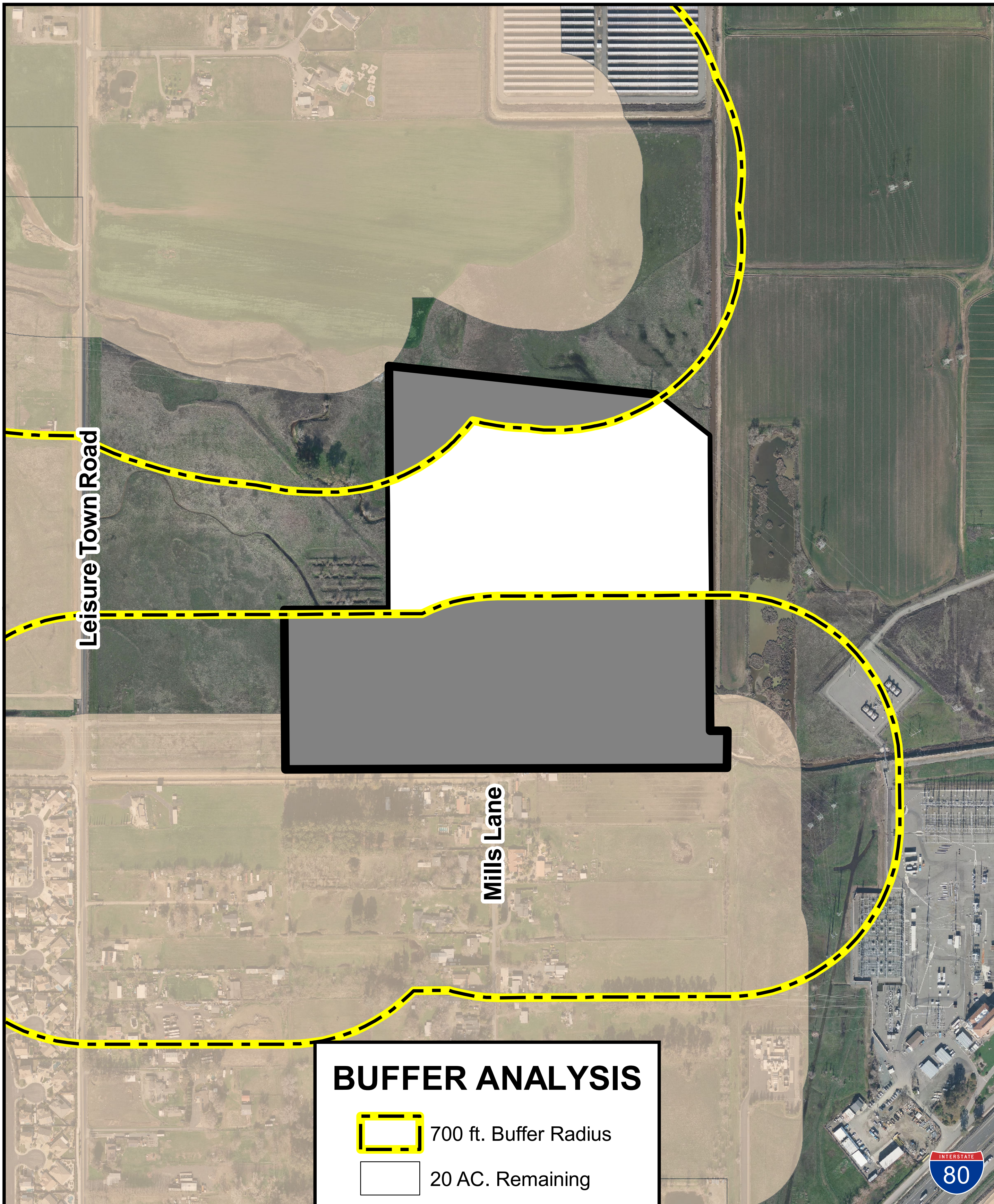
BATTERY ENERGY STORAGE SYSTEMS



CITY OF VACAVILLE
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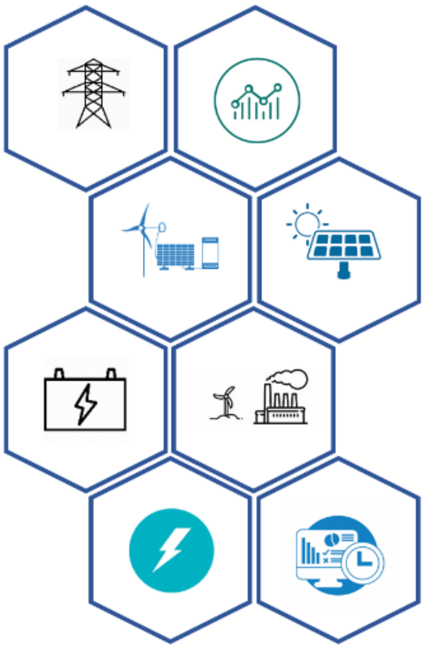
REVISED SUITABILITY ANALYSIS

BATTERY ENERGY STORAGE SYSTEMS

ATTACHMENT 6

Digital Energy Solutions
Power Transmission & Distribution



BESS Technology Assessment for the City of Vacaville

Client: City of Vacaville

Document number: LTDES-PSI- COV-BFR-00

Rev number: R00

Executive Summary

Utility-scale Battery Energy Storage Systems (BESS) have become a critical part of modern grid planning. As utilities, municipalities, and developers navigate through BESS technology options, understanding is key to choosing the right technology:

- Chemistry
- Safety
- System lifecycle
- Commercial and regulatory readiness

This report touches on various BESS technologies but emphasizes two commercially relevant technologies for large-scale deployment:

- Lithium-Ion Batteries (LIB), mainly Lithium Iron Phosphate (LFP) batteries
- Flow Batteries, mainly Vanadium Redox Flow Batteries (VRFB) as an emerging complementary long-duration solution

This document offers a technical overview of BESS, focusing on commercially relevant technologies, safety features, and operational considerations for utility-scale deployment. Its goal is to support the City of Vacaville in making informed decisions on safe, cost-effective, and scalable BESS installations.

Technology Comparison and Safety Insights

LFP batteries are currently the most commercially mature and widely deployed BESS technology in California, offering a strong balance of cost, energy density[1], and safety. LFP's non-oxygen-releasing phosphate provides significantly higher thermal stability compared to other lithium-ion types (e.g., NMC- Lithium nickel manganese cobalt, NCA- Lithium Nickel Cobalt Aluminum Oxide, reducing the risk of thermal runaway and simplifying fire protection design.

VRFB is an emerging non-flammable, water-based chemistry alternative that eliminates thermal fire risks and provides long-duration discharge capability (8–12 hours or more). However, they introduce chemical containment, ventilation, and maintenance complexity, along with a larger land footprint (low energy density) [56] and a lack of mature regulatory and safety standards compared to Li-ion.

Comparative analysis confirms that, while flow batteries have higher manufacturing environmental impacts, they offer higher recyclability (95–97%), longer life cycles (20 plus years), and enhanced fire safety than LFP. LFP systems remain the most practical and field-proven [57] choice for utility- and industrial-scale sites today, with flow batteries as an emerging complementary technology, better suited for future long-duration, utility-scale projects.

[1] *Energy density* (expressed formally as *Wh/kg* and *Wh/L*) refers to how much energy a storage technology can hold relative to the physical space it occupies. In practical utility-scale BESS development, this translates to the acreage and enclosure volume required to achieve a *target MWh capacity*. Higher energy density means fewer containers and less land per MWh to deploy a battery (LFP trait); lower energy density means larger layouts, more civil work, and higher costs (VRFB trait).

Category	Lithium-Ion (LFP)	Flow Batteries (VRFB)
Typical Use Case	Dominant in California grid BESS; preferred for fast response, smaller footprint, and lower cost.	Increasingly used for long-duration energy storage, often in pilot or industrial projects (see Section 3.10); larger footprint requirement.
Core Chemistry	Energy stored in solid electrodes; high energy density.	Energy is stored in liquid electrolytes circulating between tanks; low energy density.
Primary Safety Risk	Thermal Risk: a self-heating chain reaction that can cause fires if not mitigated.	Chemical risk: acid leaks, gas evolution, and potentially toxic off-gases under stress.
Thermal Risk	Possible cell-to-cell propagation; mitigated in LFP by stable phosphate chemistry (non-oxygen releasing). EPRI fire study notes that LFP incidents emit less heat and fewer toxic gases than NMC or NCA systems.	Non-flammable aqueous electrolytes make sustained combustion unlikely. However, polymer and gasket materials can still burn, releasing HF, SO_2, or NO_x gases under high heat.
Chemical and Leakage Risks	LIB vents gases: CO, H_2, and organic solvent vapors during failure; modern gas detection and BMS systems (NFPA 855) reduce this risk.	VRFB and ZnBr can evolve H_2 or Br_2 during imbalance or overcharge; they require ventilation, gas sensors, and pH monitoring.
Water and Fire Suppression	Standard water deluge systems are sufficient for LFP modules, with minimal environmental impact.	Water is used primarily for cooling and containment, rather than suppression; secondary containment and corrosion-resistant design are required due to the presence of acidic liquids.
Environmental Hazard During Fire	Byproduct from LIB fires can contain metals (Ni, Co, Mn), but they are treatable and can be managed. An EPRI report found no long-term soil contamination from past incidents.	Acidic electrolyte spills may require neutralization (lime or soda ash). Bromine or chlorine gases can pose local inhalation hazards if ventilation fails.

Category	Lithium-Ion (LFP)	Flow Batteries (VRFB)
Lifecycle and Recycling	3,000 to 6,000 cycles. Established recycling infrastructure for LFP, copper, and aluminum recovery.	10,000 to 20,000 cycles. 95–97% electrolyte recyclability, since vanadium does not degrade.
Regulatory Standards	Fully codified under NFPA 855, UL 9540/9540A, and the California Energy Commission BESS fire code. There is widespread AHJ familiarity.	Still maturing, as there is no unified NFPA equivalent. More operational data will be gathered as more flow batteries are deployed in the field.
Community Implication	Proven, commercially mature, compact, and safe when designed to LFP standards with proper BMS, ventilation, and setbacks.	Safer in terms of thermal risk, but introduces corrosive liquids and maintenance complexity. It is also unsuitable for dense community sites due to the large footprint requirement. Lack of mature safety standards introduces uncertainty.

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Abbreviations and Acronyms

The following is the list of abbreviations and acronyms used in this report:

Abbreviation/Acronym	Description
AC	Alternating Current
AHJ	Authority Having Jurisdiction
APN	Assessor's Parcel Number
BESS	Battery Energy Storage System
BMS	Battery Management System
CAISO	California Independent System Operator
COD	Commercial Operation Date
DER	Distributed Energy Resource
DERMS	Distributed Energy Resource Management System
DC	Direct Current
DPR	Detailed Project Report
EMS	Energy Management System
EPC	Engineering, Procurement, and Construction
ESS	Energy Storage System
EV	Electric Vehicle
GHI	Global Horizontal Irradiance
GIS	Geographic Information System
IFC	International Fire Code
IBC	International Building Code
kV	Kilovolt
kW	Kilowatt
kWh	Kilowatt-hour
LIB	Lithium-Ion Battery
LSFT	Large-Scale Fire Testing
LFP	Lithium Iron Phosphate
Li-Ion	Lithium-Ion
MWh	Megawatt-hour
MW	Megawatt

Abbreviation/Acronym	Description
NaS	Sodium-Sulphur
NiCd	Nickel-Cadmium
NMC	Lithium Nickel Manganese Cobalt Oxide
NRTL	Nationally Recognized Testing Laboratory
PCS	Power Conversion System
PG&E	Pacific Gas and Electric
PNG	Piped Natural Gas
POI	Point of Interconnection
PPA	Power Purchase Agreement
PV	Photovoltaic
UL	Underwriters Laboratories
UPS	Uninterruptible Power Supply
W/m^2	Watts per square meter
VRFB	Vanadium Redox Flow Batteries

1 Introduction

1.1 Purpose of the Report

This report provides a focused evaluation of Battery Energy Storage System (BESS) technologies in support of the City of Vacaville's current policy deliberations around the ongoing moratorium on utility-scale BESS development.

While the report introduces a broad set of energy storage chemistries, it focuses on technologies that are technically and commercially viable for utility-scale deployment. Among these, two stand out as leading candidates based on safety, performance, and regulatory alignment:

- Lithium-Ion Batteries (LIB), particularly the Lithium Iron Phosphate (LFP) subtype
- Flow Batteries, specifically Vanadium Redox Flow Batteries (VRFB) as an emerging complementary long-duration solution

These technologies are evaluated based on their operational characteristics, safety risks (e.g., thermal runaway and flammability), discharge duration, lifecycle performance, and overall commercial readiness.

This report is intended as a technical and policy resource for city staff, officials, and community stakeholders involved in BESS-related decision-making. It aims to support the City's efforts to:

- Compare and shortlist BESS technologies that meet the scale, safety, and reliability standards required for long-duration storage and grid support
- Guide ordinance development and permitting frameworks as the City considers how to refine or lift the BESS moratorium
- Clarify tradeoffs between leading BESS technologies, especially in terms of fire risk, siting constraints, and long-term cost-effectiveness

Included in the report are:

- Summary tables of safety profiles (See Table 4), scale suitability, and duration capabilities for commercially relevant utility-scale BESS chemistries
- A comparative narrative between LFP and VRFB technologies
- Best practices and regulatory precedents from other jurisdictions with active utility-scale BESS development

By combining local regulatory context with technical evidence, this report provides a clear foundation for informed policymaking around energy storage siting and safety in the City of Vacaville.

1.2 Organization of the Report

This report is structured to move from context and definitions to technical evaluation and implementation guidance:

1. **Executive Summary**: High-level findings and key takeaways.
2. **BESS Configurations and Applications**: How BESS works with other DER technologies, including PV, hybrid PV+BESS, and natural gas systems.
3. **BESS Technology Assessment**: Types of BESS technologies, selection factors, safety considerations, and national safety standards.
4. **Comparison of Battery technology**: Comparative analysis of leading battery chemistries like the Flow battery and the Lithium-ion battery.
5. **BESS Best Practices and Implementation Guidelines**: Safety, permitting, and operational guidelines for deployment.
6. **Case Studies**: Real-world examples relevant to the context.
7. **Conclusion and Recommendations**: Summary of findings and proposed next steps.

This document is designed so that readers can first understand why BESS matters to Vacaville, then explore the technical and regulatory details that will inform ordinance development and project planning.

2 BESS Configurations and Applications

2.1 How BESS Enhances Solar and Wind for Reliable Power

BESS plays a pivotal role in renewable-centric DER systems, enabling solar-plus-storage and wind-plus-storage projects to deliver consistent, reliable power, even when the sun isn't shining or the wind isn't blowing.

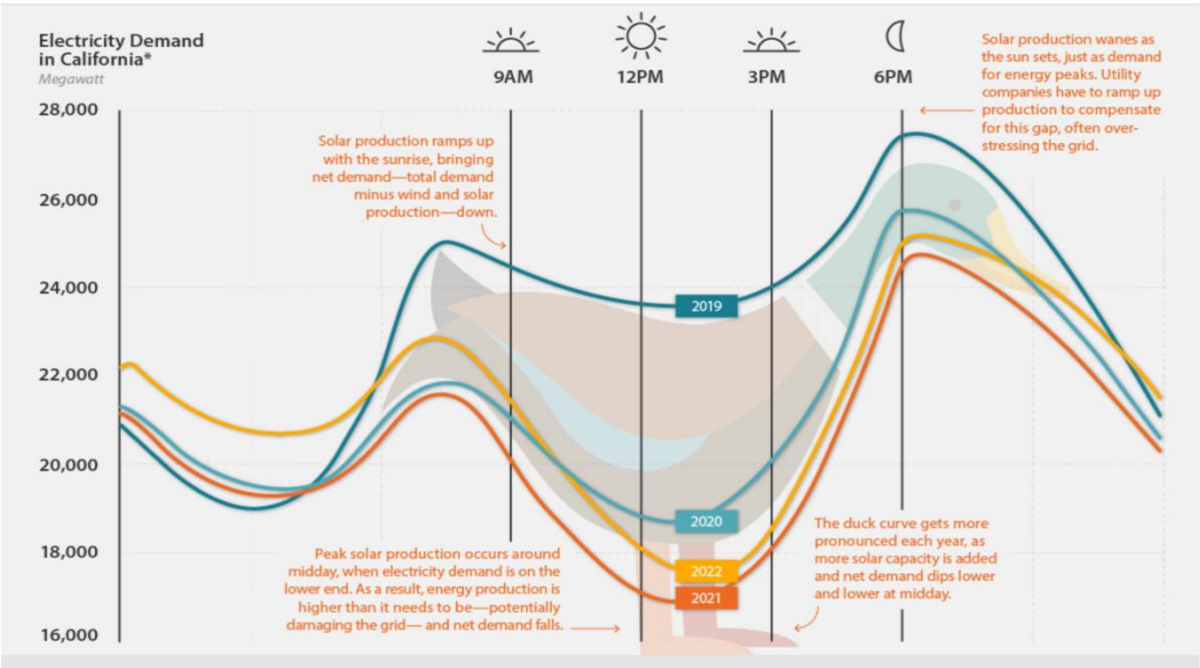

Figure 1 Duck Curve Illustrating Challenges Faced by High Solar Grids

Figure 1 illustrates "Duck Curve," which depicts the challenges faced by high-solar grids. Solar energy floods the grid with power at midday, driving net demand down (9 AM to 2 PM). Then demand spikes suddenly as the sun sets (3 PM to 6 PM), forcing other power plants (mostly natural gas) to ramp up quickly.

As solar- and wind-heavy DERs rapidly expand across the U.S., green energy consumers, policymakers, and utilities are becoming more aware of the challenges posed by the variability of renewable energy sources such as solar power. In energy systems rich in solar energy production, such as California, system operators face issues associated with too much PV in the system. One well-known example is called the "duck curve". Having a BESS directly addresses this reliability challenge by storing excess clean energy and discharging it when generation decreases.

It's important to emphasize that BESS does *not* generate power. Instead, it stores excess clean energy when renewable sources, such as solar, are producing abundantly. The BESS then releases this stored energy when generation is low, helping to smooth out variability, regulating the frequency, and ensuring the reliability of the DER system.

From a utility and more technical perspective, Battery storage is a technology that enables power system operators and utilities to store energy for later use. BESS is an electrochemical device that charges (or collects energy) from the grid or a power plant/DER and then discharges that energy later to provide electricity or other grid services when needed. Several battery chemistries are available or under investigation for grid-scale applications, including lithium-ion, lead-acid, redox flow, and molten salt [10].

2.2 What is "Hybrid" BESS

A "Hybrid" Solar + BESS system combines renewable solar generation with advanced energy storage technologies to provide a reliable, sustainable, and flexible energy solution. Solar PV panels capture and convert sunlight into electricity during the day, while the BESS stores any surplus power for later use. This integration ensures that clean solar energy can be utilized even during non-solar hours, reducing dependence on the grid and enhancing local energy resilience.

2.3 BESS Applications

Applications for BESS are shown in the Table 1 below.

Table 1 Applications for BESS

Applications	Description
Grid Reliability and Resilience	Enhances grid stability by providing backup power during outages, supports critical infrastructure such as hospitals and emergency services, and enables islanding capabilities during emergencies.
Peak Shaving and Demand Management	Reduces peak demand on distribution assets, helping to defer costly infrastructure upgrades; lowers demand charges for municipal facilities through load management.
Renewable Energy Integration	Mitigates variability in solar and wind generation; enables solar self-consumption; supports city-wide clean energy and decarbonization goals.
Lower Energy Costs	Facilitates energy arbitrage by charging during low-cost periods and discharging during peak hours, thereby reducing overall energy expenditure for city operations.
EV and Electrification Support	Supports growing electric vehicle (EV) adoption through managed charging and vehicle-to-grid (V2G) services, alleviating localized congestion from the electrification of heating and transport.
Environmental and Public Health	Reduces reliance on fossil-fueled Peaker plants, lowers greenhouse gas emissions and air pollution, and improves public health outcomes, especially in underserved communities.
Local Energy Markets and Flexibility	Enables participation in Distributed Energy Resource Management Systems (DERMS), virtual power plants (VPPs), and non-wires alternatives; enhances grid flexibility.
Data and Operational Insights	Enhances grid visibility and operational control; supports predictive maintenance, load forecasting, and integration with smart city planning tools.

2.4 Key characteristics of BESS:

BESS stores electricity when power is available and delivers it when needed. The key characteristics that determine how a BESS performs are:

- **Power Capacity:** How quickly the battery can deliver energy at a given moment (measured in kW or MW).
- **Energy Capacity:** The total amount of energy the battery can store (measured in kWh or MWh).
- **Storage Duration:** How long the battery can discharge at its rated power before running out of energy.
- **Cycle Life / Lifetime:** The total number of charge-and-discharge cycles the battery can undergo before its performance significantly degrades.
- **Self-Discharge:** The percentage of stored energy lost over time even when the battery is not being used.
- **State of Charge (SOC):** The current charge level of the battery, expressed as a percentage between 0% (empty) and 100% (full).
- **Round-Trip Efficiency:** The percentage of energy returned compared to the amount of energy used to charge the battery, accounting for internal losses.
- **Energy Density:** The amount of energy a battery can store relative to its weight or volume (measured in Wh/kg or Wh/L). Higher energy density allows for more compact systems and reduces space requirements.

Together, these characteristics determine how much power a BESS can provide, how long it can operate, how often it can be used, and how efficiently it supports the grid.

2.4.1 Key Components of BESS

The key subsystems of a BESS are depicted in *Figure 2* [10] :

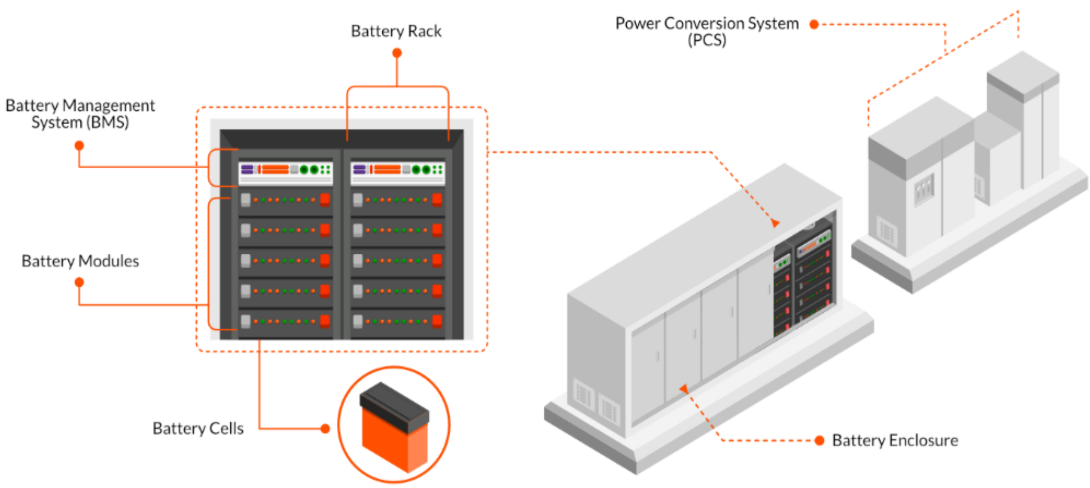

Figure 2 BESS Component-Level Diagram

In general the BESS is made up of multiple subsystems working together to ensure safe and reliable operation:

- **Battery Packs:** Battery packs hold the stored electricity that the system uses when needed.
- **Battery Management System (BMS):** Continuously monitors the battery's voltage, temperature, current, and state of charge to maintain safe and efficient operation.
- **Power Conversion System (PCS):** Allows the battery to charge from the grid and discharge back to the grid by converting AC power to DC and vice versa.
- **Thermal Management System:** Controls battery temperature using air or liquid cooling to prevent overheating and maintain performance.
- **Energy Management System (EMS):** Software that schedules charging and discharging, optimizes operation based on electricity prices or grid conditions, and coordinates with renewable energy sources.
- **Enclosures and Safety Systems:** Provide physical protection and incorporate gas detection, fire suppression, and ventilation systems to ensure safety during all operating conditions.

Combining solar PV with battery storage creates a synergistic system that addresses solar variability and enhances reliability. During sunny periods, excess solar energy charges the batteries. This stored power can then be used in the evening or during grid outages, alleviating peak demand, reducing power costs, and supporting grid stability. Advanced systems use DERMS platforms for real-time coordination, enabling smart control of energy flows and grid support. Together, PV and BESS make DERs smarter, cleaner, and more reliable—reducing grid strain, lowering energy costs, and accelerating renewable energy adoption [11].

3 BESS Technology Assessment

This section outlines the different types of BESS, compares key technologies, and offers practical guidance on selecting the right solution for specific applications [14].

3.1 About Electrical Battery

An electrical battery is an electrochemical device that stores and releases energy through reversible reactions between its anode and cathode, converting electrical energy into chemical energy during charging and converting the stored chemical energy back into electrical energy during discharging.

Figure 3 below illustrates that through these same reversible reactions, electrons flow through an external circuit to create current, while ions migrate through the electrolyte to maintain charge balance; in rechargeable batteries, applying an external voltage reverses this process and restores the original chemical state.

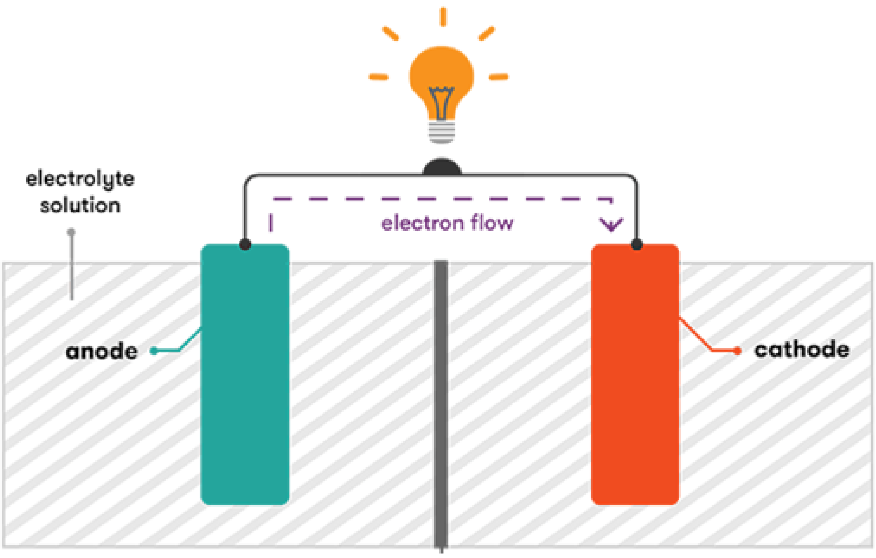

Figure 3 Working of the Battery Cell

When implemented at the community level, electrical batteries serve as the essential component of a battery storage system, often working in conjunction with variable energy sources like solar power. These batteries charge during periods of high solar energy production and discharge energy when solar production decreases in the afternoon. This fundamental capability of an electrical battery delivers clean, affordable, and resilient power, and firms up renewable-centric DER portfolios. As battery technologies continue to advance, these systems have become key enablers of local decarbonization and grid modernization efforts. Figure 4 illustrates reversible electrochemical reactions in a battery: During discharge, chemical energy at the anode and cathode is converted into electrical energy as electrons flow through the external circuit (shown by arrows); applying an external voltage reverses ion and electron flow to recharge the cell.

3.2 Types of BESS Technologies

In summary, utility-scale BESS technology requires a careful balance of cost, performance, safety, and lifespan. Currently, Lithium-ion (Li-ion) battery systems dominate the market due to their high energy density, rapid response times, and long cycle life, making them ideal for homes and small businesses.

Among the various Li-ion options, Lithium Iron Phosphate (LFP) stands out for its exceptional thermal stability and lifecycle longevity. For applications that require longer duration energy storage, flow batteries, such as vanadium redox batteries, offer higher lifecycle counts and enhanced safety. However, they come with a higher upfront cost and larger space requirements.

Emerging battery technologies, including sodium-ion and sodium-sulphur systems, show promise for robust performance in hot climates. Meanwhile, solid-state and zinc-air batteries represent the next frontier in energy density and sustainability; however, they are not yet commercially mature. Choosing the right battery technology depends on:

- battery profile alignment with local load demands
- space limitation
- budget constraints

Table 2 provides a high-level comparison across battery types, including Li-ion, used here as a benchmark but not the central focus. Notably, Solid-State Lithium-Based Batteries (SSBs) and Sodium-Ion Batteries (SIBs) are the only two technologies with energy densities and round-trip efficiencies comparable to Lithium-Ion Batteries (LIBs). However, they currently rank lower in technology readiness compared to flow batteries such as Vanadium Redox (VRFB), Iron Flow (IFB), and Zinc-Bromine (Znbr), as well as other non-flow alternatives.

Table 2 Comparison of Energy Storage Technology Characteristics

Chemistry	Li-Ion	LI SSB	IFB	Flow	Non-Flow	VRFB	SIB
Energy density (MWh/acre)	351	502	50–120	62	62	60–200	183
Discharge duration (hr)	1–10+	1–10+	5–12	2–12	3–12	5–10	4+
Round-trip efficiency, RTE (%)	90–95	90–95	55	< 80	70	65–71	91
Life (yrs)	10	10+	25	10+	20	20+	20

This battery comparison is beneficial for planning engineers or stakeholders involved in energy storage planning, procurement, or investment. It provides a clear overview of key performance indicators, such as energy density, discharge duration, round-trip efficiency, and lifespan across various battery technologies, including LFP and flow batteries.

3.2.1 Battery Types Available in the Market

Batteries are broadly classified into two types:

a) **Non-Rechargeable Batteries**: Non-rechargeable batteries, such as alkaline and lithium primary cells, are designed for single use and are commonly found in devices like remote controls, clocks, and flashlights. Once depleted, they must be replaced.
b) **Rechargeable Batteries**: Rechargeable batteries, like lithium-ion, NiMH, and lead-acid, can be used multiple times by recharging them with electricity. These are widely used in smartphones, laptops, electric vehicles, and backup power systems due to their long-term cost-effectiveness and environmental benefits.

3.2.2 Benefits of Rechargeable Batteries.

Rechargeable batteries offer several technical, economic, and environmental advantages, such as

a) **Reusability**: Rechargeable batteries can be charged and discharged thousands of times, making them highly suitable for long-term energy storage applications. This repeated usability significantly reduces the need for frequent replacements, thereby lowering operational and maintenance costs over the system's lifetime.
b) **Fast Response Time**: Rechargeable batteries can instantly supply or absorb electricity, enabling rapid response to fluctuations in power demand or supply. This swift reaction helps stabilize the grid.
c) **Renewable Energy Integration**: Rechargeable batteries play a crucial role in storing excess energy generated from renewable sources like solar and wind during periods of high generation. This stored energy can then be used during times of low or no generation, such as nighttime or cloudy days, enabling continuous and reliable use of renewable energy.
d) **Backup Power Supply**: Provides uninterrupted power during outages, ensuring reliability for homes, businesses, and critical infrastructure.

3.2.3 Types of Rechargeable Batteries

The section outlines the categories of rechargeable batteries [15]

3.2.3.1 Lithium-Ion (Li-Ion):

High energy density and long lifespan make it ideal for any use case at all scales from residential to utility-scale. Sensitive to temperature and relatively costly.

3.2.3.2 Lithium Iron Phosphate (LFP):

Safer and longer-lasting than other Li-Ion types, with slightly lower energy density. Common in solar and backup systems.

3.2.3.3 Lithium Nickel Manganese Cobalt Oxide (NMC):

Offers high energy output and efficiency but comes at a higher cost. Widely used in EVs and grid storage.

3.2.3.4 Lead-Acid (PbA):

Affordable and recyclable, suitable for backup and off-grid systems. Shorter lifespan and lower efficiency.

3.2.3.5 Flow Batteries:

Scalable and long-lasting with safe liquid electrolytes. Best for grid-scale storage, but has low energy density.

3.2.3.6 Sodium-Ion:

Cost-effective and safer alternative to Li-Ion, especially in hot climates. Still under development with lower energy density.

3.2.3.7 Solid-State:

Promises high energy density and safety with fast charging. Currently expensive and in early stages of commercialization.

3.2.3.8 Zinc-Air:

Eco-friendly with high energy density using air as a reactant. Limited cycle life and high manufacturing cost.

3.2.3.9 Nickel-Cadmium (NiCd):

Durable and reliable in extreme conditions. Environmental concerns due to cadmium toxicity.

3.2.3.10 Sodium-Sulphur (NaS):

High-temperature battery suited for large-scale grid applications. Requires heating systems and has a limited cycle life.

Table 3 provides a comparison of BESS, which helps quickly evaluate different technologies based on performance, cost, and suitability. It supports informed decision-making for selecting the right energy storage solution across residential, commercial, and utility-scale applications.[2]

Table 3 Comparison of Battery Chemistries

Battery Type	Pros	Cons	Typical Applications
Lithium-Ion (Li-Ion)	High efficiency, long lifespan, fast charging, and scalable	High upfront cost, temperature sensitivity	Residential, commercial, utility-scale
LFP (Li-Ion subtype)	Safer, longer lifespan (typically 4,000 cycles)	Lower energy density	Residential, commercial, utility-scale
NMC (Li-Ion subtype)	Higher energy density, better performance	More expensive, shorter lifecycle (typically 1,500 cycles)	EVs, commercial, utility-scale (phasing out)

[2] Amir, M., Deshmukh, R. G., Khalid, H. M., Said, Z., Raza, A., Muyeen, S. M., Nizami, A.-S., Elavarasan, R. M., Saidur, R., and Sopian, K. (2023). Energy storage technologies: An integrated survey of developments, global economical/environmental effects, optimal scheduling model, and sustainable adaption policies. *Journal of Energy Storage, 72*, 108694. https://doi.org/10.1016/j.est.2023.108694

Battery Type	Pros	Cons	Typical Applications
Lead-Acid (PbA)	Low cost, widely available, recyclable	Short lifespan, low efficiency, slow charging	Off-grid systems, UPS
Flow Batteries	Long lifespan, scalable, safe (non-flammable electrolytes)	Low energy density, high initial cost	Grid-scale, long-duration storage
Sodium-Ion	Safer, cost-effective, eco-friendly, high-temp tolerance	Lower energy density, early-stage development	Emerging markets, high-temp environments
Solid-State	High energy density, fast charging, enhanced safety	High production cost, still developing	Future EVs, advanced grid storage
Zinc-Air	High energy density, low environmental impact	Limited cycle life, expensive manufacturing	Backup power, small-scale storage
Nickel-Cadmium (NiCd)	Robust, long cycle life, performs well in extreme temperatures	Toxic materials, lower energy density, higher self-discharge rate	Industrial, remote off-grid, backup systems
Sodium-Sulphur (NaS)	High power, energy density, and high efficiency are suitable for large-scale applications	Higher manufacturing cost, requires special heating systems, and has a limited cycle life.	Utility-scale, grid load balancing

3.3 Factors to Consider When Selecting BESS Technology

The selection of an appropriate BESS technology involves a strategic assessment of multiple key parameters [16]. The following factors should be evaluated to ensure the suitability and efficiency of the system for the intended application:

3.3.1 Energy Requirements and Storage Capacity

It is essential to define the purpose of the BESS installation, whether it is intended for residential energy storage from solar PV systems or utility-scale grid support and fluctuation management. This will determine the required energy storage capacity (measured in kilowatt-hours, i.e., kWh) and power output (measured in kilowatts, i.e., kW).

3.3.2 Cost Considerations and Budget Constraints

The overall cost of a BESS is influenced by the technology employed. Among the commonly used chemistries, lithium-ion systems tend to be the most expensive, followed by flow batteries and sodium-ion technologies. Nonetheless, various financial incentives, subsidies, and rebate programs are available, particularly for residential solar-plus-storage systems, which can significantly offset the initial investment cost.

3.3.3 Environmental Impact

The environmental footprint of the chosen battery technology is a critical consideration. Li-ion batteries, for instance, generally have a higher carbon footprint compared to alternatives such as lead-acid or sodium-ion batteries. While advancements in recycling technologies are ongoing, the end-of-life disposal and recycling of batteries still pose significant environmental challenges and should be factored into the decision-making process.

3.4 BESS Technology Utility-Scale Selection Guidance

Evaluating and selecting the appropriate BESS type depends on a number of factors, primarily power and energy requirements, how often the BESS will be fully charged/discharged (cycling), response time, and cost considerations. The list below offers guidance on BESS selection.

3.4.1 Assess Energy Requirements:

Determine the average and peak power (in kW) needed, as well as the duration (in hours) required. Multiplying the average power by the duration requirement will yield energy requirements.

3.4.2 Evaluate Space Constraints:

Consider the physical space available for installation; compact systems are ideal for limited areas.

3.4.3 Review Project Finance Model and Incentives:

Factor in Project Finance Models and explore available rebates, subsidies, or tax incentives to offset costs.

3.4.4 Check for Scalability:

Ensure the system can be expanded in the future to accommodate growing energy demands.

3.4.5 Prioritize Safety Features:

Ensuring the safety and reliability of BESS is a top priority. Given the project's scale and its critical role in supporting loads, the design and selection of BESS will emphasize robust safety mechanisms over purely cost-driven considerations.

3.4.5.1 Thermal Management and Fire Protection

a) Advanced Thermal Management: High-efficiency cooling systems and thermal monitoring will prevent overheating and runaway thermal events.
b) Comprehensive Fire Protection: Integrated detection, suppression, and isolation systems will be deployed to minimize fire risks and enable rapid incident response.

3.4.5.2 Compliance with Safety Standards

All BESS systems will adhere to internationally recognized safety standards, including:

a) UL 9540 and UL 9540A for system safety and thermal runaway testing

b) NFPA 855 for fire protection in energy storage installations

c) Preference may be given to certified and field-proven solutions to ensure maximum operational reliability.

3.4.5.3 Real-Time Monitoring and Diagnostics

BESS installations will include following features as advanced monitoring systems. This ensures early fault detection and mitigates potential safety risks before escalation.

a) Tracking cell and module temperature profiles

b) Detecting anomalies in voltage or current in real time

c) Issuing predictive alerts to enable proactive maintenance

By prioritizing safety in design, compliance, monitoring, and evaluation metrics, the project ensures that BESS installations will operate reliably, protect critical loads, and meet the long-term safety expectations of the consumers and regulatory bodies.

3.4.6 Applying the BESS Technology Selection Guidance to Shortlist Utility-Scale BESS Technology Candidates

The preceding subsections 3.4.1 to 3.4.5 have outlined a structured framework for evaluating BESS technologies based on energy requirements, spatial constraints, commercial viability, scalability, and safety. These considerations are especially important for utility-scale and industrial-scale deployment, where battery systems must meet long-duration storage needs while also adhering to stringent fire, environmental, and permitting standards.

Hence, the BESS technology selection guidance shortlists the viable chemistries for utility-scale applications, excluding certain battery chemistries based on specific factors:

- Incompatibility with fire codes or high thermal risk (e.g., NMC)
- Insufficient commercial maturity or market readiness (e.g., solid-state, zinc-air)
- Low energy density requiring excessive land area (e.g., legacy lead-acid or NiCd)
- Limited cycle life or duration unsuitable for grid integration

What remains is a shortlist of commercially available technologies that are technically mature/promising and suitable for deployment at scale. Among these, two have emerged as the leading options for long-duration, utility-scale storage:

- LFP – A safer subtype of lithium-ion, widely deployed across California, as shown in Section 3.5
- VRFB – An emerging non-flammable, long-duration alternative gaining traction for grid reliability and resiliency applications as shown in Section 3.10

Table 4 summarizes the key safety features, scale suitability, and duration ranges for each BESS technology reviewed in this report. Technologies marked as not applicable are either not feasible at utility scale or fail to meet the core criteria outlined in sub-sections 3.4.1 through 3.4.5. This table serves as a practical reference for decision-makers engaged in evaluating BESS technology options.

Table 4 BESS Technologies Suitable for Utility-Scale & Industrial

Technology	Typical Duration	Utility-Scale Use	Industrial Use	Safety Profile
Lithium-ion (LFP)	2–4 hours	Yes	Yes	Fire risk is low but not zero due to more stable "safe chemistry" (reduced thermal runaway vs other Li-ion); requires fire monitoring/cooling systems.
Lithium-ion (NMC)	2–4 hours	Yes (still used in some utility projects, now shifting to LFP)	Yes	Higher fire risk – prone to thermal runaway if not managed; needs strict cooling and battery management for safety.
Vanadium Redox Flow (VRFB)	6–12+ hours	Yes - Emerging (pilots for utility-scale long-duration[3])	Emerging (less common for small sites due to size)	No fire risk – non-flammable liquid electrolyte (water-based); safe chemistry (no thermal runaway), but uses corrosive acid (requires spill containment).
Sodium–Sulfur (NaS)	6 hours (typical module)	Yes	Uncommon (high-temp system)	High operating temp (300 °C); sodium and sulfur are reactive – risk of fire if casing is breached (sodium ignites in air). Modern units have built-in insulation and fire suppression (e.g., sand).
Lead–Acid	1–4 hours (best for short backup)	Not applicable (used only in small-scale backups)	Yes (UPS, backup power in telecom/industry)	No thermal runaway, but emits hydrogen gas when charging (explosion hazard without ventilation); contains corrosive acid requiring safe handling.
Zinc-based (e.g., Zn–Br flow, Zn-ion)	4–10 hours (long-duration capable)	Yes - Emerging (pilot projects at utility scale)	Emerging (some C&I demonstrations)	No fire risk – aqueous (water-based) electrolyte; safe from thermal runaway. **Note:** Uses chemicals such as bromine (toxic if leaked), so it requires chemical safety measures.

[3] See State of the Market for Flow Batteries in Section 3.10

3.5 Dominant BESS Technologies in California: Lithium-Ion

Utility-scale BESS deployments have increased in recent years, especially between 2023 and 2024, with lithium-ion batteries dominating across all sectors. Two chemistries, LFP and NMC, make up most BESS technologies.

Based on the California Energy Commission's *"California Energy Storage System Survey,"* California is recognized as a global leader in utility-scale battery storage. As of Q1 2025, California had installed over 15,700 MW of battery storage, up from just 500 MW in 2018. Most of this capacity is utility-scale and grid-connected to provide peak power and ancillary services, as illustrated in the figure below. In 2024 alone, 4,336 MW of new utility-scale storage was added in California, raising the state's total utility-scale battery capacity to approximately 13 GW with an estimated 44.5 GWh[4] of energy (vs. 0.2 GWh of flow batteries underway in the U.S. as an emerging long-duration BESS technology as of 2024; See Section 3.10).

Statewide Energy Storage Power Capacity: **15,763 MW**

Customer Sector	Total Capacity (MW)	Installations	Average Capacity (kW)
Residential	1,829	249,340	7
Commercial	686	3,335	206
Utility	13,248	214	61,907
Total	15,763	252,889	62

Figure 4 California BESS Installed Capacity per Sector

Among the utility-scale BESS deployed, LFP and NMC are the dominant BESS chemistries used in the industry. However, California's large-scale installations have rapidly shifted toward LFP in recent years: about 67% of surveyed California battery facilities (>50 MW) use LFP, 30% use NMC, and only 3% use other blends (e.g., NMC/NCA)[5] as shown in *Figure 5*. This reflects a broader industry trend; NMC projects (many built in the late 2010s) have lost market share to LFP as newer projects favor LFP's lower cost and safety profile.

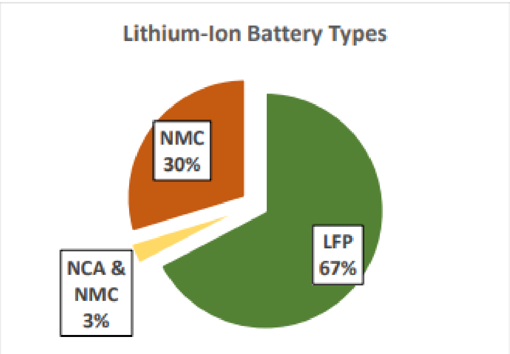

Figure 5 Dominant Lithium-Ion Battery Technologies in California are LFP and NMC, and Shifting Towards LFP due to Lower Cost and Better Safety Profile

[4] Inferred from EIA BESS data as of 2023, stating that California had 8,056 MW of BESS Capacity and 27,105 MWh of BESS Energy Capacity (ratio of 3.36 MWh/MW BESS)
[5] California Public Utilities Commission, Safety and Enforcement Division. *2025 Battery Energy Storage System Facility Survey: Fact Sheet.* July 2025

Across the U.S., a similar pattern is also observed. Most new utility-scale batteries commissioned in 2023–2024 use LFP chemistry (globally, LFP comprised roughly 88% of new 2024 battery installations by capacity). NMC chemistry, while still present in the installed base, is increasingly limited to older projects; it now likely represents well under half of U.S. utility-scale MW capacity.

The widespread shift to LFP is partly a response to safety incidents and performance data from high-profile facilities using NMC chemistry. Thermal runaway incidents, such as those at Terra-Gen's Valley Center in San Diego County, Gateway Energy in Otay Mesa, and Vistra's Moss Landing facility in Monterey County, have raised public concerns. In contrast, LFP operates at cooler temperatures and tolerates full charging, which gives stakeholders greater confidence in deploying storage solutions on the necessary scale.

3.6 BESS Technology Thermal Management

One of the most serious threats to BESS safety is thermal runaway, a chain reaction triggered by overheating within a battery cell. This can escalate into fires or explosions, posing risks to infrastructure and personnel. Without proactive thermal regulation, BESS installations are vulnerable to performance degradation and hazardous incidents.

3.6.1 Heat Generation in Batteries

Batteries naturally produce heat during operation due to several factors [17]:

a. **Internal Resistance**: Electrical resistance within the battery causes energy loss in the form of heat.
b. **Charge/Discharge Rate**: Faster energy transfer increases heat generation.
c. **Environmental Conditions**: High ambient temperatures or poor ventilation can trap heat and raise battery temperature.
d. **Battery Aging**: Over time, internal resistance increases, leading to more heat during use.

3.6.2 Dangers of Excessive Heat Buildup in BESS

Excessive heat accumulation in BESS presents significant risks to both system performance and operational safety. Prolonged exposure to elevated temperatures accelerates battery degradation, leading to reduced efficiency, shortened lifespan, and increased maintenance costs due to more frequent replacements.

Heat stress also compromises energy efficiency, as overheated batteries struggle to store and discharge energy effectively. This results in power losses and higher operational expenses, ultimately diminishing the return on investment for energy storage solutions.

The most critical consequence of poor thermal regulation is the heightened risk of thermal runaway. In this dangerous chain reaction phenomenon, overheated cells ignite adjacent ones, potentially causing fires, explosions, and complete system failure. Without robust cooling mechanisms and thermal management strategies, the impact of excessive heat can be catastrophic, endangering infrastructure, personnel, and the surrounding environment.

3.6.3 Major BESS Fire Incidents and Lessons Learned

Thermal mismanagement has been a key factor in several high-profile BESS fire incidents globally. Inadequate cooling, poor ventilation, and environmental stressors such as extreme heat and humidity have contributed to overheating and thermal runaway events.

3.6.3.1 Key Contributing Factors:

Some of the contributing factors are:

- Insufficient cooling and heat dissipation
- Environmental stress (temperature, humidity, airflow)
- Overcharging and unregulated discharge cycles

Notable incidents, including the 2019 McMicken facility fire in Arizona and the 2022 California BESS fire in Monterey County, highlight the consequences of poor thermal control—ranging from system damage to safety hazards for personnel. These events underscore the urgent need for advanced thermal management solutions to ensure safe and reliable BESS operation.

3.7 The Role of Thermal Management in Fire Prevention

3.7.1 Temperature Regulation for Battery Safety

Maintaining an optimal operating temperature, typically between 60°F and 95°F, is essential for lithium-ion battery safety and performance. Exceeding this range accelerates degradation, reduces efficiency, and increases the risk of thermal runaway. Hotspots within cells can lead to uneven performance, component damage, and higher maintenance costs [17].

3.7.2 Cooling Approaches in BESS

Some of the cooling approaches utilized in BESS are as follows:

3.7.2.1 Passive Cooling:

Utilizes natural convection, insulation, and phase change materials. Suitable for low-power systems but insufficient for large-scale BESS due to limited heat dissipation capacity.

3.7.2.2 Active Cooling:

Table 5 provides an overview of the different types of active cooling systems along with their respective advantages and disadvantages.

Table 5 Types of Active Cooling

Cooling Method	Advantages	Limitations
Air Cooling	Cost-effective, simple setup	Poor temperature uniformity across battery cells
Liquid Cooling	More efficient heat dissipation	Requires complex infrastructure and maintenance
Refrigerant Cooling	High cooling efficiency	Expensive, potential environmental concerns

3.7.2.3 Hybrid Cooling:

Combines passive and active methods to enhance thermal regulation. These systems optimize performance and safety while minimizing energy consumption, making them ideal for modern, scalable BESS deployments.

3.7.3 Thermal Runaway - Common Cause of BESS Fire

As temperatures rise due to thermal runaway, chemical reactions within the battery accelerate, producing even more heat [27]. BESS thermal runaway occurs when a damaged lithium-ion battery cell releases flammable or toxic gases, triggering a chain reaction that spreads to adjacent cells. As this process accelerates, extreme heat and pressure build up, significantly increasing the risk of fires or explosions.

3.7.3.1 Causes of Thermal Runaway

Thermal runaway can be triggered by a variety of factors, including:

a) **Overcharging:** If neither the charger nor the protection circuit stops the charging process, then more energy enters the cell. As a result, the voltage in the cell rises – this is known as overcharging. Regardless of size (cellphone or large-scale), battery overcharging poses a fire hazard to the battery cell and shortens its lifespan. It is also a safety risk for the user. Excess energy leads to heat generation, which, in the worst case, leads to thermal runaway.

b) **Deep discharging:** When a battery is drained too much, it can get damaged inside and heat up when used again. This extra heat can build up quickly, making the battery unstable. In some cases, it can get so hot that it catches fire.

c) **Manufacturing Defects***:* Sometimes batteries have hidden defects from the factory, like tiny cracks, impurities, or poor materials**.** These minor problems can cause short circuits inside the battery, making it heat up more than usual. If the heat builds up too much, it can lead to thermal runaway, where the battery gets hotter, possibly causing a fire or explosion.

d) **Physical Damage:** If a battery gets crushed, punctured, or dropped hard, it can get damaged inside. This damage can cause a short circuit in the battery, causing rapid increase of internal temperature. When the heat can't escape, it can lead to thermal runaway, where the battery keeps getting hotter and can catch fire or explode.

e) **High External Temperatures**: When a battery is left in very hot places, like direct sunlight or near a heat source, it can get too hot from the outside. This outside heat can cause the batteries' temperature to rise, leading to thermal runaway.

3.8 BESS Fire Prevention

Preventing BESS fires requires a layered, multi-faceted approach, including [28]:

3.8.1 Battery Management Systems (BMS)

A Battery Management System is the central logic component of a BESS responsible for monitoring and controlling the system. The BMS:

a) Calculates the charge remaining on the battery
b) Monitors the temperature of the battery system
c) Monitors for shorts and faulty connections
d) Maintains the charge within the cells in the optimal performance range

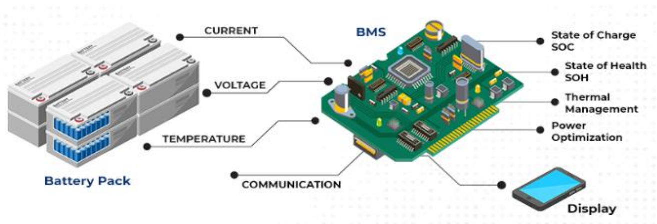

Figure 6 BMS Component-Level Diagram

The BMS monitors and implements safety measures to prevent overcharging, over-discharging, and overheating, thereby extending battery life and optimizing performance. It also diagnoses issues and logs events, providing valuable data for troubleshooting and improving system reliability. Components of BESS are given in *Figure 6***Error! Reference source not found.**.

If the BMS detects any abnormal conditions, it shuts the battery down. This protects the cells from damage.

3.8.2 Gas Detection Systems

These systems detect the release of flammable gases from a faulty battery cell. When the gas detector alerts the presence of an off-gas, it can activate several mitigating actions. Perhaps the most important thing is shutting down power to the affected cell(s). Additionally, the gas detection equipment can:

- Activate a ventilation system within the BESS enclosure to remove flammable gases and heat
- Activate local and remote alarms
- Provide an early warning for operators to take additional measures

Gas detection offers the first chance to intervene after the BMS fails. Gas detection provides far quicker notification of the problem than does a smoke, heat, or flame detector. With gas detection, this is an opportunity to mitigate the problem before it requires a response action from fire suppression equipment.

3.8.3 Fire Suppression Systems

An illustration of a typical fire suppression system is shown in *Figure 7***Error! Reference source not found.**. It is the final line of defense, meaning that all other interventions have failed. However, the way in which batteries fail, and their design make total extinguishment difficult.

Specialized fire suppression agents, such as condensed aerosol systems, can quickly suppress fires and limit thermal runaway.

Figure 7 Fire Suppression Systems

3.8.4 Thermal Barriers

Figure 8 Thermal barrier - sourced from the Tecman UK case study [62]

In BESS, Thermal Barriers are illustrated in *Figure 8* [62] can be placed in between two consecutive battery cells, modules, or trays to create physical separation that will limit the heat transfer. A thermal barrier slows down and prevents the propagation of fire to neighboring cells. This prevents a single cell's thermal runaway from triggering a chain reaction in neighboring cells.

3.9 National Blueprint for BESS Technology Safety

On March 28, 2025, the American Clean Power Association (ACP) released a comprehensive framework to ensure the safety of battery energy storage systems (BESS) in every community across the United States, informed by a new assessment of previous fire incidents at BESS facilities.

The assessment, conducted by the Fire and Risk Alliance, analyzed historical data and scientific studies on fire incidents over the last decade in the U.S. The findings indicate no impact on public health or surrounding communities from the incidents studied [29]. ACP's Battery Storage Blueprint for Safety outlines key actions and policy recommendations for state and local jurisdictions to regulate battery storage, enforce the country's most rigorous safety standards, and ensure coordination on safety and emergency response in all communities.

The assessment's key finding reveals that, in all reviewed cases of environmental sampling related to the BESS fire events, no previous incidents resulted in contaminated concentrations that would pose a public health concern or require further remediation.

A critical component of the blueprint is understanding where the industry has been successful in efforts across the country to advocate for the enforcement of the National Fire Protection Association's standard for energy storage, NFPA 855. The set of standards includes exhaustive requirements and ensures that facilities use certified batteries and equipment.

3.10 Flow Battery Technology as an Emerging Non-Flammable Long-Duration Alternative to Lithium-Ion

As discussed in Section 3.5, majority of grid-connected BESS deployed in California utilize lithium-ion chemistries, most commonly LFP. The high energy density and decreasing costs of LFP have contributed to its rapid adoption across the state. However, as outlined in Sections 3.6 to 3.9, this lithium-ion architecture, particularly NMC, delivers compactness and performance but also raises thermal management concerns. Mitigation strategies and facility setback buffers, and other thermal containment standards as per NFPA 855 and SB 38, address these issues in exchange for additional regulatory complexity and cost for the BESS developer.

Alternatively, utilities[6], municipalities[7], and regulators[8] are increasingly evaluating flow batteries for long-duration energy storage applications (typically 8-12 hours) without the thermal risk. Unlike Li-ion, flow batteries store energy in liquid electrolytes held in external tanks and circulated through electrochemical stacks during charge and discharge. This fundamental difference allows the separation of power capacity (stack size) from energy capacity (tank volume), allowing for extended discharge durations of 8 to 12 hours or more, and eliminating cell-to-cell thermal propagation (discussed in detail in Section 4.2).

State of the Market for Flow Batteries

Across the U.S. as of 2024, multiple flow battery pilot and demonstration projects are underway, with an estimated 200 MWh of capacity either already operational or slated for commissioning within the next 2–3 years.[9] These projects span a range of applications, including utility-scale pilots, military installations, microgrids, and behind-the-meter systems. Notable examples include:

- A 10 MWh VRFB integrated with a solar microgrid for the Viejas Band of the Kumeyaay Indians
- A 2 MWh VRFB microgrid project by Orcas Power and Light

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[6] In 2019, the California Independent System Operator tested a 2MW/8MWh vanadium redox flow battery pilot in coordination with SDG&E (Sumitomo Electric) to evaluate its behavior in the electricity market

[7] In 2024, SMUD announced it was awarded a $10 million state grant from the California Energy Commission (CEC) to deploy a 3.6 MW, 8-hour iron flow battery demonstration project.

[8] California, through the CEC, has allocated over $270 million to fund non-lithium long-duration energy storage (LDES) demonstrations through its LDES Program, encouraging of non-lithium LDES deployment.

[9] Aaron Hollas, Allan Tuan, Vilayanur Viswanathan, Isabella Ragazzi. *Adoption Readiness Level Assessment of Redox Flow Batteries*. PNNL-36780. Pacific Northwest National Laboratory and U.S. Department of Energy, Office of Technology Transition, September 2024.

- An 8 MWh VRFB installation supporting grid services for San Diego Gas & Electric
- A 0.1 MWh pilot system operated by Snapping Shoals EMC
- Two iron flow battery systems at Sacramento Municipal Utility District (SMUD), sized at 2.4 MWh and 29 MWh, respectively, supporting decarbonization and resiliency goals
- A 50 MWh organic flow battery project deployed by the Salt River Project for renewable energy integration and demonstration purposes

These projects reflect growing interest in non-lithium, long-duration storage solutions across a range of climates, ownership models, and technical use cases.

3.10.1 Flow Batteries are Non-Flammable but Have Inherent Safety Risks

While flow batteries are inherently non-flammable because their electrolytes are water-based, their safety risk shifts from thermal runaway to electrolyte leak hazards, necessitating safety standards for chemical containment and electrolyte management.

Regulatory standards for flow batteries are still maturing, unlike NFPA 855 and UL 9540 for Li-ion. A balanced safety assessment when considering flow batteries must acknowledge hazards identified in industry literature[10] such as (1) gas evolution under overcharge, electrolyte imbalance, or thermal stress, (2) Acidic leaks and corrosion that can damage secondary containment materials and create localized hazards, and (3) Combustion (In unlikely fire scenarios involving polymer components, small quantities of HF, SO_2, or CO/NO_x may form).

3.10.2 Flow Battery Operational and Lifecycle Value

Currently, flow batteries represent the most commercially mature non-lithium technology alternative that trades energy density and cost for safety, longevity, and long duration. The typical service life exceeds 20 years with minimal capacity fade, and electrolyte reuse or recycling can recover up to 95–97% of the active materials. For municipal applications such as the City of Vacaville, this alternative offers reduced fire-safety requirements, potential simplified permitting, and alignment with long-term resiliency and sustainability goals.

3.11 BESS Technology Recommendation:

In conclusion, both LFP and VRFBs are viable options for large-scale storage projects, with the status quo in California skewing heavily towards LFP. LFP batteries remain the preferred near-term choice due to their compactness, mature regulatory framework, and proven field safety. However, for projects that put high importance on long-duration energy storage, vanadium redox flow batteries remain the leading alternative, despite their higher upfront costs and larger land requirements. To give the client more insights on these two BESS technologies, A comprehensive comparison between lithium-ion and flow batteries is available in Section 4.

The decision on which BESS technology to select depends on the project's key economic drivers, , safety objectives, and operational priorities:

[10] Electric Power Research Institute (EPRI). Review of Environmental Life Cycle Assessments for Select Advanced Lithium and Non-Lithium Energy Storage Technologies. Palo Alto, CA: EPRI, December 2024. Report 3002030237, p.7.

3.11.1.1 Lithium-Iron Phosphate (LFP):

a) Thermal Stability and Safety: High tolerance and minimal risk of thermal runaway when installed, monitored, and maintained properly.
b) Longer Life Cycle vs. NMC: 3,000 to 6,000 cycles [37], reducing replacement frequency and lifecycle costs.
c) High Energy Density: Lower land requirement (100 MWh per acre[11]), making it suitable where available battery footprint is limited.
d) Mature Supply Chain and Cost Curve: Broad commercial availability and declining capital costs, especially when combined with solar incentives.
e) Round-Trip Efficiency: Typically, 90-95%, resulting in higher usable energy output and improved economic performance compared to flow batteries [58].
f) Supply Dependency: LFP technology relies on imported materials such as lithium and phosphate compounds, which may affect long-term cost stability and supply security [59].

3.11.1.2 Vanadium Redox Flow Batteries (VRFB):

a) Thermal Stability: Non-flammable with negligible risk of thermal runaway.
b) Marginally Longer Life Cycle: 15,000 to 20,000 cycles [38], with minimal degradation, ideal for frequent cycling.
c) Flexible and Scalable Energy Capacity: Energy capacity can be increased independently of power by enlarging electrolyte storage, suitable for multi-hour or multi-day storage.
d) Suitable for RE Integration: long-duration (8-12 hours) storage alternative to LFP for grid support that goes well with wind and solar for minimizing environmental impact. However, it requires higher upfront investment and more site area.
e) Round-Trip Efficiency: Typically, 70–80%, which is lower than LFP systems, potentially impacting overall cost economics for shorter-duration applications [60].
f) Supply Chain Advantage: Vanadium is more widely available and less import-dependent, offering a potential advantage in domestic sourcing and supply resilience, though it requires higher initial capital investment and larger site area [61].

4 Comparing Flow and Lithium-ion Batteries

As outlined in Sections 3.5 through 3.11, California's battery portfolio mainly consists of Li-ion batteries, leaning towards LFP chemistry, for energy storage because of their cost and footprint efficiency. However, recent incidents at Li-ion facilities have raised *safety concerns and regulatory scrutiny regarding the expansion of* Li-ion BESS facilities.

Alternatively, flow batteries offer a safer, non-flammable alternative with longer duration and less capacity degradation over time; however, they introduce different *operational and chemical risks*, necessitating pump management, electrolyte containment, and gas-evolution control.

[11] To calculate this acreage requirement, storage footprint was assumed to be 0.01 acres per MWh of energy stored (Guidehouse 2020: 9). A typical grid-scale lithium-ion battery has a duration of 4 hours (CAISO 2023: 8). Therefore, a 1 MW battery with a 4-hour duration can store 4 MWh of energy. This battery will occupy 0.01 acres per MWh * 4 MWh per MW = 0.04 acres per MW.

Given these contrasting characteristics, this section introduces a comparative life-cycle assessment (LCA) framework to evaluate total environmental impact, safety performance, and long-term sustainability across both technologies.

This section begins by outlining the LCA methodology applied to quantify trade-offs between flow and lithium-ion batteries, aligning the analysis with the City's overarching goal to understand these competing BESS technologies in terms of safety, cost, and environmental impact for utility-scale deployment. The table below summarizes the comparison between flow and lithium-ion batteries in this document.

Table 6 Safety and Use Comparison Between Flow and Lithium-Ion Battery Technologies[12][13]

Category	Lithium-Ion (LFP)	Flow Batteries (VRFB)
Typical Use Case	Dominant in California grid BESS; preferred for fast response, smaller footprint, and lower cost.	Increasingly used for long-duration energy storage, often in pilot or industrial projects (see Section 3.10); larger footprint requirement.
Core Chemistry	Energy stored in solid electrodes; high energy density.	Energy is stored in liquid electrolytes circulating between tanks; low energy density.
Primary Safety Risk	Thermal Risk: a self-heating chain reaction that can cause fires if not mitigated.	Chemical risk: acid leaks, gas evolution, and potentially toxic off-gases under stress.
Thermal Risk	Possible cell-to-cell propagation; mitigated in LFP by stable phosphate chemistry (non-oxygen releasing). EPRI fire study notes that LFP incidents emit less heat and fewer toxic gases than NMC or NCA systems.	Non-flammable aqueous electrolytes make sustained combustion unlikely. However, polymer and gasket materials can still burn, releasing HF, SO_2, or NO_x gases under high heat.
Chemical and Leakage Risks	LIB vents gases: CO, H_2, and organic solvent vapors during failure; modern gas detection and BMS systems (NFPA 855) reduce this risk.	VRFB and ZnBr can evolve H_2 or Br_2 during imbalance or overcharge; they require ventilation, gas sensors, and pH monitoring.

[12] Electric Power Research Institute (EPRI). *Review of Environmental Life Cycle Assessments for Select Advanced Lithium and Non-Lithium Energy Storage Technologies.* Palo Alto, CA: EPRI, December 2024. Report 3002030237, pp. 7–12.
[13] Electric Power Research Institute (EPRI). *Global Battery Energy Storage System Fire Suppression Water Management Practices.* Palo Alto, CA: EPRI, November 2023. Report 3002031835, pp. 45–98.

Category	Lithium-Ion (LFP)	Flow Batteries (VRFB)
Water and Fire Suppression	Standard water deluge systems are sufficient for LFP modules, with minimal environmental impact.	Water is used primarily for cooling and containment, rather than suppression; secondary containment and corrosion-resistant design are required due to the presence of acidic liquids.
Environmental Hazard During Fire	Byproduct from LIB fires can contain metals (Ni, Co, Mn), but they are treatable and can be managed. An EPRI report found no long-term soil contamination from past incidents.	Acidic electrolyte spills may require neutralization (lime or soda ash). Bromine or chlorine gases can pose local inhalation hazards if ventilation fails.
Lifecycle and Recycling	3,000 to 6,000 cycles. Established recycling infrastructure for LFP, copper, and aluminum recovery.	10,000 to 20,000 cycles. 95–97% electrolyte recyclability, since vanadium does not degrade.
Regulatory Standards	Fully codified under NFPA 855, UL 9540/9540A, and the California Energy Commission BESS fire code. There is widespread AHJ familiarity.	Still maturing, as there is no unified NFPA equivalent. More operational data will be gathered as more flow batteries are deployed in the field.
Community Implication	Proven, commercially mature, compact, and safe when designed to LFP standards with proper BMS, ventilation, and setbacks.	Safer in terms of thermal risk, but introduces corrosive liquids and maintenance complexity. It is also unsuitable for dense community sites due to the large footprint requirement. Lack of mature safety standards introduces uncertainty.

4.1 Life Cycle Assessment as a Framework to Compare the Safety and Environmental Impact of Flow and Lithium-ion Batteries

Life Cycle Assessment (LCA) is a systematic method used to evaluate the environmental impacts of a product, process, or technology throughout its entire life cycle, from raw material extraction and manufacturing to transportation, usage, and end-of-life management activities, such as recycling, repurposing, or disposal.

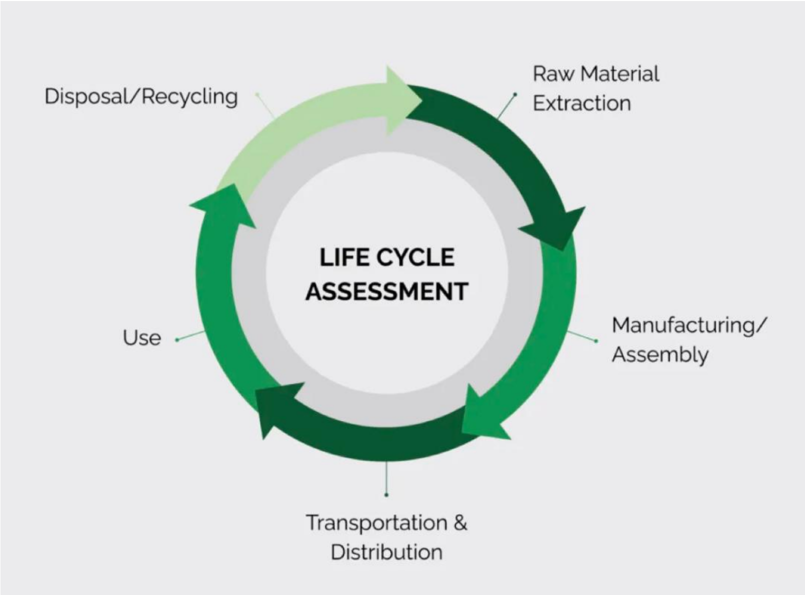


Figure 9 LCA Framework Overview. Image Reproduced from Berger Maritiem

When applied to different BESS technologies, LCA provides a structured framework for comparing technologies, such as flow and lithium-ion batteries, on an apples-to-apples basis in terms of environmental performance, safety, and sustainability. It helps identify design improvements, reduce resource use, and anticipate safety or regulatory challenges before large-scale deployment.

Forward-looking LCAs offer critical insights for comparing technological options, guiding investment and deployment decisions by highlighting trade-offs across manufacturing, policymaking, project location, operations, and maintenance.

However, LCAs have inherent limitations. Their accuracy relies on the quality and availability of input data, which is often limited, confidential, or derived from small-scale pilot projects for emerging technologies.

Additionally, differences in scope, macroenvironment, assumptions, and methodology across references can also affect how results are compared or applied to policy.

Despite these limitations, LCAs remain a valuable tool for assessing the *socio-economic and environmental trade-offs* of BESS technologies and for guiding decisions that promote their sustainable development and deployment.

4.2 Flow Batteries

Flow batteries, also known as redox flow batteries (RFBs), are often highlighted as promising alternatives to lithium-ion batteries for stationary energy storage. They stand out for being safer, easier to maintain, and capable of providing power for much more extended periods, making them a good BESS technology candidate to pair with solar and wind.

4.2.1 How Flow Batteries Work

All flow batteries work under the same concept: they store energy in liquids rather than solid materials (e.g., Li-ion). These liquids, called electrolytes, hold charged particles that move through a "stack" (the heart of the battery) separated by a thin membrane (see the green portion of the Figure 10). When charging or discharging, the two liquids are pumped through the stack, and electricity is produced as ions flow across the membrane.

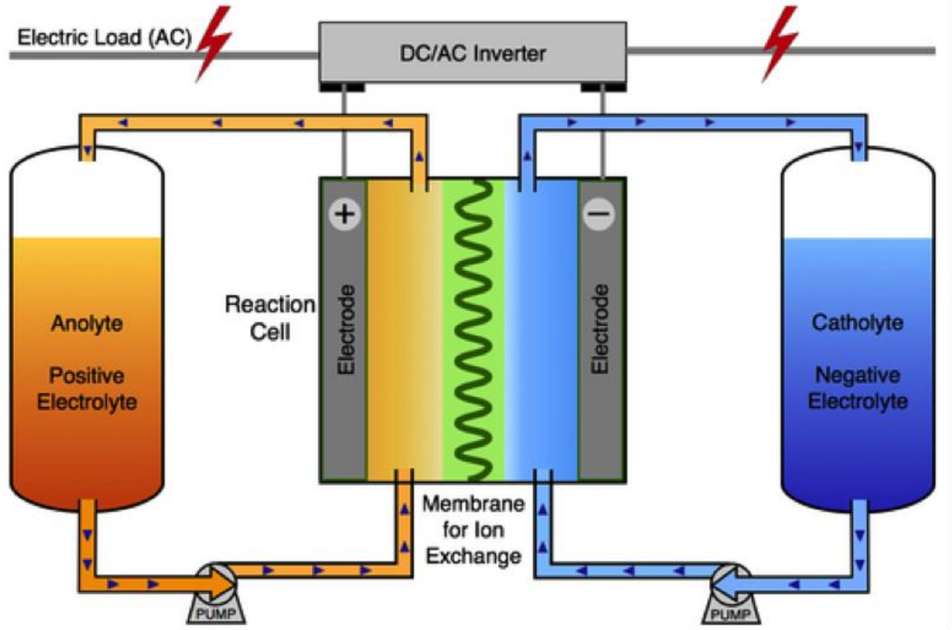


Figure 10 How Flow Batteries Work

A flow battery stores energy in two liquid electrolytes kept in separate tanks—one positive (anolyte, orange) and one negative (catholyte, blue) as shown in *Figure 10*. When the system operates, these liquids are pumped through a central reaction cell, where a membrane lets ions move between them without mixing. This ion exchange produces an electric current that can be supplied to equipment through an inverter. During charging, the reactions reverse, restoring the liquids to their original state. Because the electrolytes are reusable and stored externally in tanks, flow batteries offer long life, easy scaling, and a refillable-fuel-like operation.

Because the energy is stored in the liquid itself, the capacity of a flow battery can be increased simply by adding more liquid to its storage tanks, much like filling a fuel tank. Another advantage of flow batteries is that they can also be immediately "recharged" by replacing the spent liquids in the tank with energized liquid.

In contrast, lithium-ion batteries store energy in solid electrodes, which limits the amount of energy they can hold and makes them more susceptible to heat buildup and aging. Energy storage is the key differentiator between flow and conventional batteries.

4.2.2 Types of Flow Batteries: Vanadium Redox, Zinc-Bromine, and Iron

Flow batteries come in several types, each using different chemical liquids to store and release energy. Vanadium Redox Flow Batteries (VRFBs) are the most mature technology of those included in this review and have the largest deployed capacity, while Iron Flow Batteries (IFBs) and Zinc-Bromine (Znbr) flow batteries [40] are considered "emerging" technologies, limited to pilot or demonstration projects only.

- VRFBs and IFBs use the conventional "dual-flow" design where both positive and negative electrolytes circulate through the stack.
- ZnBr systems: Use a hybrid configuration where one side of the reaction involves a solid material instead of two liquid electrolytes.

Diagrams of these two common flow battery designs are provided in *Figure 11* for reference.

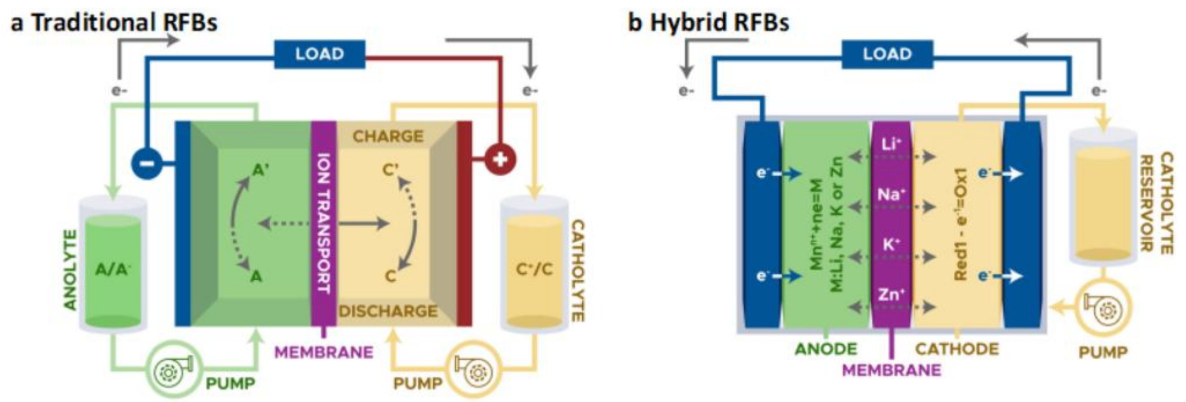


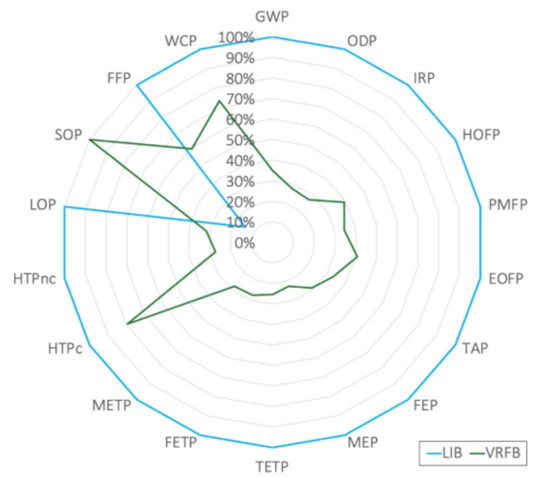
Figure 11 Two basic flow battery designs: (a) standard dual-flow system with dissolved active species, and (b) hybrid system with a solid anode active species.

4.2.3 LCA Studies and Safety Risk Comparison of LIBs and VRFBs

Recent research has compared the environmental footprint of manufacturing LIBs and VRFBs. In summary, flow batteries offer significant advantages in terms of safety, recyclability, and long-duration performance. Flow battery environmental impact studies with respect to LIB have mixed findings. Some claim that flow batteries have higher manufacturing impacts than lithium-ion systems (see *Figure 13*Error! Reference source not found.**), but they balance the emission scales during their operational phase and end-of-life, assuming they utilize substantial renewable energy systems. Another group of researchers concluded that flow batteries (specifically VRFB) produce *lower* overall manufacturing impacts compared to LIB (see** *Figure 12*Error! Reference source not found.**).**

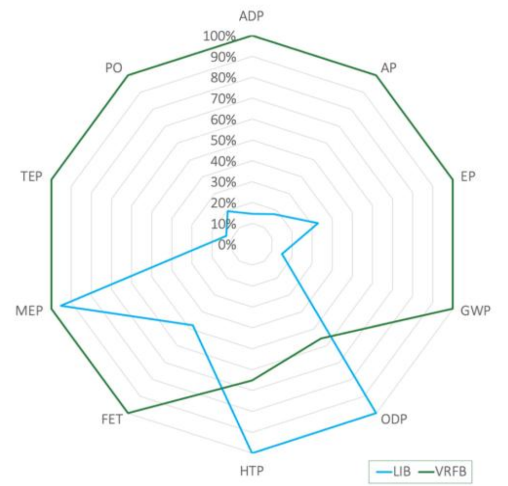
4.2.3.1 Manufacturing Phase Environmental Impact

Flow battery environmental impact studies with respect to LIB have mixed findings. A 2020 study found that manufacturing VRFBs has less battery manufacturing environmental impact than lithium-manganese-oxide (LMO) LIBs when measured per unit of stored energy, except for the 'mineral resource scarcity' category [42]. Alternatively, a 2023 study [43] reported that VRFB manufacturing has higher environmental impacts than NMC LIB production except for the 'human toxicity' and 'ozone layer depletion' categories.



Environmental Indicator	Acronym	Unit
Global Warming	GWP	kg CO_2 eq
Stratrospheric Ozone Depletion	ODP	kg CFC-11 eq
Ionizing radiation	IRP	kBq Co-60 eq
Ozone formation, Human health	HOFP	kg NO_x eq
Fine particulate matter formation	PMFP	kg PM2.5 eq
Ozone formation, Terrestrial ecosystems	EOFP	kg NO_x eq
Terrestrial acidification	TAP	kg SO_2 eq
Freshwater eutrophication	FEP	kg P eq
Marine eutrophication	MEP	kg N eq
Terrestrial ecotoxicity	TETP	kg 1,4-DCB
Freshwater ecotoxicity	FETP	kg 1,4-DCB
Marine ecotoxicity	METP	kg 1,4-DCB
Human carcinogenic toxicity	HTPc	kg 1,4-DCB
Human non-carcinogenic toxicity	HTPnc	kg 1,4-DCB
Land use	LOP	m^2a crop eq
Mineral resource scarcity	SOP	kg Cu eq
Fossil resource scarcity	FFP	kg oil eq
Water consumption	WCP	m^3

Figure 12 Environmental Impact Comparison of Lithium-Ion and Vanadium Redox Flow Batteries with Associated Indicator Definitions sourced from [42]



Environmental Indicator	Acronym	Unit
Abiotic resource depletion	ADP	kg Sb eq
Acidification	AP	kg SO_2 eq
Eutrophication	EP	kg PO_4 eq
Global warming	GWP	kg CO_2 eq
Ozone layer depletion	ODP	kg CFC-11 eq
Human toxicity	HTP	kg 1,4-DB eq
Freshwater ecotoxicity	FET	kg 1,4-DB eq
Marine ecotoxicity	MEP	kg 1,4-DB eq
Terrestrial ecotoxicity	TEP	kg 1,4-DB eq
Photochemical oxidation	PO	kg C_2H_4 eq

Figure 13 Environmental Impact Comparison of Lithium-Ion and Vanadium Redox Flow Batteries with Associated Indicator Definitions sourced from [43]

Amongst flow battery chemistries, iron-flow (IFB) systems have been found to have the lowest overall manufacturing impacts, followed by zinc-bromine (ZnBr) systems, and then VRFB systems. However, it is important to note that these findings may *not* be representative of final commercial system designs, given the limited commercial deployment of these *emerging* battery chemistries.

The most significant environmental impacts highlighted in LCAs arise from the production of electrolytes, bipolar plates, membranes, electrodes, and peripheral components (such as tanks, pipes, pumps, and steel structures), as well as from the electricity mix used for charging during operation. However, these impacts can be greatly reduced through recycling, which allows recovery of metals and electrolytes in much the same way as lithium-ion battery materials.

With continued improvements in materials, design, and renewable integration, flow batteries are well-positioned to play a growing role in California's sustainable, utility- and industrial-scale energy storage landscape.

4.2.3.2 Use-Phase Environmental Impact

Beyond the manufacturing phase, flow batteries generally exhibit higher use-phase environmental impacts than lithium-ion systems due to their lower round-trip efficiency (see Table 2**Error! Reference source not found.**). However, over their full operating life, typically exceeding 20 years with minimal capacity loss, these impacts become more balanced. When charged with renewable energy, such as solar or wind, flow battery use-phase emissions and cumulative energy demand can approach or even fall below those of lithium-ion systems [44–47].

4.2.3.3 End-of-Life Environmental Impact

Studies focusing on recycling, particularly for VRFBs, show recycling's significant contribution in reducing overall life-cycle environmental impacts. Jones et al. [48] and Weber et al. [20] estimated that recycling can cut global warming impacts by 14%–75%, depending on the electricity mix and battery utilization.

Flow battery recycling is generally less complex than Li-ion systems because the liquid electrolytes do not degrade over time. Up to 95% of stack metals and 97% of vanadium electrolytes can be recovered at end-of-life [49], significantly lowering the emissions of replacement materials. Section 4.2.4 provides insights on how the industry is implementing this in practice.

However, since flow batteries still represent a smaller share of the market, a robust recycling infrastructure has not yet been established.

4.2.3.4 Primary Safety Risk for Flow Batteries

From a safety standpoint, flow batteries are non-flammable and highly resistant to thermal runaway due to their water-based electrolytes. However, they introduce different operational risks, primarily acidic leaks, gas evolution (hydrogen, bromine, or chlorine), and minor off-gases (HF, SO_2, NO_x) that may form under high-heat or poor maintenance conditions [23]. These risks can be managed through effective system design, engineering controls, including secondary containment, corrosion-resistant materials, ventilation, continuous gas monitoring, and advancements in electrode materials.

In contrast, LFP systems, while storing energy in solid electrodes that gradually degrade over time, are now considered the safest lithium-ion chemistry for stationary applications. Their stable phosphate composition prevents oxygen release, significantly reducing the risk of fire propagation. LFP systems are also covered by well-established safety standards such as NFPA 855 and UL 9540A, ensuring proven design, ventilation, and suppression protocols for utility-scale installations.

Overall, flow batteries trade thermal safety for chemical complexity, while LFP systems combine thermal stability, regulatory maturity, and compactness, making them the more practical and reliable choice for utility-scale energy storage.

4.2.4 Industry Perspective: Comparing Vanadium, Zinc-Bromine Flow Batteries to Lithium-ion

From a practical industry perspective, the environmental impact of flow batteries, particularly Vanadium Redox Flow Batteries (VRFB), primarily stems from the production of vanadium electrolytes. However, manufacturers are addressing this challenge through several strategies:

- Implementing “circular” electrolyte models (discussed further in sub-section 4.2.4.1);
- Developing reuse strategies.
- Integrating renewable energy sources; and
- Branching out to other chemistries (e.g., Zinc-Bromine).

These initiatives help establish a viable path toward commercial sustainability.

This section offers insights into the actual sustainability practices adopted by industry leaders and manufacturers, building on the life cycle impact reports discussed earlier. This section examines how companies such as Largo Inc., CellCube, EOS Energy Storage, and Gelion Technologies are minimizing environmental impacts in flow battery production through improved electrolyte management, recycling efforts, and the use of renewable energy sources.

4.2.4.1 Largo Inc - Circular Electrolyte Ownership Model to Reduce Mining Impacts

Largo Clean Energy, a subsidiary of Largo Inc., manufactures VRFBs. Largo adopts a “holding company” model, *retaining ownership* of its vanadium electrolyte to:

(1) reduce the high upfront cost of electrolytes for customers, and

(2) ensure recovery and recycling at end-of-life.

This strategy not only lowers costs for end-users but also delivers environmental benefits by avoiding new vanadium mining and processing.

Largo’s sustainability report indicates that 25% of its electricity use now comes from renewable sources. The reported global warming impact of vanadium electrolyte production, estimated at 80–100 kg C02e per kWh of VRFB capacity, is consistent with independent findings. Table 7 summarizes Largo’s reported GHG emissions intensity trends from 2020 to 2023, showing gradual increases linked to lower annual production volumes.

Table 7 Direct GHG Emissions Intensity of Largo Vanádio de Maracás S.A. (LVMSA) for V_2O_5 Production

GHG EMISSION INTENSITY	2020	2021	2022	2023
Direct GHG emissions (tCO2e)	78,506	77,817	82,948	93,872
Annual Production (tV2O5)	11,825	10,319	10,436	9,680
GHG emissions intensity (tCO2e/tV2O5)	6.99	8.32	8.22	9.70

4.2.4.2 CellCube - Lowering Life-Cycle Emissions through Electrolyte Reuse and Renewable Charging

In 2022, German VRFB manufacturer CellCube published a life cycle assessment (LCA) of its FB 500-2000 Rel.4.0 system [29]. The study analyzed a 4-hour system cycling daily for 20 years.

The results showed that vanadium pentoxide (V_2O_5) production was the largest contributor to global warming potential (57%), followed by power unit production (16%), energy unit production (11%), and transportation (9%). However, electrolyte reuse substantially reduced environmental impact: reusing 97.5% of the electrolyte and introducing only 2.5% new material lowered the system's global warming potential by 66%

A 2023 follow-up LCA led by Blume et al. [51], based entirely on primary operational data. The results highlighted that VRFBs charged with solar power exhibit higher emissions than those charged with wind power, regardless of location, while the transport distance of structural components had a negligible impact since the heavy electrolyte dominates transport emissions.

The study also noted that onsite electrolyte production, as being explored by manufacturers such as Largo Clean Energy, can further reduce both the financial and environmental burdens associated with transporting electrolyte materials.

In summary, CellCube's analyses confirm that *vanadium production* and *electrolyte management* have the most environmental impacts in VRFB systems. Electrolyte reuse and renewable-based charging are the most effective strategies to minimize life-cycle emissions and improve the long-term sustainability of flow battery technology.

4.2.4.3 EOS Energy Storage and Gelion Technologies - Early Zinc-Bromine Flow Battery Designs Show Strong Economic and Environmental Performance

Zinc-bromine flow batteries (ZBFBs) remain in early commercial development stages but show potential for safe and sustainable stationary storage. While Redflow was one of the first major manufacturers of ZBFB, other companies, such as EOS Energy Storage and Gelion Technologies, have published independent Climate Impact Reports assessing the environmental performance of their batteries using LCA.

While many metrics are evaluated, the overall trend is clear:

- **Lower greenhouse-gas and energy intensity:** Both EOS and Gelion batteries use *less energy* and produce *fewer lifecycle emissions* per kWh than typical lithium-ion systems.
- **Reduced water use:** Their water-based electrolytes and simpler manufacturing processes minimize water demand and volatile-organic-compound (VOC) emissions.
- **Shorter carbon payback time:** The batteries offset their production-phase emissions more quickly, meaning they achieve net climate benefits sooner in operation.

These results indicate that zinc-bromine batteries combine strong environmental performance with the inherent safety of non-flammable, water-based chemistries. Although still maturing commercially, they demonstrate how alternative flow and hybrid chemistries can contribute to the long-term sustainability of the stationary storage market.

In summary, EOS and Gelion's climate impact studies show that zinc-bromine batteries perform well environmentally compared to lithium-ion. They use less energy and water over their lifetime, emit fewer greenhouse gases, and pay back their carbon footprint faster. Their results also demonstrate how non-flammable, water-based chemistries can reduce both environmental and safety risks for stationary energy storage.

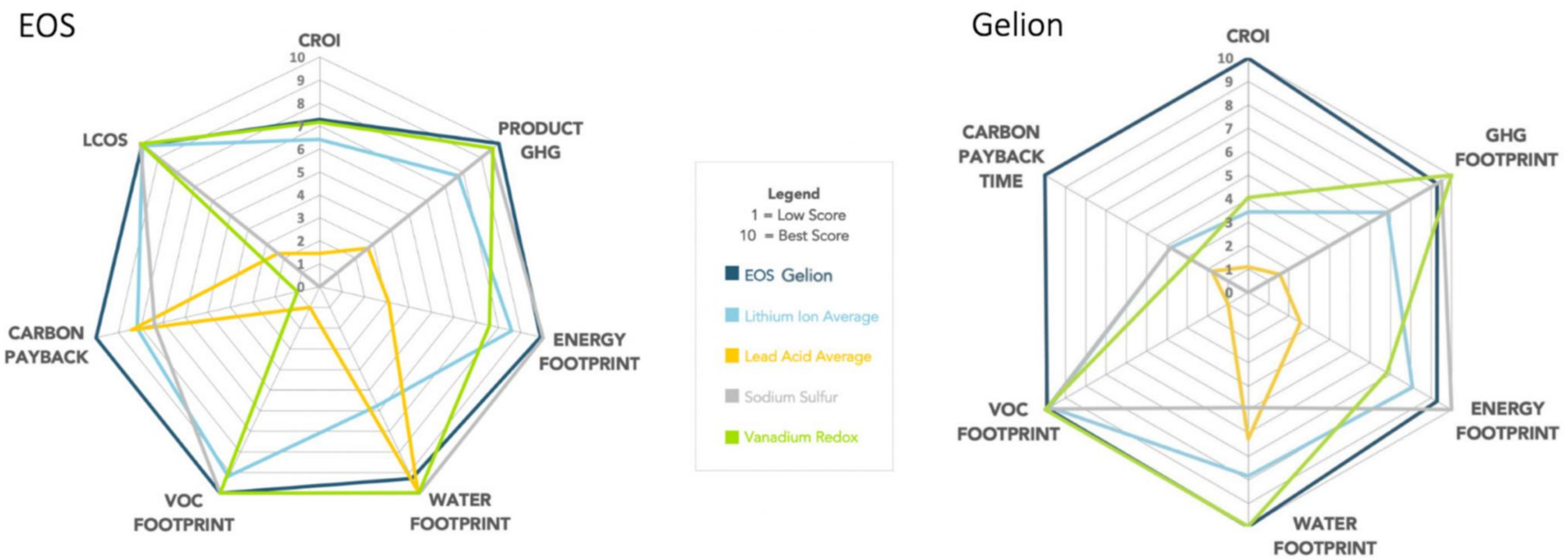


Figure 14 Summary results from the Climate Impact Profiles for EOS (Left) and Gelion (Right), showing strong performance across GHG, energy, water, and VOC metrics.[14]

[14] Image reproduced from EPRI. *Review of Environmental Life Cycle Assessments for Select Advanced Lithium and Non-Lithium Energy Storage Technologies*. Palo Alto, CA: EPRI, December 2024. Report 3002030237

Table 8 Description of Metrics Used for Comparing VRFB, EOS, Gelion, and Li-ion BESS Technologies[15]

ENVIRONMENTAL KEY PERFORMANCE INDICATOR (EKPI)	UNIT OF MEASURE	DESCRIPTION
Energy Intensity	MJ/kWh · lifetime	A measure of the energy input per kWh of stored energy during the lifetime of the battery.
GHG Intensity	$kgCO_2e$/kWh · lifetime	A measure of the greenhouse gas impact per kWh of stored energy during the lifetime of the battery.
Levelized Cost of Production/ Levelized Cost of Storage (LCOS)	$/kWh	The levelized unit-cost of battery production in terms of storage capacity.
Water Footprint	Gallons/kWh · lifetime	A measure of the water use per kWh of stored energy during the lifetime of the battery.
Solvent/VOC Footprint	mg/kWh	A measure of the VOC avoided by using water-based manufacturing, measured per kWh of stored energy.
Carbon Return on Investment (CROI)	$kgCO_2e$ saved/$1M investment	A measure of the climate impact (positive or negative) of each $M dollars (USD) investment.
Carbon Payback Time	Years	A measure of the time that it takes for a product's use to offset the GHG of its production.
Carbon Return on Purchase	$kgCO_2e$/kWh installed	A measure of the greenhouse gases avoided by customers per kWh of customer energy storage.

Table 9 Comparative environmental scores for EOS, Gelion, Li-Ion, and VRFB from manufacturing to use phase

Metric	EOS	Gelion	Li-Ion Avg	VRFB Avg
CROI (Carbon Return on Investment)	7	10	5	5.5
GHG Footprint	10	9.5	7.5	9.5
Energy Footprint	10	9	8.5	7
Water Footprint	9	10	8	10
VOC Footprint	10	10	9.5	10
Carbon Payback Time	10	10	6	2
LCOS / Product Cost Efficiency	10	N/A	10	10

Overall, emerging zinc-bromine technologies demonstrate that non-flammable, water-based chemistries can deliver both safety and sustainability advantages, supporting California's transition to low-impact utility- and industrial-scale energy storage.

[15] Image reproduced from EPRI. *Review of Environmental Life Cycle Assessments for Select Advanced Lithium and Non-Lithium Energy Storage Technologies.* Palo Alto, CA: EPRI, December 2024. Report 3002030237

4.2.5 Key Takeaways on Flow Battery and Li-ion: Maturity, Comparative Outlook, and Path Forward

Flow batteries represent one of the most promising emerging alternatives to lithium-ion for long-duration and utility-scale energy storage with little to no thermal safety concerns. Their non-flammable, water-based electrolyte characteristics nearly eliminate the thermal runaway risks inherent even in the safest lithium-ion chemistries. In addition, their independent scaling of energy and power, along with a 20- to 30-year design life, enable predictable long-term operation.

Finally, while it might take VRFB longer than LFP to offset their greenhouse gas emissions during manufacturing, their high recyclability, combined with renewable energy integration and electrolyte management, allows them to have a smaller overall environmental impact vs. LFP over their full life cycle.

Among all flow battery chemistries, VRFB remains the most commercially mature option. They benefit from standardized stack designs, electrolyte chemistry, and growing recycling pathways that recover up to 97% of vanadium content. However, their up-front cost, land footprint, and dependence on mined vanadium continue to constrain near-term competitiveness against LFP systems for projects below multi-megawatt scale.

Iron-Flow Batteries and Zinc-Bromine Flow Batteries address some of these material and cost barriers by replacing vanadium with more abundant elements. IFBs offer potential cost advantages and lower embodied energy, though they are still limited by prototype-scale demonstrations and uncertain stack durability. ZBFBs, on the other hand, show strong environmental performance and safety in early-stage analyses (e.g., EOS and Gelion studies), but have yet to prove long-term reliability and scalability.

When compared with LFPs, flow batteries trade compactness and round-trip efficiency for thermal safety, durability, and recyclability. LFP remains the most practical choice for dense community sites and short-duration applications. At the same time, flow batteries, especially VRFBs, are better suited for multi-hour storage supporting renewable integration, grid-support functions, and remote microgrids.

In summary, flow batteries complement rather than replace lithium-ion technology. They fill a distinct market niche where safety, longevity, and environmental stewardship outweigh footprint and efficiency. As material innovations and circular-electrolyte business models mature, VRFBs, and eventually IFBs and ZBFBs, are poised to play a central role in California's transition to safe, sustainable, long-duration energy storage.

5 Development Guidelines

This section provides BESS safety practices and standards, and development guidelines with a focus on thermal safety, UL/NFPA compliance, and local permitting requirements. These guidelines ensure that battery storage projects are designed, certified, and implemented to meet industry standards while addressing safety, regulatory, and community concerns.

5.1 Introduction

5.1.1 Case Study: McMicken, AZ Battery Fire Incident

On April 19, 2019, a significant incident occurred at a 2 MW / 2 MWh lithium-ion BESS facility located in McMicken, Arizona, operated by Arizona Public Service (APS). The system used lithium Nickel Manganese Cobalt Oxide (NMC) battery cells housed within a single containerized unit.

A thermal runaway was triggered by a battery cell failure, likely caused by a manufacturing defect or electrical fault. This led to overheating and the release of flammable gases inside the battery container. Although gas detectors were installed, the system did not activate ventilation quickly enough to prevent gas buildup. When first responders opened the container door without full awareness of the explosive environment, oxygen entered and caused an explosion, injuring four firefighters, two of whom suffered serious injuries.

5.1.2 Impact, Lessons Learned, and Industry Response:

The McMicken incident became a landmark event for the energy storage industry, prompting:

a) Strengthened adoption and enforcement of NFPA 855 and related fire safety standards.
b) Mandatory UL 9540A testing for thermal runaway and fire propagation risks.
c) Improved training for first responders and revised emergency response protocols for BESS sites.
d) Design improvements such as module isolation, gas monitoring, blast venting, and automatic ventilation triggers.

5.1.3 Summary

In summary, the McMicken incident demonstrated that even small failures in design, detection, or emergency response can escalate into large-scale safety events. To prevent such outcomes, the industry adopted:

a) BESS safety practices by requiring BESS technology certifications, testing frameworks, and
b) Development guidelines through regulatory compliance, permitting, and local standards.

Sections 5.2 (BESS Fire and Thermal Safety Practices and Standards) and Section 5.3 (UL Certification) build on the safety lessons of 5.1 by showing how system-level certification (UL 9540) and fire-propagation testing (UL 9540A) provide independent validation that a BESS can contain, suppress, and manage thermal runaway risks under real-world conditions. This ensures that failures like McMicken are anticipated and designed against before projects are deployed.

Section 5.4 (Local Permitting and Compliance Requirements) complements certification by addressing the regulatory and siting safeguards that must be in place for BESS projects. From detailed project reports and grid impact studies to spacing, fire protection plans, farmland mitigation, and LSFT testing, these requirements ensure projects are not only technically safe but also acceptable to communities, utilities, and permitting agencies.

Together, Sections 5.2, 5.3, and 5.4 provide the standards and governance framework that translate the lessons of past incidents (See Section 6) into practical, enforceable guidelines for safe BESS development.

5.2 BESS Fire Safety Practices and Standards - NFPA 855

5.2.1 Overview of NFPA 855

NFPA 855, Standard for the Installation of Stationary Energy Storage Systems, provides critical guidance for minimizing risks and ensuring safe and compliant installation of ESS, with a strong emphasis on life safety. The standard outlines detailed requirements for fire protection based on factors such as the specific ESS technology, installation environment, system size, separation distances, and the implementation of fire suppression and control systems [33].

Additionally, NFPA 855 addresses key safety aspects, including fire detection and suppression systems, explosion mitigation, exhaust ventilation, gas detection mechanisms, and the management of thermal runaway events.

5.2.2 Applicability and Scope

NFPA 855 applies to a broad range of ESS technologies, including electrochemical, chemical, mechanical, and thermal systems. The standard specifies requirements based on factors such as system size, technology type, installation setting (indoor/outdoor), spacing, and the presence of fire protection and suppression systems.

5.2.3 Fire Protection and Explosion Control

The 2023 edition mandates fire suppression systems for all ESS installations, although the AHJ may grant exceptions under specific risk-controlled conditions [34]. The standard outlines two key approaches to managing explosion risk:

a) Deflagration Control – Implementing venting mechanisms such as blast panels, in accordance with NFPA 68, to safely direct overpressure away from critical areas.
b) Explosion Prevention – Utilizing continuous exhaust ventilation, as per NFPA 69, to prevent gas accumulation and ignition.

An integrated approach combining both methods, along with containment solutions for thermal runaway, offers enhanced protection, minimizes propagation risk, and improves firefighter safety, especially in scenarios like the McMicken, AZ incident given in above section.

5.3 UL certification

5.3.1 Overview of UL9540 and UL9540A

UL 9540 is a system-level safety standard developed by Underwriters Laboratories (UL) in 2016 to ensure the safe operation of Energy Storage Systems (ESS). It evaluates the entire system, including the battery and inverter, rather than just individual components. This standard covers a wide range of safety aspects such as electrical, mechanical, thermal, and environmental performance. It ensures that the system can operate safely under normal and fault conditions. Importantly, UL 9540 certification must be obtained through a Nationally Recognized Testing Laboratory (NRTL), and it is often required by fire and building codes such as NFPA 855, NFPA 1, the International Fire Code (IFC), and the International Building Code (IBC). While component-level certifications like UL 1973 (for batteries) and UL 1741 (for inverters) are important, they are not sufficient on their own to meet UL 9540 requirements [30].

UL 9540A, on the other hand, is not a certification but a test method designed to evaluate the fire risks associated with thermal runaway in battery systems. It provides a structured approach to assess how a fire might propagate within an ESS and how effectively it can be contained. The test is conducted at four levels: cell, module, unit, and installation. At the cell level, it examines flammability and gas emissions. The module level assesses whether thermal runaway can spread between cells. The unit level evaluates the behavior of the entire system during a fire event, and the installation level simulates real-world conditions to test fire suppression and spacing requirements. UL 9540A is particularly useful for permitting, as it provides data that can justify reduced spacing between systems or other deviations from standard fire code requirements. It is often used in conjunction with NFPA 855 to demonstrate that a system can be safely installed even in more compact configurations [30].

5.3.2 UL 9540A testing

UL 9540A is a test method shown in *Figure 15* [32] is to evaluate the fire safety hazards associated with propagating thermal runaway within battery systems. The tests establish that a storage technology is capable of reaching thermal runaway and then assess the fire and explosion hazards of that technology.

Thermal runaway occurs when a chemical reaction has gotten out of control and can no longer safely dissipate excess heat. Thermal runaway can be caused by internal short-circuits, overcharging, physical damage to cells, or high- and low-temperature environments.

The UL 9540A test method starts at the cell level and gradually builds to the installation level over four steps. If an ESS technology meets the performance criteria of any of the first three tests, there is no requirement to continue testing the subsequent levels. If not, it moves to the next level [31].

5.3.2.1 Cell-Level Tests

The UL 9540A testing process begins at the cell level, which is the smallest unit of a battery system. The objective is to determine whether a single cell can be driven into thermal runaway using multiple methods and repeated attempts. This stage sets a high benchmark for safety, as very few technologies successfully pass without exhibiting signs of failure. If no observable flaming, smoke, or gas venting occurs during these tests, the process concludes at this level, indicating strong cell-level safety performance.

5.3.2.2 Module-Level Tests

If the cell-level tests indicate potential risk, the next stage involves assembling cells into modules and retesting. The goal here is to force thermal propagation between one or more cells within the module. Observations focus on external flaming, smoke emission, and heat release. Additionally, any gases produced during the test are collected and analyzed for hazardous content. Like the cell-level tests, this stage also presents a stringent safety threshold. In most cases, systems proceed to the next level due to the complexity of containing propagation at the module level.

5.3.2.3 Unit-Level Tests

At this stage, the ESS unit is tested without any external fire suppression systems, unless such systems are integrated within the ESS itself. A variety of indoor and outdoor mounting configurations are evaluated. Performance criteria differ based on the installation type and whether the system is residential or non-residential. Residential ESS must meet strict performance standards at this level, as it cannot be assumed that homes are equipped with fire suppression systems. Non-residential systems that do not meet the criteria at this stage are advanced to the final level of testing.

5.3.2.4 Installation-Level Tests

The final stage of UL 9540A testing closely resembles the unit-level tests but includes the evaluation of fire suppression agents. The effectiveness of these agents is analyzed to determine whether they can prevent detonation, deflagration, flaming, or reignition after the initial fire event. Systems that pass this stage demonstrate robust fire safety and are deemed compliant. Those that fail must either modify their technology or revise their installation approach before undergoing retesting.

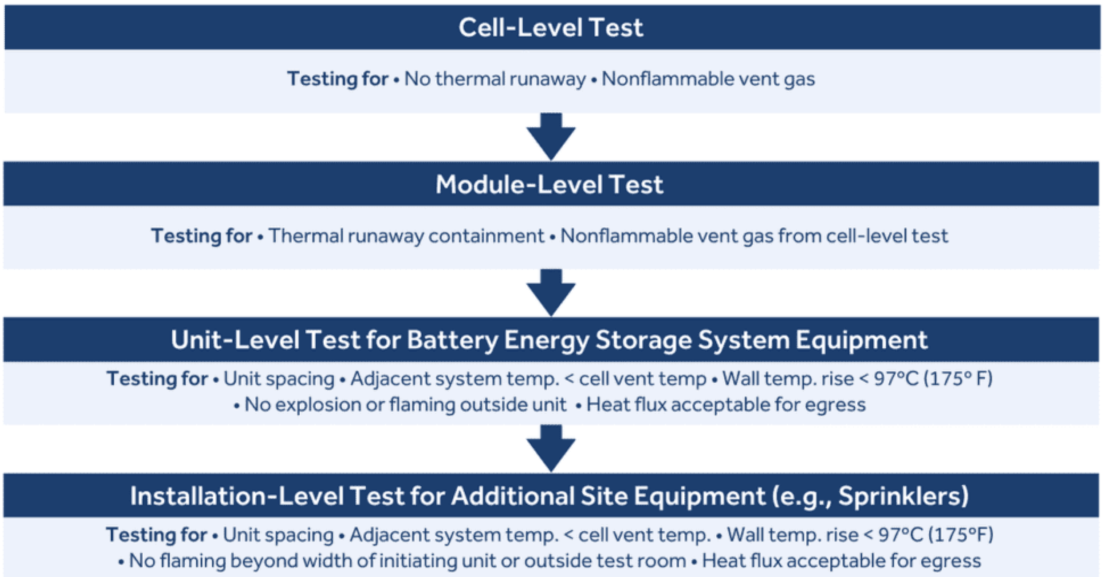


Figure 15 UL9540A Test Sequence (Image Reproduced from Mayfield Renewables)

It is the primary safety certification standard for energy storage systems, especially those using lithium-ion technology. It is essential for assessing and validating the entire BESS, including the battery modules, inverters, control systems, and associated safety features.

5.3.2.5 Ensures System-Level Safety Compliance

UL 9540 evaluates the integrated BESS as a complete system. This includes:

a) Fire and electrical safety
b) System functionality under normal and fault conditions
c) Proper interaction between components (battery, inverter, BMS, etc.)
d) Emergency shutdown and fault isolation features

This system-level testing ensures that safety is preserved even in complex, interconnected configurations.

5.3.2.6 Supports UL 9540A Testing for Thermal Runaway

UL 9540 certification is often paired with UL 9540A**,** which specifically tests a system's resistance to thermal runaway propagation—a key concern with lithium-ion batteries. UL 9540 ensures the system design incorporates containment, suppression, and controls that are validated by UL 9540A fire behavior data.

5.3.2.7 Reduces Fire and Explosion Risk

UL 9540 testing verifies critical safety mechanisms such as:

a) Battery Management System (BMS) functionality
b) Overvoltage, overcurrent, and thermal protection
c) Safe ventilation and shutdown controls
d) Fire containment and suppression capabilities

5.3.2.8 Enhances Market Credibility and Insurance Compliance

For developers, integrators, and utilities, having UL 9540 certification:

a) Demonstrates compliance with best practices and third-party validation
b) Facilitates smoother project approvals and interconnection processes
c) Is often required by insurers and financiers to mitigate project risk

5.3.2.9 Key players in the US market

Table 10 provides a summary of key players in the US market providing UL9540-certified BESS

Table 10 UL 9540 certified BESS vendors

Company	Product/System	Application
Tesla	Megapack	Utility-scale
Fluence Energy	Fluence Cube	Grid-scale, hybrid systems
LG Energy Solution	RESU, Rack-based modules	Residential and commercial
Powin Energy	Stack750, Centipede	Utility and commercial
Enphase Energy	IQ Battery	Residential solar + storage
Wärtsilä	GridSolv Series	Utility-scale, hybrid grids

5.4 Local Permitting and Compliance Requirements

This section highlights key factors that may influence or support the deployment of BESS, as illustrated in Figure 16.

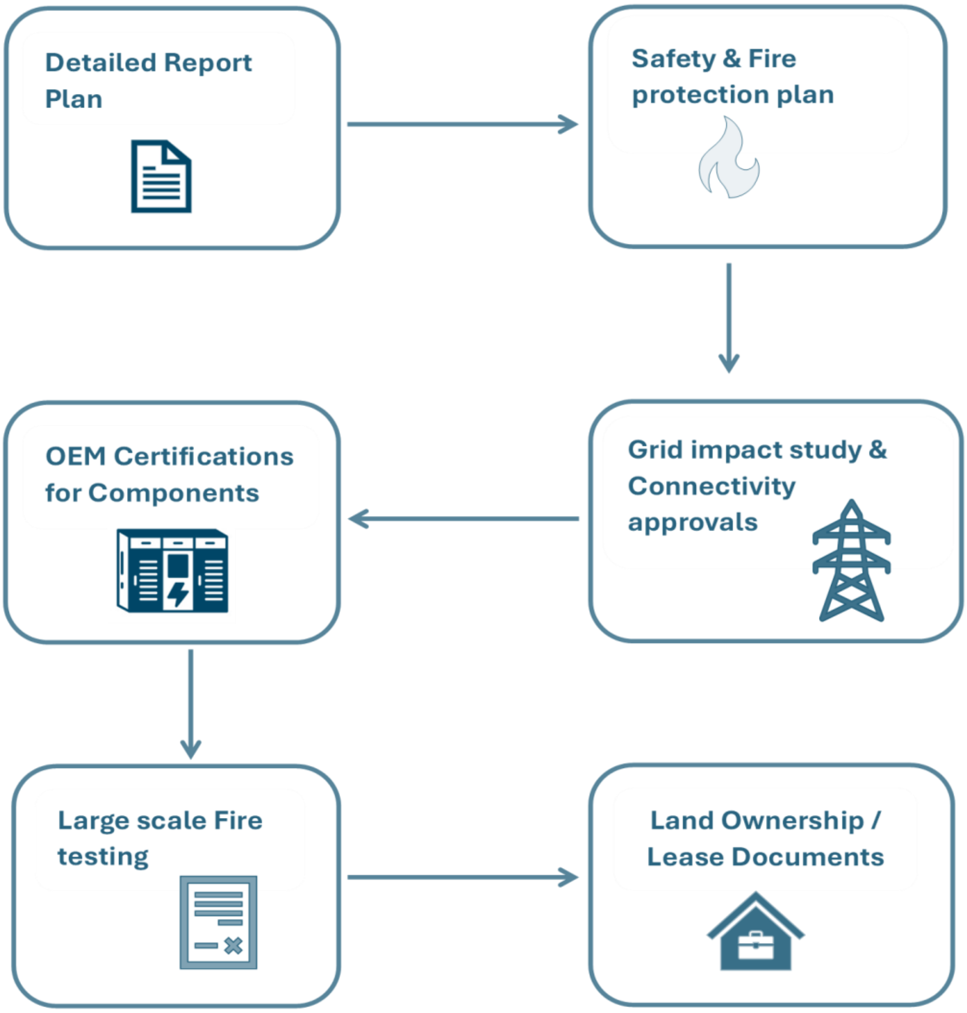


Figure 16 Key Requirements for BESS Planning in Vacaville, California

5.4.1 Detailed Project Report

Detailed project reports form the backbone of any BESS development proposal. It should provide a comprehensive overview of the system configuration, including the proposed energy and power capacity, the site layout, technical specifications of equipment, system architecture, control strategy, and the project implementation timeline. The DPR also serves as a reference for all stakeholders, including utility partners, permitting agencies, and investors.

5.4.2 Safety and Fire Protection Plan

Given the high energy density and fire risk associated with Lithium-ion batteries, developers must submit a detailed Safety and Fire Protection Plan in compliance with NFPA 855 and other applicable fire codes. This plan should include measures for fire detection, suppression systems, explosion control, and thermal runaway containment.

5.4.3 Grid Impact Study and Connectivity Approval

A Grid Impact Study must be conducted to evaluate how the proposed BESS will affect the local electrical network. This includes assessments of load flow, voltage profiles, short-circuit levels, and dynamic stability. The study should identify the Point of Interconnection (POI) and include required upgrades, protection coordination, and compliance with interconnection standards. Approval from the relevant utility or Independent System Operator (e.g., CAISO) is necessary before proceeding to construction.

5.4.4 Spacing and Safety Setback Requirements

Ensure the BESS is set back a safe distance from property lines, public roads, and especially any adjacent buildings or homes. This reduces the risk of fire spreading beyond the site and provides a buffer for heat and smoke. As a reference, San Diego County's interim BESS guidelines mandate a minimum 100-foot setback from any adjacent residences, and also a 100-foot buffer from undeveloped wildlands to comply with defensible space requirements in high fire areas.

5.4.5 Land Ownership or Lease Documents

Legal control of the project site must be established through documented land ownership or long-term lease agreements. These documents are necessary to demonstrate that the developer has the right to access, build on, and operate the proposed BESS installation. Zoning regulations and local land-use permissions must also be verified to ensure compliance with city or county development guidelines.

If a BESS is proposed on farmland, special scrutiny is needed to protect prime soils and agricultural viability. Alameda County pioneered an approach requiring 1:1 mitigation for any prime farmland converted to solar/BESS use or a demonstration that the soil will be preserved for future restoration. For example, if 10 acres of prime farmland are used for a BESS, the developer could be required to fund the permanent protection of 10 acres of farmland elsewhere or commit to restoring the site to agricultural use after decommissioning. The key is ensuring that hosting a BESS does not needlessly remove high-quality farmland from production in the long term

5.4.6 OEM Certifications for Major Components

To ensure system safety and reliability, all major BESS components must carry certifications from accredited testing bodies. The BMS should be certified under UL 991 and UL 1973, while the PCS must comply with UL 1741 and IEEE 1547. Additionally, the fully integrated system should be listed under UL 9540, which is required by fire codes such as NFPA 855 and the International Fire Code (IFC).

5.4.7 Large-Scale Fire Testing (LSFT) Reports

It is a critical safety validation process for BESS, particularly those utilizing lithium-ion technology. Conducted in accordance with CSA TS-800:24, LSFT provides a standardized method for evaluating fire hazards such as thermal runaway propagation, gas release, fire spread, and explosion risks within energy storage systems. Unlike traditional UL 9540A tests, which may not always result in a fire condition, CSA TS-800:24 simulates worst-case failure scenarios to verify that a fire originating within a fully involved ESS unit does not propagate to adjacent units or external exposures, thereby safeguarding lives and infrastructure [36]. This testing is especially vital for containerized systems, custom rack configurations, or any design that deviates from standard installation practices outlined in NFPA 855. AHJ reviews the results from LSFT to determine if additional mitigation measures such as gas ventilation, deflagration venting, or enhanced separation are necessary.

6 Case studies for BESS Incidents

6.1 Background: Moratorium on BESS in Solano County

On January 23, 2024, Solano County decided to place a two-year moratorium on the development and installation of new front-of-the-meter BESS due to increasing safety concerns following a series of major fire incidents at similar facilities across California.

According to Solano County spokesperson Matthew Davis, that moratorium will remain in effect until January 23, 2026, or until county staff can develop and adopt new regulations governing the permitting, siting, safety, and operation of such systems, whichever comes first [20] [21].

BESS thermal runaway or fire safety concerns began after a 2023 fire at the Valley Center Energy Storage Facility in San Diego County. These BESS thermal runaway events at the Terra-Gen Valley Center facility, the Gateway Energy Storage site in Otay Mesa, and SDG and E's Escondido BESS each involved lithium-ion battery containers. Additionally, they triggered evacuations, prolonged fire suppression efforts, and environmental monitoring.

6.2 Terra-Gen Facility in Valley Center BESS Thermal Event

Located in Valley Center, San Diego County, CA, the Valley Center Energy Storage Facility is a stand-alone 139MW energy storage project situated on a 7-acre property within Valley Center's commercial-industrial zone, as shown in Figure 17. The key specifications about the project and the incident are provided in Table 11.

VALLEY CENTER, CA – FEBRUARY 15, 2022: Terra-Gen, a leading operator and developer of critical renewable energy projects, announced the Valley Center Battery Storage Project is online and providing clean energy to the local power grid.

The Valley Center Energy Storage Facility produces enough electricity to power up to 140,000 homes for four hours on a single charge. It includes long-term power purchase agreements with San Diego Gas and Electric. The Project provides essential grid reliability services to the local area and helps integrate greater supplies of renewable energy in California [22].

The Project is providing about $40 million to the local area in jobs and economic activity in and around Valley Center, with about 100 direct construction jobs and other indirect jobs as workers eat, shop, and stay in Valley Center. There will also be millions of dollars in property tax benefits resulting from the Project [23]. A BESS unit in the Valley Center Energy Storage System caught fire at approximately 5:15 PM local time on 18 September 2023 [24]. The Investigation is in process.

Figure 17 Terra-Gen Facility, Valley Center

Table 11 Valley Center BESS – Specifications and Incident Timeline

Parameter	Details
Location	Valley Center, San Diego County, CA
Area	7 acres
Capacity	140 MW / 4 Hr
Power Purchase Agreement (PPA)	With San Diego Gas and Electric
Commercial Operation Date (COD)	2022
Battery Type	Lithium-ion
Date of Fire Incident	September 2023

6.3 Gateway Energy Plant in Otay Mesa BESS Thermal Event

Gateway Energy Storage is a lithium-ion energy storage facility located in Otay Mesa, CA (San Diego County). The project provides energy storage services for the wholesale energy market. Phase One provides 250 MWh capacity, while Phase Two will provide an additional 250 MWh [25].

On May 15, 2024, a fire broke out at the Gateway Energy Storage facility, with periodic flare-ups until May 28. The facility contained approximately 14,796 nickel-manganese-cobalt lithium-ion batteries, as shown in Figure 18. The key specifications about the project and the incident are provided in Table 12.

The root cause of the fire remains under investigation. EPA and local agencies will continue to oversee cleanup activities until all work is completed, and the site no longer poses a threat to public health or the environment [26].

Figure 18 Gateway Energy plant in Otay Mesa

Table 12 Otay Mesa – Specifications and Incident Timeline

Parameter	Details
Location	Otay Mesa, CA
Area	4 acres
Capacity	250 MW / 1 Hr
Power Purchase Agreement (PPA)	With San Diego Gas and Electric
Commercial Operation Date (COD)	2020
Battery Type	Lithium-ion
Date of Fire Incident	May 2024

6.4 Chandler, Arizona BESS Fire

On April 18, 2022, a large fire broke out at the Dorman battery energy storage system (BESS) in Chandler, Arizona, a 10 MW facility operated by AES for the Salt River Project (SRP). The BESS was situated in an 8,000–9,000 square foot steel building constructed in November 2019. The incident began as a smoldering fire inside the lithium-ion battery containers, triggering the facility's sprinkler systems and leading to the release of smoke and potentially hazardous gases. Due to the risk of thermal runaway and explosion, firefighters adopted a cautious strategy, using robots to open doors, ventilate the site, and measure internal conditions before sending personnel inside. Authorities ordered evacuations within a quarter-mile radius as a precaution. The fire continued to smolder for several days before being brought under control, with the Chandler Fire Department finally declaring it extinguished on May 1.

This BESS consisted of 3,600 batteries placed in a series of arrays with a total capacity of 10MW as depicted in Figure 19. The incident is believed to involve thermal runaway (a cascading failure in battery cells leading to self-heating), though the exact root cause was under investigation and not confirmed at the time of reports.

Figure 19 Interior battery rack setup of Chandler, Arizona facility

6.5 Liverpool, UK ESS Fire

A fire occurred at the Carnegie Road ESS in Liverpool, United Kingdom on September 15, 2020. This facility had an energy storage capacity of 20 MW split among three outdoor shipping-type enclosures. Firefighters used main water jets and ground monitors to fight the blaze, which burned for several hours. Nearby residents were asked to keep windows and doors closed due to heavy smoke.

The exact ignition source was never publicly confirmed, but the fire originated inside one of the 20 MW NEC-supplied lithium-ion battery containers. Reports and later analyses suggest thermal runaway in a cell or rack as the likely trigger, which then spread within the container. Like most lithium-ion ESS fires, this produced intense heat, toxic smoke, and re-ignition risks, making suppression extremely difficult.

6.6 Moss Landing BESS Overheating & Meltdown Incident

The Moss Landing Energy Storage Facility in Monterey County [63] one of the world's largest lithium-ion BESS installations—has experienced multiple safety events that significantly influenced California's energy-storage regulations. The first major incident occurred on 4 September 2021, when smoke inside the Phase-I facility triggered the water-based suppression system at a threshold lower than intended. Due to un-tested hose couplings and floor cracks, water leaked onto battery racks, causing short-circuiting and thermal damage to about 7 % of the modules, prompting highway closures and a shelter-in-place advisory.

A second, far more severe event occurred on 16 January 2025 [64], when a large-scale fire in the 300 MW system led to the evacuation of 1,200–1,500 residents. Fire crews allowed the batteries to burn out due to the difficulty of extinguishing lithium-ion fires, and subsequent environmental assessments detected heavy-metal contamination in nearby soil. The County declared a state of emergency, moved toward a moratorium on new BESS projects, and the U.S. EPA issued a CERCLA-based cleanup order requiring removal of damaged modules under federal oversight. Collectively, these incidents underscored vulnerabilities in detection, suppression, water-ingress protection, and emergency response, prompting design changes, stricter operating protocols, and renewed scrutiny of large-scale lithium-ion energy-storage safety across California.

6.7 BESS Incident Case Studies Key Takeaways

These case studies illustrate that while large-scale BESS projects such as Terra-Gen's Valley Center and Gateway Energy in Otay Mesa deliver significant economic, reliability, and clean energy benefits, high-profile thermal runaway incidents have raised public safety concerns.

Hence, the resulting moratorium in Solano County reflects a broader industry challenge: balancing the rapid deployment of storage needed for California's clean energy goals with community trust through safety, compliance, and operational standards and requirements. By aligning development with frameworks such as NFPA 855, UL 9540/9540A, and local permitting requirements, upcoming BESS projects can mitigate risks, maintain public confidence, and avoid policy setbacks that slow progress toward decarbonization.

7 Conclusion

This report provides a detailed and strategic assessment of Battery Energy Storage System deployment, integrating technical and regulatory considerations. Through a structured evaluation of DERs, including solar PV and natural gas-based systems, the report emphasizes the critical role of BESS in enhancing grid reliability, supporting renewable integration, and improving energy resilience.

The report also outlines best practices for implementation, including fire safety, permitting, and system certification, ensuring that future BESS projects are both technically sound and community aligned. Overall, the findings serve as a roadmap for transition toward a modern, flexible, and sustainable energy infrastructure.

7.1 Key Findings

a) **Technology Selection:** Vanadium Redox Flow Batteries (VRFBs) provide strong advantages for an emerging long-duration storage, including inherent safety (non-flammable electrolyte), long cycle life, and suitability for daily cycling over decades. Lithium-ion batteries offer high energy density, compact footprint, scalability, and proven performance in grid applications. Both technologies are viable depending on project priorities—it will ultimately be up to the *client* to decide whether to pursue LFP, flow batteries, or a combination of both, based on cost, duration needs, and site-specific requirements.

b) **BESS Safety and Compliance:** UL 9540 and UL 9540A certifications, along with NFPA 855 compliance, are essential for mitigating fire risks and ensuring safe deployment.

c) **Thermal Management:** Active and hybrid cooling systems are critical to prevent thermal runaway and ensure long-term reliability.

d) **Regulatory Landscape:** The current moratorium on BESS installations in Vacaville underscores the need for proactive planning, stakeholder engagement, and alignment with evolving city policies.

7.2 Call to Action for Stakeholders

To realize the full potential of DERs and BESS in Vacaville, stakeholders, including city planners, utility partners, developers, and community leaders, are encouraged to:

a) **Engage in Policy Dialogue:** Collaborate with city officials to shape regulatory frameworks that balance innovation with safety and community interests.

b) **Adopt Certified BESS Technologies:** Ensure that all deployed systems, whether Lithium-ion or Flow Batteries, comply with UL 9540, UL 9540A, and NFPA 855 standards to facilitate regulatory approvals, guarantee safety, and minimize operational risks..

c) **Require Developers to Invest in Safety Infrastructure and Practices:** Incorporate advanced thermal management, disaster response principles, fire suppression, and gas detection systems in all BESS designs.

d) **Promote Public Awareness:** Educate residents and businesses on the benefits of energy storage, including grid resilience, cost savings, and environmental impact.

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ATTACHMENT 7

Albert Enault

From: Dennis Billeci <billfam3@sbcglobal.net>
Sent: Monday, January 5, 2026 4:29 PM
To: Albert Enault
Subject: Proposed Battery storage in north Vacaville

I'm in writing this in response to a notification I got in the mail about a month ago. I was unable to attend the City Hall meeting as we were out of the state. I live in North Vacaville, and I am surprised there is another proposal to put another battery storage in North Vacaville area near our houses. The last thing the mayor said was, he asked himself would I want one of these in my neighborhood? and his answer was no. so you all voted 'no' on the last battery storage facility. honestly I don't understand why this is happening again, not much has changed in the last few months. If it wasn't a good idea then, it still is not a good idea. Please do not put something like this near my neighborhood, if they want to build battery storage facilities, they need to be away from homes. Remember, I'm sure you wouldn't want it in your neighborhood near your home.

Sincerely
Sandy Billeci

Albert Enault

From: Jodee Hanson <jjhansen230@gmail.com>
Sent: Friday, January 2, 2026 11:40 AM
To: John Carli; Greg Ritchie; Ted Fremouw; Roy Stockton; Sarah Chapman; Michael Silva; Jeanette Wylie; Albert Enault; Erin Morris; Michelle Thornbrugh; Savita Chaudhary; Andria Borba
Subject: Saying no to the lithium battery sites in Vacaville

Saying no to the lithium battery sites in Vacaville . It is hazardous for us here in vacaville we have enough problems with the water quality and recently the hike in our fire insurance and having them here will insure that we will have another price rise. Please keep our community safe . For our children and grandchildren.

Albert Enault

From: Grace USA <graceusa2026@gmail.com>
Sent: Wednesday, December 24, 2025 12:59 PM
To: Albert Enault
Subject: Updated Bess Ordinance link

CAUTION: This Email is from an EXTERNAL source. Ensure you trust this sender before clicking on any links or attachments.

Wed Dec 24, 2025

Hello,

According to the Milestone chart, the next public hearing on the Bess draft Ordinance is January 20th to the Planning Commission.

When will that updated version of the draft revised Bess Ordinance that will go to the Planning Commission, be available to the public to review? Can you send me the link to it and let me know when it will be updated?

Thanks

Cheryl

Albert Enault

From: dashmesh singh <singhd.web@gmail.com>
Sent: Friday, December 19, 2025 6:43 PM
To: John Carli; Greg Ritchie; Ted Fremouw; Roy Stockton; Sarah Chapman; Michael Silva; Jeanette Wylie; Albert Enault; Erin Morris; Michelle Thornbrugh; Savita Chaudhary; Andria Borba
Subject: ban BESS in the city limits

ban BESS in the city limits

Albert Enault

From: m cruz <mcruzrn@gmail.com>
Sent: Thursday, December 18, 2025 12:42 PM
To: Albert Enault
Subject: Keeping Vacaville Safe

Dear Sir,

I echo what long standing (and future) citizens of Vacaville have already stated in this issue: please ban BESS near residential areas. Let's keep Vacaville safe.

Thank you and happy holidays.

Marilou Cruz

Albert Enault

From: Gayle Falt <grfalt@gmail.com>
Sent: Thursday, December 11, 2025 7:19 AM
To: John Carli; Greg Ritchie; Ted Fremouw; Roy Stockton; Sarah Chapman; Michael Silva; Jeanette Wylie; Albert Enault; Erin Morris; Michelle Thornbrugh; Savita Chaudhary; Andria Borba
Subject: BESS

CAUTION: This Email is from an EXTERNAL source. Ensure you trust this sender before clicking on any links or attachments.

Please Ban BESS in the City limits

Doug & Gayle Falt
Residents in Brighton Landing

Sent from my iPhone

Albert Enault

From: Julie Tucker <tucker.j.6@icloud.com>
Sent: Wednesday, December 10, 2025 7:11 AM
To: Albert Enault
Cc: Eric Romingquet
Subject: Battery plant concern

CAUTION: This Email is from an EXTERNAL source. Ensure you trust this sender before clicking on any links or attachments.

Hello, I am a resident of Vacaville and love living here!! I retired 4 years ago and decided to leave So. Cal after 60 years and purchase a new home closer to my kids ! One of the best decisions I have made as Vacaville is wonderful place to live.

As you are all to well aware the proposed Battery Plants have many residents on edge and very worried. I was unable to attend last night meeting, but have attended a few prior meetings and I wanted to bring up another concern I had not heard mentioned as of yet.

The concern is for all the livestock and other animals that are living within 5 -10 minutes of proposed site. In addition there is an Animal Sanctuary that houses over 130 Rescued animals that is less than 1/4 mile of proposed site!

When, not if a fire breaks out how are all these Cows, Horses, Goats, Sheep, Pigs, etc. going to be evacuated? If they can't be rescued and become ill from toxic fumes or contaminated water who pays for the Veterinary bills??

I appreciate all the City is doing to navigate these dangerous proposals and hoping between the City council and the Residents we can put a final stop to this !

Thank you for your time.

Julie Tucker
951 775-5085

Sent from my iPhone

Albert Enault

From: Sarah Hoving <hoving345@yahoo.com>
Sent: Tuesday, December 9, 2025 6:22 PM
To: John Carli; Greg Ritchie; Ted Fremouw; Roy Stockton; Sarah Chapman; Michael Silva; Jeanette Wylie; Albert Enault; Erin Morris; Michelle Thornbrugh; Savita Chaudhary; Andria Borba
Subject: Please Use Lithium Free Battery Storage

Dear Mayor and City Council, also anyone who is responsible for BESS ordinances,

Thank you for your time and consideration.

This is a plea from one family who resides in Vacaville, but echoing so many around us.
We don't want battery energy storage systems that are a fire risk. We don't want the constant hum. We don't want commercial lights and equipment and facilities in neighborhoods or close to critical Services/Agriculture/Water Sources like hospitals, schools, orchards, crop fields, livestock meant for consumption, creeks that would be contaminated with run off.

You have an opportunity to say, "yes, but not lithium"!! "Yes, but not within a mile or two or three of hospitals, major thoroughfares, schools, protected lands or species, not near necessary and limited water sources and not near prime agriculture land and already developed agriculture land.

Our farmers barely get by on what they make from what they grow and sell after all is said and done. Imagine, if you will, losing a farm or ranch that has been in your family multiple generations because fire or metals and toxins from the lithium BESS destroy your future and land.

We need you to stand for us, to speak for us and to make the ordinances that will protect every person, animal and crop that makes up our very special town of Vacaville.

Thank you again for hearing our comments and taking them into your consideration.

In God's Presence,
Sarah Erickson Hoving

Sent from my iPhone

Albert Enault

From: Penny Osterhoudt <pmohappy@icloud.com>
Sent: Tuesday, December 9, 2025 6:11 PM
To: John Carli; Greg Ritchie; Ted Fremouw; Roy Stockton; Sarah Chapman; Michael Silva; Jeanette Wylie; Albert Enault; Erin Morris; Michelle Thornbrugh; Savita Chaudhary; Andria Borba
Subject: No BESS for Vacaville

Greetings,

Please do not allow Lithium-ion BESS to be set up in Vacaville.

Providing sufficient protection from toxic fumes and other health issues is impossible. There are too many things that can go wrong without enough resources to stop the negative progress or do a complete clean up once something has happened.

Please do not put our city at risk of toxic fumes, the risk of explosions, and contamination risks.

Please consider other sources of income.

Thank you.

Penny Osterhoudt
107 Christine Drive

Albert Enault

From: Lizzy McKenzie <lizzymckenzie25@gmail.com>
Sent: Tuesday, December 9, 2025 2:13 PM
To: John Carli; Greg Ritchie; Ted Fremouw; Roy Stockton; Sarah Chapman; Michael Silva; Jeanette Wylie; Albert Enault; Erin Morris; Michelle Thornbrugh; Savita Chaudhary; Andria Borba
Subject: Ban Bess in Vacaville

Hi,
From so many concerned citizens and residents in Vacaville, we plead with you to ban BESS in city limits.
We do not want the risk to these systems.
Thanks so much for hearing our concerns.

-Liz McKenzie

Albert Enault

From: Jessica A <parentis831@gmail.com>
Sent: Tuesday, December 9, 2025 1:48 PM
To: Albert Enault
Subject: Re: Public Comments - BESS Ordinance

Good afternoon,
Please let me know how we can help. Thank you for your good work.

Regards,
Jessica Ayala

On Dec 9, 2025, at 9:21 AM, Albert Enault <Albert.Enault@cityofvacaville.com> wrote:

Good Morning,

Thank you for your public comment. We'll make sure your email is provided to the City Council in preparation for the upcoming Battery Energy Storage Systems Study Session that is scheduled to be heard tonight, December 9, 2025.

Thank you and have a nice day.

Albert Enault
Senior Planner
Community Development Department
City of Vacaville, California
Office (707) 449-5364
Fax (707) 449-5423
Email albert.enault@cityofvacaville.gov
Vacaville
Small City. Big Opportunities.

Albert Enault

From: Grace USA <graceusa2026@gmail.com>
Sent: Tuesday, December 9, 2025 1:37 PM
To: John Carli; Greg Ritchie; Ted Fremouw; Roy Stockton; Sarah Chapman; Michael Silva; Jeanette Wylie; Albert Enault; Erin Morris; Michelle Thornbrugh; Savita Chaudhary; Andria Borba
Subject: Bess Ordinance comments: Vacaville to be Sister City with Cubatão, Brazil?

Tues Dec 9, 2025

Hello

I recently heard that the Vacaville was considering to allow Bess facilities in town, at three locations that are right next door to homes. Bess facilities are known to explode and burn for days while spewing toxic fumes to surrounding areas, and toxifies the soils forever.

I was shocked that a city in the USA would consider such a dangerous project to subject upon its residents.

This current draft Bess Ordinance showing three allowable Bess project locations being proposed next to homes, is dangerously unacceptable.

When I found out about this proposed Bess Ordinance and it's proposal to allow Bess facilities in three locations next to homes, it immediately reminded me of the huge 1984 petrochemical plant explosion in the city of Cubatão Brazil. The explosion incinerated hundreds of next door residents, and polluted soils and streams for decades.

The pollution in Cubatão continues to this day, with toxic soils and waterways, causing unimaginable birthday defects. Due to this global corporate industrial pollution in Cubatão, the city became known as the most polluted city in the world and was given the nickname name of: "The Valley of Death."

Following the 1984 Cubatão explosion, global NGOs have assisted the city with environmental cleanup and restoration, but despite this cleanup assistance, much of the city's pollution is still permanent. Generations of residents have been born with horrific birth defects due to this permanent corporate pollution.

For your reference, this 1984 corporate environmental catastrophe in Cubatão is presented in the first 5 minutes of this video:

https://youtu.be/QiqsD4wF8II?si=YmsL0PbCzlZJcMqH

I've lived in and traveled all throughout South America and have seen first hand how global corporations in South America are indifferent to the relentless and toxic pollution that their manufacturing operations perpetuate upon cities and surrounding populations throughout South America, and without consequence. Their only corporate interest is in making a profit, with no concern about the harmful pollution their facilities cause to surrounding communities.

Here in the USA, we have laws and standards and high expectations for the safety of corporate industrial projects. We have to rely upon our elected leaders to uphold these standards and laws, and not allow corporations to pollute our city populations, like the industrial corporations do in their operations in South America and in other countries of the Global South.

Sadly, it looks like the global corporations have partnered with California state-level government, which has allowed these global corporations to open Bess facilities at the local level, thereby threatening the health and safety of residents.... just like global manufacturing corporations have a pattern of doing in South America. Same playbook, different location.... but this time ....in the USA.

Given the passage of AB205, it appears state government has been compromised by the Bess manufacturing industry. Duh...its obvious. Therefore city and county residents statewide now have only their local elected City Council members to protect them against the corporate Bess industry cronies' alliances with folks in state government, like the California Energy Commission and their homeboys in the Bess manufacturing industry.

So please protect the residents of Solano County and Vacaville by not allowing Bess facilities in the city.

Don't let Vacaville become the Sister City of Cubatão!

Don't let Vacaville become the American city known as "The Valley of Death."

The article below indicates that California Governor Newsom attended the COP30 global climate conference meeting in Belem, Brazil, last month. I read that and wondered if he did so, in order to meet up with the elected officials of Cubatão in attendance. Perhaps Newsom attended in order to get their insight on how best to clean up the toxic pollution that will happen in California cities, after Bess facilities planned throughout the state, end up exploding and toxifying surrounding neighborhoods. Wouldn't surprise me that he could have attended COP-30 for that reason. Well at least Governor Newsom is thinking ahead, eh?

Please protect us against state government and their corporate Bess cronies. Keep Vacaville safe. Prohibit Bess facilities in Vacaville.

-Cheryl

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Fyi...Article @ Cubatão: https://www.nytimes.com/1985/05/18/world/in-acrid-brazilian-factory-zone-a-fear-of-disaster.html

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11/18/2025: "This Bay Area City doesn't want to be part of Newsom's energy plan."

https://www.sfgate.com/politics/article/bay-area-city-part-newsom-plan-21171342.php
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11/11/2025: "Newsom talks up California as highest-profile American at COP-30."
https://www.sfgate.com/politics/article/gavin-newsom-attends-climate-conference-21156622.php

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