Environmental and Public Health Risks from Clean Energy Manufacturing:

Assessment for the Green Empowerment Zone

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About PSE Healthy Energy

PSE Healthy Energy (PSE) is a scientific research institute generating energy and climate solutions that protect public health and the environment. PSE provides expertise in public health, environmental science, and engineering and brings science to energy policy through actionable research, communications, and advising. **Visit us at psehealthyenergy.org and follow us on LinkedIn**.

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Abbreviations

AEM	Anion Exchange Membrane
BAAD	Bay Area Air District
CAA	Clean Air Act
CAP	Criteria Air Pollutant
CARB	California Air Resources Board
CEIDARS	California Emissions Inventory Data Analysis and Reporting
CO	Carbon Monoxide
CWA	Clean Water Act
DCFC	Direct Current Fast Charger
DMR	Discharge Monitoring Report
DPM	Diesel Particulate Matter
ECHO	Enforcement and Compliance History Online
EMS	Electronic Manufacturing Services
EPA	U.S. Environmental Protection Agency
EV	Electric Vehicle
eVTOL	Electric Vertical Takeoff and Landing Vehicle
GEZ	Green Empowerment Zone
H_2S	Hydrogen Sulfide
HAP	Hazardous Air Pollutant
HV	High Voltage
HVDC	High Voltage Direct Current
LDV	Light-Duty Vehicle
LFP	Lithium Iron Phosphate
LIB	Lithium-Ion Battery
LiOH	Lithium Hydroxide
LQG	Large Quantity Generator
MDV	Medium-Duty Vehicle
MIBK	Methyl Isobutyl Ketone
MV	Medium Voltage
MWF	Metalworking Fluid
NEI	National Emissions Inventory

NESHAP	National Emission Standards for Hazardous Air Pollutants
NH_3	Ammonia
NMC	Nickel-Manganese-Cobalt
NMP	N-Methyl-2-Pyrrolidone
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NVFB	Non-Vanadium Flow Battery
OSHA	Occupational Safety and Health Administration
PCB	Printed Circuit Board
PCBA	Printed Circuit Board Assembly
PEM	Proton Exchange Membrane
PFAS	Per- and Polyfluoroalkyl Substance
PM	Particulate Matter
$PM_{2.5}$	Fine Particulate Matter (≤ 2.5 micrometers)
PM_{10}	Coarse Particulate Matter (≤ 10 micrometers)
RCRA	Resource Conservation and Recovery Act
SCAQMD	South Coast Air Quality Management District
SF_6	Sulfur Hexafluoride
SO_2	Sulfur Dioxide
SQG	Small Quantity Generator
SSB	Solid State Battery
SWPPP	Stormwater Pollution Prevention Plan
tpy	Tons per Year
TRI	Toxic Release Inventory
TSDF	Treatment, Storage, and Disposal Facilities
UCB	University of California Berkeley
VOC	Volatile Organic Compound
VSQG	Very Small Quantity Generator
XLPE	Cross-Linked Polyethylene
ZAWE	Zero Gap Alkaline Water Electrolyzer
ZEV	Zero Emissions Vehicle

Executive Summary

The Green Empowerment Zone (GEZ) is an economic development zone established by the State of California in the historic heavy industrial corridor of the San Francisco Bay Area in Contra Costa and Solano Counties. The GEZ was established amid the decline of oil refining and the closure of other major industrial facilities, prompting the need for the region to diversify its economy into new sectors. The GEZ is currently focused on pursuing a high-road sector strategy (High Road Strategy Center, n.d.) for clean energy manufacturing, with research and technical assistance led by the University of California Berkeley (UCB) Labor Center, focused on generating quality jobs and tax revenue for local jurisdictions, while supporting community health and environmental sustainability.

PSE Healthy Energy was engaged by the UCB Labor Center to complete an analysis on the potential environmental and public health risks of 18 clean energy technologies that the UCB Labor Center considered economically viable to grow in the GEZ. These technologies are generally grouped into seven categories: batteries, electric grid components, heat pumps, electrolyzers, electric vehicle (EV) chargers, zero emissions vehicles (ZEVs), and offshore wind. We reviewed regulatory data, scientific and industry literature, and public media to understand the air pollution, water pollution, and hazardous waste risks posed by such facilities to nearby communities. We provide the GEZ board with recommendations for assessing and mitigating the risks posed by each technology, as well as recommendations for further study.

The risk classification across the sub-technologies can be found in **Table 1**. We found that most technologies reviewed carry Very Low to Low risk, especially in the air pollution and water discharge categories. In particular, technologies that focused on the final assembly stage of manufacturing, such as ZEVs, EV chargers, and heat pumps, posed lower risks. However, a few areas warrant close attention:

- **Hazardous waste is the most consistent concern.** Across nearly all technology types, hazardous waste generation — from solvents, coatings, and chemical byproducts — is the primary risk. Most facilities studied were in compliance with existing regulations, but waste volumes could increase significantly as operations scale up.
- **Certain technologies carry higher risks.** High-voltage transformer manufacturing carries the highest overall risk, scoring High risk for both air pollution (volatile organic compounds) and hazardous waste, and Medium risk for water pollution. Distribution transformers are somewhat lower risk but still warrant attention. Solid-state battery

manufacturing carries notable hazardous waste risks. While air and water pollution risks are low, some facilities generate tens of thousands of kilograms of hazardous waste per year — including reactive and corrosive compounds. In general, these technologies are the only ones that approach the risk levels seen at legacy industrial facilities.

- **Many risk ratings carry lower confidence due to limited data.** Many clean energy manufacturers are early-stage companies that fall below federal reporting thresholds, meaning less regulatory data is available. Less data does not mean lower risk — it means greater uncertainty, which is reflected in confidence ratings throughout the report.

Table 1: Air Pollution, Water, and Hazardous Waste Risk Rating. Risks are rated as Very Low, Low, Medium, High, or Very High, with a confidence level of A (high confidence), B (medium confidence), or C (low confidence).

Category	Sub-Category	Air Pollution Risk (Confidence)	Water Pollution Risk (Confidence)	Hazardous Waste Risks (Confidence)
Batteries	Solid State Battery	Very Low (B)	Very Low (B)	High (B)
	Non-Vanadium Flow Battery	Very Low (C)	Very Low (C)	Medium (B)
	Thermal batteries	Very Low (C)	Very Low (C)	Medium (B)
	Module assembly	Very Low (A)	Very Low (A)	Very Low (C)
	Cathode material	Low (C)	Very Low (C)	Low (B)
Electric Grid Components	Electronics Manufacturing Services	Low (B)	Low (B)	Medium (B)
	Power Electronic Module Assembly	Low (B)	Low (B)	Medium (B)
	High Voltage Distribution Grid Transformers	Medium (B)	Low (B)	High (B)
	High Voltage Transmission Grid Transformers	High (B)	Medium (B)	High (B)
	Medium Voltage Switchgear	Low (B)	Low (B)	Low (B)
	High Voltage Switchgear	Low (C)	Low (C)	Low (C)
Heat Pumps	Commercial and Residential Water Heaters	Low (C)	Low (B)	Medium (C)
Electrolyzers	Catalyst, Stack, and Module Assembly	Very Low (C)	Very Low (C)	Medium (B)
EV Chargers	Direct Current Fast Charger, Final Assembly	Very Low (C)	Very Low (C)	Very Low (C)
Zero Emissions Vehicles	Light to Medium Duty Vehicles, Final Assembly	Very Low (C)	Very Low (C)	Medium (C)
	Drone Manufacturing, Final Assembly	Very Low (C)	Very Low (C)	Very Low (C)

	Electric Ferry Manufacturing, Final Assembly	Very Low (C)	Very Low (C)	Very Low (C)
	Electric Powertrain Manufacturing	Very Low (C)	Very Low (C)	Very Low (C)
Offshore Wind	Floating Offshore Wind Platform	Medium (C)	Very Low (C)	Very Low (C)
	High Voltage Direct Current Subsea Cable Manufacturing	Very Low (C)	Very Low (C)	Very Low (C)

To protect community health while supporting the GEZ's clean energy manufacturing goals, we recommend engaging with the regulatory community and other decision-makers to:

- **Plan for growing hazardous waste infrastructure demand.** As operations scale, waste volumes will grow. The region should ensure licensed hazardous waste processing capacity and emergency response infrastructure are in place before they are needed.
- **Assess cumulative impacts**. Contra Costa County already carries a disproportionate environmental burden from legacy heavy industrial facilities. Even individually small facilities can have significant collective effects. Siting decisions should account for cumulative community exposure.
- **Track risks as facilities grow.** Many facilities that were reviewed are early-stage startups. Risk profiles can change substantially as production scales up. Ongoing monitoring and regulatory review are essential.
- **Prioritize low-emission materials and processes.** Facilities should select low-VOC coatings and adhesives, biodegradable transformer oils, and non-toxic alternatives to hazardous chemicals wherever technically feasible.
- **Require engineering controls.** Requiring proper ventilation, exhaust systems, and filtration equipment for GEZ facilities will mitigate air pollution risks, while requiring proper storage of materials and hazardous waste will mitigate water discharge and hazardous waste risks.
- **Require operational best practices**. Facilities should develop spill response procedures, stormwater pollution prevention plans, and emergency response plans with clear communication channels to the surrounding community. Training workers on proper material handling and protecting their ability to report safety hazards can reduce both occupational and community exposure.

1.0 Introduction

1.1 The Green Empowerment Zone

In 2021, Assembly Bill No. 844 (AB844, 2021) established the Green Empowerment Zone (GEZ, 2026) for the Northern Waterfront area of Contra Costa County and Southern Solano County, California. This region is the industrial hub of the San Francisco Bay Area and is facing transition as major industrial facilities have closed or downsized. This is particularly true in the oil refining industry, which has seen multiple rounds of mass layoffs, with further closures anticipated as California decarbonizes its economy. The GEZ aims to catalyze the clean energy economy in the region by providing clean energy manufacturing companies with access to funding, research, workforce training, and expedited regulatory compliance (GEZ, 2026). The shift towards clean energy manufacturing, or the manufacturing of technologies related to clean energy generation, distribution, and use (U.S. Department of Energy [DOE], n.d.-a), provides Contra Costa with a proactive strategy to mitigate the economic impacts from declining oil refining operations in the region's northern waterfront area.

The GEZ's Governing Board contracted UCB Labor Center to lead research, technical assistance, and action plan development for the GEZ, with a specific focus on identifying opportunities and strategies to grow a high-road clean energy manufacturing industry that focuses on quality job creation, along with community health and long-term economic resilience. As part of their research, UCB identified initial priority clean energy manufacturing technologies for the region based on their economic viability. Those technologies are now being further analyzed based on their job creation potential, environmental impacts, and facility infrastructure needs. The technologies identified as viable for the GEZ include batteries, electric grid components, heat pumps, electrolyzers, zero emissions vehicles, EV chargers, and offshore wind. For each technology type, UCB also identified both the most viable sub-technology and the most feasible stage of the manufacturing process (e.g., module assembly or final assembly) based on factors such as land, energy, and water use requirements, and prevalence and feasibility for domestic manufacturing. The selected sub-technologies and manufacturing stages are described in detail in **Section 4**. Lastly, UCB prepared a list of existing companies across the U.S. that best represent potential example facilities for each sub-technology and manufacturing stage.

The UCB Labor Center contracted PSE Healthy Energy (PSE) to complete a qualitative environmental health assessment for the GEZ, with additional funding provided by BlueGreen Alliance through a parallel initiative, the Bay Area High Road Manufacturing Initiative. To complete our analysis, we conducted a high-level review of the potential hazards for communities and the environment for the sub-technologies and manufacturing stages identified as viable by the UCB Labor Center. In this report, we synthesize our findings and provide recommendations to the GEZ board for mitigating those risks.

1.2 Scope of Review

This assessment evaluates the potential public health and environmental risks to nearby communities from direct on-site activities associated with the specific manufacturing stage identified for each technology subtype. Specifically, we evaluate risks from air pollution, water pollution, and hazardous waste generation.

Worker health and safety risks are noted where relevant to understanding community exposure pathways, but a comprehensive occupational health assessment is outside the scope of this work. Additionally, we do not assess upstream impacts (raw material extraction, component manufacturing, and shipping) or downstream impacts (product transportation, use, or disposal). While there are health and environmental impacts from every stage of a product's life cycle, we focus specifically on the manufacturing activities that would take place in the GEZ.

2.0 Methods

This review was conducted using a three-pronged approach that relies on regulatory data, scientific and industry literature, and publicly available media. We first gathered facility-specific data from federal and state regulatory sources for the companies in each technology subcategory provided by UCB. We then conducted a scientific literature review to evaluate hazards and risks associated with each technology subtype that current regulatory processes may not capture. Finally, we reviewed news sources to identify reports of facility accidents, operational issues, and community concerns related to facility activities.

2.1 Regulatory Research

The regulatory history of existing clean energy manufacturing facilities provides information on the known and acknowledged public health and environmental risks related to air pollution, water pollution, and hazardous waste generation. For each facility, we searched for regulatory data on facility air emissions, water discharges, toxic releases, hazardous waste generation, and permit information from federal and state sources. The primary federal source was the U.S. Environmental Protection Agency's (EPA) Enforcement and Compliance History Online (ECHO) database (EPA, n.d.-a) which integrates information from several EPA programs, including permitting programs like the Clean Air Act (CAA), Clean Water Act (CWA), and Resource Conservation and Recovery Act (RCRA), as well as emissions reporting programs like the Toxic Release Inventory (TRI) (EPA, 2026a), and the National Emissions Inventory (NEI; 2020).

For facilities with CAA, CWA, and RCRA permits, ECHO provides permit classifications, permit status, compliance records, and enforcement information. For facilities that report to the TRI and NEI, ECHO provides facility identification numbers to facilitate access to detailed emissions and release data in the respective databases. NEI data were used to characterize air emissions of criteria air pollutants (CAPs) including fine particulate matter ($PM_{2.5}$), particulate matter (PM_{10}), sulfur dioxide (SO_2), nitrogen oxides (NO_x), ammonia (NH_3), carbon monoxide (CO) and lead, as well as hazardous air pollutants (HAPs) which include the 188 pollutants that are known or suspected to cause cancer. TRI data were used to identify releases of toxic chemicals to air and water.

Air Pollution: The CAA gives the EPA the power to regulate CAP and HAP emissions from facilities. The EPA classifies each facility with a CAA permit as either a major, minor, synthetic minor, or 80% synthetic minor source based on the amount of CAP or HAP emissions that facility is anticipated to emit per year.

- Major sources emit:
  - ≥ 100 tons per year (tpy) of any CAP,
  - ≥ 10 tpy of any individual HAP, or
  - ≥ 25 tpy of any combination of HAPs (40 C.F.R. § 70.2, 2026).
- Minor sources emit less than the emissions thresholds for a major source (40 C.F.R. § 49.152, 2016).
- Synthetic minor sources have the capacity to emit at or above the major source threshold but are required to emit below those thresholds via permit limits.
- 80% synthetic minor sources are a subcategory of synthetic minor sources that emit or have the potential to emit (i.e., are permitted to emit) at least one pollutant at or above 80% of the major source emissions limit (EPA, 2025a).

We reviewed each facility's permit classification and compliance records. CAA permit classifications were used as indicators of the potential magnitude of air pollution hazards at a facility, while permit violations and enforcement records were used to evaluate compliance risks.

Where available, we used emissions inventories to evaluate the types of pollutants and quantity of emissions for each type of pollutant. While the NEI and TRI are federal datasets that may provide this information, individual states may also provide emissions inventories, which sometimes include more facilities and more recent data than federal sources. For example, for California-based companies, we used the 2024 California Emissions Inventory Data Analysis and Reporting System (CEIDARS) (California Air Resources Board [CARB], n.d.). We compared emissions to the major, minor, synthetic minor, and 80% synthetic minor thresholds defined above, as well as the Bay Area Air District's (BAAD's) operational threshold of significance (10 tpy) (BAAD, 2022).

Water Pollution: The CWA provides the EPA with the authority to regulate industrial wastewater, including stormwater, wastewater discharged to treatment facilities, and wastewater discharged to nearby water bodies. The EPA classifies each facility with a CWA permit as either a major or non-major (minor) discharger (40 C.F.R. § 122.2, 2026). Major facility status for industrial facilities is determined using EPA's National Pollutant Discharge Elimination System (NPDES) Permit Rating Work Sheet, which assigns points based on criteria including toxic pollutant potential, flow volume, and water quality factors such as impairment of the receiving water or proximity to coastal waters (EPA, 2025b). A facility accumulating sufficient points under this system is designated a major discharger; facilities below this threshold are classified as non-major.

Facilities with CWA permits may have permit limits that require them to limit discharges of certain hazards to below an established threshold, or monitoring requirements that require them to submit discharge monitoring reports (DMR) for each controlled pollutant. TRI releases and CWA permit classifications, permit limits, and compliance records were used to evaluate potential water pollution risks and compliance concerns.

Hazardous Waste: Regulation of hazardous waste is managed through the RCRA permitting program, which provides the EPA with the authority to regulate hazardous waste from its generation, including at industrial facilities, to its treatment. The EPA classifies each facility with a RCRA permit as either a Large Quantity Generator, Small Quantity Generator, or Very Small Quantity Generator, based on the amount of hazardous waste that is generated per month (40 C.F.R. § 262.13, 2019). We provide annual equivalents, calculated by multiplying the monthly threshold by 12, as a reference point since waste quantities are usually reported publicly as annual amounts.

- Large Quantity Generator (LQG) generates:
    - ≥ 1000 kg of hazardous waste per month, equivalent to a minimum 12,000 kg/yr
- Small Quantity Generator (SQG) generates:
    - < 1000 kg/month (12,000 kg/yr), and
    - ≥ 100 kg/month (1,200 kg/yr)
- Very Small Quantity Generator (VSQG) generates:
    - < 100 kg/month (1,200 kg/yr)

SQGs and LQGs are also required to report the type of hazardous waste generated on site, such as ignitable waste or corrosive waste. RCRA generator classifications and reported waste types were used to evaluate both the magnitude and nature of hazardous waste risks.

We also pulled detailed facility reports from ECHO for existing chemical and fossil fuel operations in the GEZ as a reference point for comparison regarding permit violations, air emissions, water discharges, toxic releases, and hazardous waste generation in the area.

2.2 Scientific Literature Review

The regulatory review provided information on facility-specific emissions, waste streams, permitting status, and compliance history, which helped characterize known environmental and public health risks associated with individual facilities. However, due to incomplete facility data in regulatory databases, we turned to scientific literature to identify the *potential* environmental or health hazards from manufacturing each sub-technology.

First, we conducted a literature review on the environmental and public health impacts for each sub-technology. For some technologies, such as batteries, this included reviewing Life Cycle Assessment research comparing manufacturing impacts from next-generation battery technology, such as solid-state or non-vanadium flow batteries, with their current-generation counterparts, Lithium-Ion Batteries.

However, there was a paucity of research on specific manufacturing stages for most sub-technologies identified as viable for the GEZ. As a result, we focused on identifying the risks posed by the core manufacturing processes and materials required for each sub-technology. For each sub-technology, we used Claude AI to compile an initial list of core manufacturing steps and associated potential environmental and public health hazards. We then independently verified each listed manufacturing process and potential hazard using research conducted by the UCB Labor Center, publicly available literature, and company information. We did not include any processes or hazards that could not be substantiated through independent review. The substantiated processes and hazards still reflect potential risks associated with each technology, rather than guaranteed processes or impacts from specific facilities. Actual manufacturing processes and associated risks may vary across facilities based on that company's specific technology and operations.

2.3 Public Media Review

After conducting the regulatory and scientific literature reviews, we checked media sources to determine if there were known accidents, incidents, or concerns reported from relevant facilities that the public would have access to. This largely consisted of searching for headlines involving the specific facilities of interest in news articles, from national outlets to local media. The focus remained on the manufacturing stage for the specific subtechnologies outlined in **Section 1.1**. Therefore, news stories on incidents like battery fires from a car accident or a malfunctioning energy storage system, or chemical leaks from an established, large-scale lithium-ion battery manufacturing plant, were not considered.

2.4 Risk Classification

Risk categories (Very Low, Low, Medium, High, Very High) were assigned to each environmental module based on a qualitative assessment of regulatory permit status, reported air emissions and water discharges, hazardous waste generation amounts, compliance status, and literature regarding potential risks from the generalized manufacturing processes. We also assessed permit compliance status; however, we note that noncompliance is found through enforcement and therefore may go undetected. A summary of the risk category definitions are shown in **Table 2**.

Table 2: Risk Classification Definitions.

Risk Level	Air Pollution Risk	Water Pollution Risk	Hazardous Waste Risks
Very Low	Minimal/no reported emissions; few or no CAA permits; none above lowest permit level	Few or no CWA permits; none above lowest permit level	Few or no RCRA permits; none above lowest permit level
Low	<10 tpy of any pollutant (BAAD significance threshold); minor source permit; no violations	Non-major permit status; generally no discharge monitoring; no permit limits; no violations	Very Small Quantity Generator (<100 kg/month hazardous waste); no violations
Medium	<50 tpy of any pollutant; minor/synthetic minor source permit status; some violations	Non-major permit status; some discharge monitoring, permit limits, exceedances, or violations	Small Quantity Generator (<1000 kg/month hazardous waste); some violations
High	≥50 tpy; major source permit status; some significant violations	Major permit status; consistent discharge monitoring, permit limits, exceedances, or violations	Large Quantity Generator (>1000 kg/month); significant violations
Very High	≥100 tpy; major source permit status; significant/persistent violations	Major permit status; significant toxic releases; consistent exceedances/violations	Very large quantities; consistent significant violations

To capture uncertainty in the underlying data, each risk classification was assigned a confidence rating (A–C). High confidence (A) indicates the risk classification was supported by consistent findings across several facilities and supported by the literature. Typical indicators include complete permit data, consistently reported emissions with quantitative values, and a sufficient number of facilities to make a determination. Medium confidence (B) reflects partial data completeness, such as missing emissions quantities or incomplete pollutant reporting, or inconsistent quantities reported across facilities, such that the classification may not fully capture the range of operations in this category. Low confidence (C) denotes cases where classification relies on limited, indirect, or qualitative information, including missing emissions data or inferred waste and release profiles, or too few facilities examined (≤ 3) to identify a pattern, resulting in greater uncertainty in the assigned risk level.

Risk classification confidence is closely tied to the risk classification itself, because regulatory reporting requirements increase with facility size and emissions. Higher-risk facilities are required to report in greater detail and therefore tend to have more complete data. Very Low risk facilities, by contrast, often fall below regulatory reporting thresholds, resulting in less data and lower confidence ratings.

Several limitations should be considered when interpreting the risk classifications. First, findings are generalized to sub-technology and manufacturing process categories rather than specific facilities; actual risks at any individual GEZ facility will depend on that facility's specific processes, scale, and operations. Second, the facilities reviewed are located across the U.S., and their regulatory and emissions profiles may not directly reflect what a GEZ facility would look like under California's unique regulatory environment, which may reduce risks relative to those characterized here. Third, and most importantly, many of the facilities examined are early-stage operations that fall below federal reporting thresholds and, as a result, had little to no regulatory data. While falling below federal reporting thresholds can indicate that the risks from this facility are low, limited or absent regulatory data should not be interpreted as confirmation of low hazard. This is reflected in the lower confidence ratings assigned to Very Low risk classifications throughout this assessment. Additionally, as facilities graduate from early-stage operations to larger scale manufacturing operations, the potential hazards may increase accordingly. This longer-term risk development, while out of scope for this analysis, should be evaluated throughout the course of a facility's lifetime.

2.5 Stakeholder Engagement

This methodology was developed with feedback from community stakeholders over the course of the project. A stakeholder engagement session was conducted in December 2025 to present our draft methodology. Feedback from this session was collected and, where appropriate, incorporated into our final methodology and subsequent research, which was then presented to community stakeholders in June 2026. Final feedback and recommendations gleaned from this stakeholder session are discussed in **Section 5.0 Recommendations for Future Work**.

3.0 Risks of Core Manufacturing Processes

Here, we first present the findings from the literature review of risks from general manufacturing processes. As many of the core processes are present across most of the sub-technologies analyzed, we report them independently of the sub-technologies. The sub-technology-specific risk assessment follows in **Section 4**.

3.1 Mechanical Machining

Machining is a manufacturing process that involves shaping, cutting, and removing material to produce the desired part. Common operations include milling, lathing, sawing, drilling, and grinding. Machining poses health and environmental hazards through both wastewater contamination and air emissions. These risks primarily arise from the generation of swarf—chips, shavings, and particulate matter of metal or polymer, depending on the material being shaped—and from the use of metalworking fluids (MWFs), which are lubricants and coolants that may contain oils, detergents, surfactants, biocides, and anti-corrosive agents (Occupational Safety and Health [OSHA], n.d.).

Wastewater contaminated with swarf may contain metals, while spent MWF generates oily wastewater that may contain toxic pollutants, including those associated with skin disorders, respiratory conditions, and elevated cancer risks (National Institute for Occupational Safety and Health [NIOSH], 1998; EPA, 2015b). Fine metal particulates generated during machining may also contribute to air pollution risks (Khettabi et al., 2010). In addition to metal particulate emissions, MWFs may aerosolize, contributing to particulate matter emissions. When local exhaust is inadequate to control these particles, the mist may migrate to facility exhaust and be released to the surrounding environment (OSHA, n.d.).

The health risks associated with exposure to particulate matter, MWF, and metals are summarized in **Table A1**.

3.2 Thermal Cutting

Thermal cutting encompasses a group of methods that use heat to cut metals or other materials. Common methods include oxy-fuel cutting, plasma cutting, and laser cutting. The thermal cutting method used depends on the material type and thickness. Oxy-fuel cutting is primarily used for carbon-manganese and low-alloy steels, while plasma cutting is typically used for stainless steel or non-ferrous metals such as copper and aluminum (Health and Safety Executive [HSE], 1997; South Coast Air Quality Management District [SCAQMD], 2024). Laser cutting can be applied to a wide range of materials, including metals, polymers, wood, and others (SCAQMD, 2024).

Air emissions are the primary risk pathway associated with thermal cutting operations, typically from metal particulate matter. The composition and volume of particulate matter depend on the process being used. While plasma cutting generates the highest volume of fumes (HSE, 2001), laser cutting generates particulates in the ultrafine nanoparticle range (<300 nm), which can penetrate deeper into the lungs (Paulin et al., 2025). Depending on the material being cut, all thermal cutting processes can generate toxic metal particulates (SCAQMD, 2024; HSE, 2001). Using laser and plasma cutting to cut stainless steel can emit hexavalent chromium and nickel (SCAQMD, 2024), cutting galvanized steel can emit zinc oxides (HSE, 2001), and additional common emissions include manganese, copper, and phosphorus (SCAQMD, 2024). Additionally, oxy-fuel cutting and plasma cutting can generate NO_x emissions (HSE, 2001; HSE, 1997), and plasma cutting can also produce ozone (HSE, 1997). Materials with surface coatings such as paint or polyurethane may also release hazardous gases including isocyanates and metals (HSE, 2001). While the highest health risk from metal fume exposure is posed to workers in the facility, there have been concerns about exposure to high ambient levels of toxic metal particulates by communities living near metal processing facilities; laser and plasma cutting were specifically identified as a source of community concern in SCAQMD's Community Emission Reduction Plans (SCAQMD, 2024).

Wastewater is a secondary risk pathway if waste is improperly handled. Wet capture systems such as water tables and water baths absorb fumes and slag during oxy-fuel and plasma cutting; the resulting water becomes contaminated with metal particulates and must be disposed of properly (HSE, 2001; HSE, 1997).

The health risks associated with exposure to particulate matter, NO_x, isocyanates, hexavalent chromium, nickel, and other metals are summarized in **Table A1**.

3.3 Welding/Brazing

Welding and brazing are manufacturing processes where metals are fused using heat and a filler material. In welding, both the base and filler material are melted to create the joint, while in brazing only the filler is melted (OSHA, 2013). These processes share similar air emission profiles and are typically assessed together by regulatory agencies. The welding or brazing method used depends on the type and thickness of material, but the risk profile is similar across methods (OSHA, 2013).

Welding and brazing produce metal fumes when the material is melted and vaporized. These fumes consist of metal particulate matter as well as ozone, NO_x, hydrogen fluoride, and other gases (OSHA, 2013; Gonser & Hogan, 2011). Fume composition depends on the base material, filler material, and flux type. Welding stainless steel produces hexavalent chromium (OSHA, 2013), and welding galvanized steel produces zinc oxides (American Welding Society, 2002). Fume composition may also include manganese, copper, aluminum, and beryllium, among other metals. Additionally, welding coated materials may produce isocyanates or other hazardous gases (Gonser & Hogan, 2011). Brazing fumes may contain hydrogen fluoride generated by heating the flux (Gonser & Hogan, 2011), but otherwise the risks are comparable.

The health risks associated with exposure to particulate matter, NO_x, fluoride fumes, isocyanates, hexavalent chromium, zinc oxides, and other metals are summarized in **Table A1**.

3.4 Soldering

Soldering is a manufacturing process used primarily to join electronic components and populate circuit boards. Different soldering methods share similar risk profiles and include wave, reflow, and hand soldering. Components are bonded by melting a filler metal without melting the base material. Flux is used while soldering to promote bonding. Lead-tin alloys were historically used for solder but have largely been replaced with lead-free alternatives (Zhou & Schoenung, 2011; California Department of Toxic Substances Control [DTSC], n.d.) such as tin-silver-copper and tin-copper variants (Cheng et al., 2017).

The primary risk pathway associated with soldering is air emissions of HAPs from flux fumes. When flux is heated, it generates fumes that can contain aliphatic aldehydes such as formaldehyde and acrolein, as well as benzene, toluene, and other HAPs (Massachusetts Institute of Technology, 2018; NIOSH, 2019c; Smith et al., 2000). While metal fumes are negligible due to the low temperatures used in soldering, the surface of molten lead-bearing solder oxidizes to form a layer of lead oxide dross that can become airborne particulate when disturbed (Massachusetts Institute of Technology, 2018; University of Warwick, 2021; Towell, 2025). Elevated airborne lead exposure exceeding the OSHA action level has been documented during maintenance of wave solder equipment (NIOSH, 2009). Wave soldering involves a molten-solder bath that generates higher quantities of dross and may carry this risk more prominently than reflow or hand soldering (Towell, 2025). Hazardous waste is a secondary risk pathway and includes solder dross that may contain lead, copper, antimony, zinc, and other metals, depending on the type of solder used onsite. Where water-soluble flux is used, there may be minor water pollution risks as well (PCBCart, n.d.).

The health risks associated with exposure to flux fumes, formaldehyde, acrolein, benzene, as well as lead and other metals are summarized in **Table A1**.

3.5 Potting, Encapsulation, Sealing, and Bonding

Adhesive bonding is used to join surfaces in a wide variety of manufacturing. Sealing, potting, and encapsulation are a group of methods that use polymer-based compounds to create an environmental barrier and/or encase assemblies in protective resin (EPA, 2008; Gluespec, n.d.). These processes share a similar risk profile due to overlap in their chemistries, emissions pathways, hazards, and control methods (EPA, 2008; SCAQMD, 2022). Materials commonly used include epoxies, polyurethanes, silicones, and cyanoacrylates, and there is a similar risk profile across types (Elkem, n.d.; Aron Alpha, n.d.; EpoxySet, 2015).

Solvents or solvent-borne primers are used to prepare the surface (EPA, 2008), then the adhesive, sealant, or potting compound is applied and cured. The working piece may then be cleaned up using solvents. Each stage has air emissions. The solvents contained in many primers, adhesives, and cleaning materials used emit volatile organic compounds (VOCs). For adhesives, most VOC content is emitted while drying, and the amount of emissions generated during application depends on the transfer efficiency of the technology used (EPA, 2008). Polymers commonly used in sealing, potting, and encapsulation release reactive monomer vapors. The uncured component of polyurethane systems can release isocyanate vapors. Epoxies exposed to excessive heat during curing can release aldehyde vapors such as formaldehyde or acrolein (Lourenco et al., 2020; West System, n.d.). Hazardous waste is a secondary pathway and may include spent, unused, or off-spec solvents, adhesives, resins, and potting compounds.

The health risks associated with exposure to VOCs, monomer vapors, isocyanates, formaldehyde, and acrolein are summarized in **Table A1**.

3.6 Surface Coating and Painting

Surface coating refers to a variety of processes by which a thin continuous layer of material is applied to a surface. Coatings can provide desirable properties such as corrosion and abrasion resistance or be for aesthetic purposes (Ramakrishnan et al., 2022). Coatings may be liquid or powder and may be dipped, rolled, sprayed, electrostatically applied, or brushed on (IQS Directory, n.d.). The type of coating depends on the substrate and the function it serves. The most common forms of anticorrosive coatings include epoxy, polyurethane, acrylic, alkyd, and polyester resin systems (Faccini et al., 2021).

While the brunt of the risk associated with surface coating is posed to workers, with improper control, these activities may pose risks to nearby communities. The primary public health risk pathway from surface coating is air emissions of VOCs and HAPs, as well as particulate matter from coating application, drying, and cleanup. Anti-corrosive coatings often rely on organic solvents with high VOC content (Faccini et al., 2021). Solvents may evaporate from the coating before, during, and after application, emitting VOCs. Across EPA National Emission Standards for Hazardous Air Pollutants (NESHAP)-regulated coating categories, the dominant HAPs include xylenes, toluene, methyl ethyl ketone, methyl isobutyl ketone (MIBK), glycol ethers, and N-methyl-2-pyrrolidone (NMP) (EPA, 2015c). Spray overspray and powder coating application also release respirable particulates that can contain crystalline silica, heavy metals, isocyanates, and triglycidyl isocyanurate (Air Systems, 2026; NIOSH, 2018).

Secondary pathways are wastewater discharge from application systems such as booths, and hazardous waste from overspray and sludge. Wastewater generated from water-curtain spray booths, waterborne coating operations, and equipment cleaning may contain pigments, resin emulsions, heavy metals, and residual solvents. Paint sludge from booth water, used filters, and off-spec coating typically meets RCRA hazardous waste criteria due to heavy-metal content (cadmium, chromium, lead) and ignitable solvent content (EPA, 2015a).

The health risks associated with exposure to VOCs, xylene, toluene, methyl ethyl ketone, MIBK, glycol ethers, NMP, powder coating powder, and metals are summarized in **Table A1**.

3.7 Surface Pretreatment

Surface pretreatments are processes used to clean parts and condition their surfaces before applying coatings, or for the components' final use. A typical pretreatment line moves parts through a series of immersion or spray baths. Common stages include de-greasing with solvents or other chemicals, de-rusting with acids, anodizing, or applying phosphate or chromate conversion coatings. The net result of this sequence is a clean, durable, corrosion-resistant surface (Thermaset, n.d.; Velling, 2021).

Degreasing is commonly achieved using solvents or alkaline cleaners to remove organic residues and soils from the surface (Thermaset, n.d.; George, 2022). EPA's emission factor for solvent degreasing assumes essentially all VOCs in purchased solvent are emitted to the atmosphere (EPA, 1995). While low-VOC solvent alternatives are available, they may shift risk to the wastewater pathway (Better Engineering, n.d.; EPA, 2016a). Alkaline cleaners are often used in conjunction with surfactants and chelating agents and carry wastewater risks (Rudy, 2024).

Acid pickling and etching are done by applying an acid, such as sulfuric, hydrochloric, or phosphoric, to the metal surface through spraying or immersion to remove rust or scale and expose the bare metal surface. Pickling tanks emit acid mists and steam (International Agency for Research on Cancer [IARC], 1992), and spent pickle liquor from steel processing is an EPA-listed hazardous waste (K062) because of its acidity and dissolved metal content (40 C.F.R. § 261.32, 2026).

The final surface pretreatment step is commonly phosphating, anodizing, or chromating, depending on the material of the component and the purpose of the treatment. Phosphating is typically done in preparation for painting or coating, while chromating and anodizing may either serve as the final surface or be coated. Phosphate conversion coating is done by applying a phosphoric acid solution to the surface (Thermaset, n.d.). Anodizing involves applying an electric current to an acid bath containing the piece (Valence Surface Technologies, n.d.). Chromate conversion coating applies an acidic chromium-based solution to metals to improve corrosion resistance and paint adhesion. The use of hexavalent chromium baths is being phased out in favor of trivalent chromium or non-chromium alternatives (CARB, 2023), but limited information is available on the risk profile of these alternatives (Defense Systems Information Analysis Center, 2021). Tanks emit chromic acid mist (OSHA, 2009) and per- and polyfluoroalkyl substances (PFAS) are commonly used to control chromium emissions (EPA, 2015b).

The primary risk pathway associated with surface pretreatment is air emissions of acid mists, chromic acid mist, and solvent vapors. Notably, the chromic acid mist may contain hexavalent chromium if it is used in the facility. Wastewater is also a significant risk pathway. Each pretreatment step has the potential to produce rinse water carrying contaminants including heavy metals, phosphorus, cyanide, grease, PFAS, chelating agents, and other toxics (Lewis & Niebuhr, 2020). Hazardous waste can include sludge produced by on-site wastewater treatment systems as well as spent pickle liquor and solvents.

The health risks associated with exposure to VOCs, PFAS, acid mists, hexavalent chromium, and other metals are summarized in **Table A1**.

4.0 Risks of Each Technology Type

Here, we present the findings from each sub-technology, including the risk rating and confidence classification. A summary of the findings across the sub-technologies can be found in **Table 1**. For each facility analyzed, we provide violation data (**Table A2**), air permit data and emissions (**Table A3**), water permit data (**Table A4**), toxic chemical releases to air (**Table A5**) and to water (**Table A6**), and hazardous waste permit and generation data (**Table A7**).

4.1 Batteries

Lithium-ion batteries (LIB) are the most common and well-known type of battery. They are used in a variety of applications from consumer electronics to electric vehicles and grid storage systems. While the LIB industry is rapidly growing in the U.S., with several facilities manufacturing different components and chemistries across the U.S. (National Laboratory of the Rockies, 2026), there is growing interest in next-generation batteries which have reduced safety concerns or different end-use applications. UCB identified that large-scale lithium-ion battery assembly facilities were likely not viable for the GEZ due to the large size of the facilities, significant power demands, and other factors, such as geographic proximity to auto manufacturing facilities, which have driven domestic LIB manufacturing towards other regions of the U.S., such as the Midwest and Battery Belt of the Southeast. However, the Bay Area has a strong cluster of next-generation battery manufacturing companies composed primarily of smaller-scale, R&D, and early-stage battery manufacturing companies. These companies focus on emerging battery technologies – including cathode material development, solid state batteries, non-vanadium flow batteries, and thermal batteries – as well as later-stage module assembly. These areas were the focus of our analysis.

4.1.1 Solid State Batteries

Solid state batteries (SSB) offer similar applications as LIBs (EVs, short-duration grid storage), but use a solid electrolyte instead of a liquid one, avoiding many of the safety concerns around runaway fires in case of an accident (Communications with UC Berkeley Labor Center, 2026). In addition to improved safety, SSBs are more energy-dense than LIBs and can enable EVs with more range or storage systems with longer duration storage. Battery chemistries may still be lithium-based (lithium-sulfur, lithium metal), but can also be silicon-based. Companies in this space operate in a vertically-integrated manner due to IP protection and their small size (tens to hundreds of MWh battery production). This means most, if not all, major manufacturing processes (electrolyte, separator, cathode, and anode fabrication) will be conducted on-site.

4.1.1.1 Solid State Batteries Manufacturing Process Literature Findings

Three main SSB chemistries were reviewed: Lithium-Sulfur, Lithium Metal, and Silicon. While each has manufacturing steps and associated impacts specific to their chemistry, they all share common processes. These include:

- <u>Active material synthesis:</u> Active materials refer to the electrochemically active components of the battery. These can include lithium or graphite in the anode (negative terminal) and nickel-manganese-cobalt (NMC) or sulfur in the cathode (positive terminal). NMC-based SSBs (lithium metal or silicon), active material precursors must be co-precipitated (Dong & Koenig, 2020) and sintered at high temperatures to compact the powder into a solid mass. For sulfur-based SSBs, this step requires sulfur composite synthesis (Díez et al., 2019).
- <u>Mixing:</u> The active battery material is batch-mixed with a polymer binder, a solvent, and conductive additives. Traditionally, mixing involves a liquid solvent that then forms a slurry. However, there is a push to move away from wet processing to dry processing for SSBs, due to the equipment requirements, energy consumption, and toxic solvents (Neware, 2026). The dry method eliminates the use of solvents – active materials, conductive agents, and powdered binders are directly mixed, fibrillized into a framework, and then compacted to create an electrode film, which is then laminated onto a current collector (Neware, 2026). This process is particularly well suited to sulfur-based SSB cathodes (Neware, 2026).
- <u>Calendering and cutting:</u> This step further compresses the electrode sheets to increase density (Battery Design, n.d.), then the sheets are cut to be layered into cell packs.
- <u>Cell assembly:</u> Electrode sheets are stacked to form cell packs.

A literature review of each SSB chemistry highlighted *potential* chemical and physical risks associated with the different core manufacturing processes, as well as with steps unique to a particular chemistry.

Lithium-Sulfur

Many of the potential risks associated with lithium-sulfur batteries derive from the elemental sulfur used in the electrolyte. Sulfide electrolyte fabrication and processing are sensitive to humidity and have the potential to release hydrogen sulfide (H_2S) (Randrema, et al., 2023), which is a toxic pollutant (Ting, et al., 2022). The lithium metal used in the anode is also highly sensitive to moisture and, if exposed, can react violently (van den Borg, et al., 2021) and form lithium hydroxide (LiOH), a corrosive compound (Ting, et al., 2022). The kind of solvent used to facilitate cathode processing could also present a chemical hazard. For instance, NMP is a common solvent in Lithium-ion battery technology (Panjalingam, et al., 2025), but is a known reproductive toxin (California Department of Public Health, 2014), and more sustainable alternatives are being pursued. These risks would fall under the hazardous waste category.

Lithium Metal

Lithium Metal SSBs share some risks with Lithium-Sulfur SSBs – the use of a lithium metal anode presents reactivity risks if exposed to moisture (van den Borg, et al., 2021). These batteries may use a garnet-type solid ceramic electrolyte ($Li_7La_3Zr_2O_{12}$, or LLZO), necessitating high-temperature sintering, which can release fine particulate matter (Kravchek, et al., 2022). If using an NMC cathode, NMC machining can present additional toxicological risks as well (see **Section 4.1.5**) (Li, et al., 2026).

Silicon-Based

Silicon-based SSBs avoid the use of lithium anodes entirely, opting instead to use silicon. Silicon nanopowders are mixed with binders and additives to form the anode, but these nanopowders can present health risks including lung irritation from inhalation (Marques de Silva, et al., 2022). These batteries also may use a sulfur-based electrolyte and an NMC cathode, which offer the same health risks listed above (H_2S release risk from sulfur-based electrolytes, toxicological impacts from NMC).

4.1.1.2 Solid State Batteries Regulatory Findings

Nine solid-state battery manufacturers based in the U.S. were assessed for their air emissions, water discharges, and hazardous waste production, according to their federal CAA, CWA, and RCRA permits.

Of these nine companies, one does not appear in federal databases and was not investigated further. Of the remaining eight companies, totaling 10 facilities, only one had CAA permits (Solid Power, at both facilities) and had synthetic minor air emissions of CAPs (NO_x, SO_2, VOCs, less than 10 tpy), and HAPs (xylenes, less than 10 tpy), with no permit violations. Lyten, QuantumScape, and Sonocharge had trace emissions of CAPs (less than 1 tpy), per CEIDARS.

Two companies had CWA permits – both are non-major and are in compliance. This implies that the remaining companies either do not have air emissions and water discharges, or these fall below the threshold required to obtain a permit.

All nine companies have RCRA permits, but none violate their permits. QuantumScape and Solid Power were the largest generators of hazardous waste (both LQG facilities), producing up to 80,000 kilograms of hazardous waste annually. Lyten in San Jose (LQG), Blue Current (LQG), Sepion (SQG), and Factorial Energy (SQG) produced between 1,000 and 5,000 kilograms of hazardous waste annually, and PolyPlus Battery produced less than 500 kilograms of hazardous waste annually.

The most common hazardous waste categories across the nine SSB manufacturers studied were Ignitable Waste, Corrosive Waste, and Reactive Waste, which appears consistent with literature review findings on possible H_2S (reactive) and LiOH (corrosive) by-products. Spent nonhalogenated solvents were also common hazardous waste categories from these companies. These include compounds like xylene, acetone, toluene, and more. As there were no documented examples of noncompliance with these facilities' RCRA permits, these quantities of waste are expected to be disposed of through the correct channels; however, hazardous waste generation and related impacts and disposition may become more substantial issues at scaled-up operational levels. Noncompliance is also found through enforcement, so noncompliance can go undetected.

4.1.1.3 Solid State Batteries Risk Summary

Based on the manufacturing processes conducted on site, the primary air pollution risks are anticipated to be particulate matter and hydrogen sulfide. We classify this risk as **Very Low** with a confidence of **B** due to the limited permitting information available.

Based on the manufacturing processes conducted on site, the primary water pollution risk is effluent contaminated with solvents or metals. We classify this risk as **Very Low** because few of the facilities require a CWA permit, and those permits are non-major with no documented examples of non-compliance. We assign this a confidence rating of **B** due to the limited number of facilities with permits.

Based on the manufacturing processes conducted on site, the primary hazardous waste risks are lithium hydroxide and solvents such as NMP. The regulatory findings indicate that these facilities produce ignitable, corrosive, and reactive waste as well as spent solvents. While there are no documented non-compliance incidents, we classify this risk as **High** due to the large quantities of hazardous waste generated and the risk of a high-impact accident for such a facility. We assign this a confidence rating of **B,** as while all facilities had RCRA permits, only two were classified as LQG, suggesting the risk may vary by facility.

4.1.2 Non-Vanadium Flow Batteries

Non-Vanadium Flow Batteries can be iron oxide-based or zinc bromine-based (Zhang, et al., 2025; Rana, et al., 2023). These batteries are not meant for consumer applications or electric vehicles. Rather, they are intended for long-duration grid energy storage, providing power to the grid for days at a time instead of hours (Zhang, et al., 2024). These batteries are much larger than LIBs or SSBs, and store energy as dissolved electroactive compounds in separate tanks. The electrolyte is pumped to an electrolyzer to charge and discharge. California has procurement mandates for long-duration energy storage, so there is expected to be demand for flow batteries to fill this space (California Public Utilities Commission, 2025). This industry is in early stages, so facilities of any size were examined.

4.1.2.1 Non-Vanadium Flow Batteries Manufacturing Process Literature Findings

Iron-based batteries, such as those made by ESS, Inc., use iron chloride/hydrogen redox reactions as the basis of the chemistry. Iron is a commonly available metal, which reduces the need for rare-earth metals. There is a risk of parasitic hydrogen gas production from iron flow batteries, which is an explosive risk during battery production and during charging (Jayathilake, et al., 2018). ESS has methods to mitigate this hydrogen risk, detailed in their patents (ESS Patent US11888201B2).

Zinc bromine flow batteries operate similarly to iron-based flow batteries, but they use a zinc anode, a bromine cathode, and an aqueous zinc-bromine electrolyte (Mahmood, et al., 2023). Free bromine (Br_2) can be generated during the charging process, which can be toxic to health (Jimenez-Blasco, et al., 2023). Free Br_2 requires the use of bromine complexing agents, some of which present separate genetic mutation risks if handled improperly (IMAP Group Assessment Report, 2020).

4.1.2.2 Non-Vanadium Flow Batteries Regulatory Findings

Six companies in the non-vanadium flow battery (NVFB) space were assessed. Of these six facilities, two did not have any information listed on federal databases. Of the remaining four, only one had a CAA permit, but is listed as not having an operational status in the Integrated Compliance Information System (ICIS) database. None of the facilities had CWA permits. Five facilities had RCRA permits, and all were in compliance. Quino Energy had the largest generation of hazardous waste (SQG permit, up to 4000 kilograms annually), but the rest had either under 1000 kg/year or had no specific information available. Two facilities did not have hazardous waste quantities listed in ECHO, despite having active RCRA permits. These two facilities were also the only ones that had detailed waste categories listed in ECHO, and the most common hazardous waste types disposed of from them were Ignitable Waste, Corrosive Waste, and Lead.

4.1.2.3 Non-Vanadium Flow Batteries Risk Summary

There is limited information on the air pollution or water pollution risks associated with NVFB battery manufacturing. Still, there may be some risk associated with free bromine production and the use of toxic bromine complexing agents. Similarly, there is limited regulatory information available, with only one facility requiring a CAA permit and no facilities requiring a CWA permit. Therefore, we classify the air pollution and water pollution risks as **Very Low** with a confidence rating of **C.**

Based on the manufacturing processes that are conducted on site, there may be hazardous waste risks associated with bromine complexing agents, but further information is limited. The regulatory findings indicate that ignitable waste, corrosive waste, and lead may be produced at these sites. Due to the quantity of hazardous waste generated and lack of documented noncompliance violations, we assign a risk classification of **Medium** with a confidence rating of **B**, as there was a range of waste produced.

4.1.3 Thermal Batteries

Thermal batteries store extra electricity in heat blocks, which can then provide on-demand heat or electricity for industrial processes. The main example company in this space examined for our analysis is Antora Energy, which uses dense blocks of carbon to store heat. Thermal batteries convert electricity into heat to either be used later for industrial processes or to be later converted back to electricity, if needed. These batteries are seen as a critical step to decarbonizing the industrial sector, which often requires large amounts of process heat currently generated from fossil fuels (Winn, 2024). This analysis will focus on smaller, modular types of thermal batteries operating on a commercial scale.

4.1.3.1 Thermal Batteries Manufacturing Process Literature Findings

These batteries do not generally require complex chemistry or potentially hazardous substances (Blain, 2023). Heat is stored in a simple material, like carbon or ceramic blocks, to be then released later when needed. The main potential health or environmental impact from manufacturing these batteries would likely be $PM_{2.5}$ emissions from machining these blocks (Torch Air, n.d.) (see **Section 3.1**).

4.1.3.2 Thermal Batteries Regulatory Findings

Not much information is available for thermal battery manufacturers on regulatory databases, as the companies reviewed are still fairly nascent. Five example facilities were provided, but only three were based in the U.S. and were assessed. Of these, only one had data available in ECHO, and it does not have CAA or CWA permits. It does have a LQG RCRA permit, and disposes of between 7,000 and 13,000 kilograms of hazardous waste annually. Its hazardous waste categories were not provided on RCRA's database.

4.1.3.3 Thermal Batteries Risk Summary

Minimal information is available on the manufacturing processes for thermal batteries. Still, it is anticipated that there may be an air pollution risk of particulate matter, and it is unclear what water pollution risks may exist. As no facilities required a CAA or CWA permit and further data is scant, we assign a risk classification of **Very Low** with a confidence of **C** to both the air and water pollution pathways.

Similarly, the nature of the hazardous waste risk is unclear. One of three domestic facilities required a RCRA permit, and as that facility was classified as a LQG, we assigned a risk classification of **Medium** with a confidence of **B**.

4.1.4 Module Assembly

At the other end of the battery supply chain is module assembly, in which battery cells are processed into usable packs. These companies can range in operation size and battery types, including lithium-ion, as well as silicon and solid-state batteries.

4.1.4.1 Module Assembly Manufacturing Process Literature Findings

Module assembly consists of putting battery cells or packs together into a customizable battery module that can then be used for final applications. This does not require a facility specific to battery modules – contract manufacturers that make enclosures for other products can fulfill this role as well. This generally consists of final assembly, and limited health or environmental impacts could be found.

4.1.4.2 Module Assembly Regulatory Findings

Only two module assembly companies appear in the ECHO database with RCRA permits, and both facilities currently do not have information on hazardous waste generation amounts. One had an LQG RCRA permit, while the other had an SQG permit.

4.1.4.3 Module Assembly Risk Summary

Not much information is available for this subtechnology. Manufacturing processes gleaned from the literature indicate that final module assembly is low-impact, which corroborates the limited regulatory information available for example facilities. We assign a risk classification of **Very Low** across all three pathways, with a confidence rating of **A** for air and water pollution, and **C** for hazardous waste due to the range of quantities indicated by the RCRA permits held by two facilities.

4.1.5 Cathode Material

A cathode is the positive end of a battery, and its active materials tend to comprise metal oxides like lithium iron phosphate (LFP) and lithium NMC oxide (see **Section 4.1.1**) (Koech, et al., 2024). California companies like Sparkz (Sacramento), Sylvatex (Alameda), and Wildcat Technologies (San Diego) are developing new cathode chemistries and material processing, and all operate on the small or pilot scales (tens to hundreds of MWh of production).

4.1.5.1 Cathode Material Manufacturing Process Literature Findings

In NMC cathode production, cobalt is associated with lung cancer (IARC Vol 86, 2006), and nickel is associated with lung and nasal cancer as well (National Cancer Institute, 2024). LFP cathodes may also have health impacts for workers, mainly a decline in pulmonary function as well as elevated inflammation (Ji, et al., 2026). Community safety is paramount when handling these metals for NMC cathode production.

4.1.5.2 Cathode Material Regulatory Findings

Of the four cathode material manufacturers reviewed, only one had data available in ECHO. Wildcat has an SQG RCRA permit and generates between 1,000 and 4,000 kilograms of hazardous waste per year, as well as 1 kilogram of acute hazardous waste in 2024. This facility is in compliance with its RCRA permit. No further information on its hazardous waste categories is available through ECHO or RCRA.

4.1.5.3 Cathode Material Risk Summary

Based on the manufacturing processes conducted onsite, there may be air pollution risks associated with heavy metal emissions. Therefore, we assign an air pollution risk classification of **Low** with a confidence rating of **C** due to the lack of permitting information.

Similarly, due to the lack of permitting or regulatory information on water pollution risks, we assign a risk classification of **Very Low** with a confidence rating of **C.** For hazardous waste, we assign a risk classification of **Low** with a confidence rating of **B** as one facility had a SQG RCRA permit.

4.2 Electric Grid Components

As California modernizes its electric grid and expands renewable energy generation, demand for grid infrastructure is expected to grow significantly (California Independent System Operator [CAISO], n.d.). Rising electricity demand from electric vehicles, data centers, and distributed energy resources will require upgrades to transmission, distribution, and power management systems. The key electric grid component technologies identified as viable for manufacturing in the GEZ include electronics and power electronic module assemblies, medium- and high-voltage switchgear, and distribution and transmission transformers.

4.2.1 Electronic Manufacturing Services

Electronics such as meters, control boxes, battery systems, and printed circuit board assemblies are typically used in the manufacturing of bigger electronics, such as electric vehicle chargers, but are rarely manufactured onsite at such facilities (Communications with UC Berkeley Labor Center, 2026). Instead, these companies typically hire contract manufacturers, also known as electronic manufacturing services (EMS), to produce and assemble the electronics they rely on. EMS facilities may produce a diverse array of products; the focus of this analysis is on the general operations that may be conducted onsite.

4.2.1.1 EMS Manufacturing Process Literature Findings

The manufacturing process for electronic manufacturing services may consist of four general categories: 1) enclosure fabrication, 2) printed circuit board (PCB) manufacturing and assembly, 3) PCB assembly (PCBA), and 4) electromechanical assembly, which are described below (Communications with UC Berkeley Labor Center, 2026).

1. <u>Enclosure Fabrication</u>: Enclosure fabrication usually consists of sheet metal machining, welding, surface treating, and painting. Plastic injection molding is also used to create housings and enclosures that protect sensitive electronic components (D&M Plastics, n.d.).
2. <u>PCB Manufacturing</u>: During PCB manufacturing, copper is applied to a substrate, usually glass fiber or epoxy resin, which is then covered with a photoresist film and treated with UV light to harden (JLCPCB, 2025). This is then put in an alkaline bath and undergoes etching. Holes are drilled and then filled with copper, known as plating. The copper is then treated with anti-corrosive and anti-oxidation surface treatment via

chemical baths. Then, the layers are covered with a solder mask and silk screen. Finally, the PCB undergoes surface finishing.

3. PCB Assembly: Assembly refers to the addition of small electronic components to the PCB. This is done either with surface mount technology, where solder paste is applied before electronic components are mounted and then, using heat in a reflow oven, the solder paste joins the components to the board, or with throughhole technology, where holes are drilled into the board, component leads are placed in the holes, and everything is soldered in place (Sufyan, 2025).
4. Electromechanical Assembly: Finally, electronics are connected with any additional auxiliary parts (i.e., motors and other moving parts) before they are tested and delivered offsite (Communications with UC Berkeley Labor Center, 2026).

The risks from general manufacturing processes, namely metal machining, welding, surface treatment, surface coating, and soldering, are described above in **Section 3**. However, there are EMS specific risks that warrant further investigation.

For plastic injection molding, the greatest hazard exists from the VOCs that are formed when plastics are heated to high temperatures, releasing smoke and fumes (Sentry Air Systems, n.d.). Depending on the plastic material used, this can generate styrene, formaldehyde, and acrolein, among other VOCs. With proper ventilation and filtration, the risk to the surrounding community is low. Additionally, coolant is required to cool the mold, which must be disposed of afterwards.

The etching, surface cleaning, plating, and chemical baths conducted during PCB manufacturing requires the use of acidic etchants, abrasive and alkaline cleaning compounds, and heavy-metal solutions (EPA, n.d.-b). These materials may be highly corrosive, create vapors and fumes, and generate hazardous waste that require specific disposal and treatment, such as spent solvents and wastewater laden with heavy metal hazards.

The process of generating the photoresist film needed in PCB manufacturing requires the use of photoresist chemicals, including Propylene Glycol Monomethyl Ether Acetate and other VOCs which pose respiratory risks (National Institute for Occupational Safety and Health [NIOSH], 2019). With proper ventilation and handling/storing of these chemicals, the risk to the community is low.

4.2.1.2 EMS Regulatory Findings

We investigated the regulatory permitting for nine EMS facilities across the U.S. Among the nine facilities, none had CAA permits, three had CWA permits, and six had RCRA permits.

While none of the facilities had CAA permits, three in California reported emissions. Two only reported emissions of VOCs (between 1.1-1.4 tpy), and the third reported less than 1 tpy of CO, SO_2, NO_2, VOC, PM_{10}, and $PM_{2.5}$.

All three facilities with CWA permits were classified as non-major sources. None were required to report discharge monitoring, reported any exceedances, had effluent charts or permit limits, or reported to TRI.

Of the six facilities with RCRA permits, one was a Large Quantity Generator and reported ~1,800–2800 kg/yr and two were Small Quantity Generators that reported between 1000 and 2,500 kg/yr. Three facilities were marked as “Other” with only one reporting waste amounts under 400 kg/yr, which would likely make it a Very Small Quantity Generator. Only three facilities reported waste types. All three reported ignitable waste; two reported spent non-halogenated solvents and lead; one reported corrosive waste; and one reported silver. One facility, the LQG, had four RCRA violations over the course of four years.

4.2.1.3 EMS Risk Summary

Based on the manufacturing processes conducted on site, the greatest air pollution risk is VOC emissions from soldering, plastic injection molding, photolithography, and the solvents needed for PCB manufacturing. To a lesser extent, there may also be metal particulate matter risks from enclosure fabrication. The regulatory review suggests that similar facilities emit VOCs and particulate matter well below the CAA major source threshold and BAAD significance threshold. As a result, we characterize this risk as **Low**. Due to the number of facilities evaluated and the fact that some facilities reported emissions, we rated our confidence at level **B**.

Based on the manufacturing processes conducted on site, the greatest water pollution risk is effluent contaminated with metals, oils, detergents, and surfactants. However, the regulatory review suggests that similar facilities fall below mandatory reporting requirements and are therefore characterized as **Low** risk, with a confidence rating of **B**.

Based on the manufacturing processes conducted on site, the greatest hazardous waste risks are anticipated to be lead waste from soldering, corrosive waste from etching, and spent solvent waste from surface treatment and coating. The regulatory review confirms the risk of ignitable waste, lead waste, and solvent waste, at potentially medium volumes. Due to the quantities of waste generated, presence of violations, and amount of permitting data available, we characterize the hazardous waste as **Medium**, with a confidence level of **B**.

4.2.2 Power Electronic Module Assembly

Power electronic module assembly involves integrating components, such as power transistors, into larger modules used to manage and convert electricity (Communications with UC Berkeley Labor Center, 2026). These products include converters and inverters for solar and energy storage systems, reactive power management devices such as D-STATCOMs, smart meters, and other power management equipment used in electric grids, vehicles, and industrial applications.

4.2.2.1 Power Electronic Module Assembly Manufacturing Process Literature Findings

The manufacturing processes at facilities that assemble power electronics modules depend heavily on what is manufactured in-house versus what is bought pre-fabricated. There would likely be enclosure fabrication, electromechanical assembly, and possible PCB assembly (Communications with UC Berkeley Labor Center, 2026), meaning the risks are similar to those for EMS, with the exclusion of risks associated with PCB manufacturing.

4.2.2.2 Power Electronic Module Assembly Regulatory Findings

We investigated the regulatory permitting for 10 power electronic module assembly manufacturing facilities across the U.S. Among the 10 facilities, three had CAA permits, four had CWA permits, and seven had RCRA permits.

For the three facilities with CAA permits, one was listed as a minor source, one as a synthetic minor, and one as a major source. The major source facility reported less than one ton of emissions of SO_2, PM_{10}, $PM_{2.5}$, and NH_3. It also reported nearly 3.5, 4.1, and 4.2 tpy of CO, VOC, and NO_2, respectively. These are less than half the BAAD significance threshold. Two facilities did report hazardous air pollutants, although the combined HAP emissions were less than 0.1 tpy for each facility. These HAPs included heavy metals, polycyclic aromatic hydrocarbons, and VOCs. Two of the facilities also reported toxic air emissions to TRI. Beyond those already mentioned, one facility reported emissions of nitrate, nitric acid, and sodium nitrite. These also totaled less than one ton.

All four facilities with CWA permits are listed as non-major sources. None had discharge monitoring reports, reports of exceedances, violations, or reports to TRI. One facility did have permit limits for heavy metals.

Of the seven facilities with RCRA permits, one was classified as a Very Small Quantity Generator and reported around 30 kg/yr of waste; two were classified as Small Quantity Generators and reported ~100-400 kg/year and 1,200-1900 kg/yr of waste, respectively; one was classified as a Large Quantity Generator and reported over 500,000 kg/yr of waste; three had "Other" listed as their permit type and did not report quantities of waste generated. All facilities that reported waste type reported ignitable waste. Two facilities reported corrosive waste, barium, and methyl ethyl ketone. The LQG facility also listed severalother types of waste, including heavy metals, reactive waste, sludge and residues from electroplating, and more.

4.2.2.3 Power Electronic Module Assembly Risk Summary

Based on the manufacturing processes conducted on site, we anticipate the primary air pollution risk to be VOC emissions from soldering, plastic injection molding, and some solvents at facilities that manufacture power modules. Metal particulate matter risks may also exist from enclosure fabrication. The regulatory review suggests that similar facilities emit HAPs, VOCs, and NO_x; however, these emissions are well below the CAA major source threshold and BAAD significance threshold. While one facility was permitted as a major source, its emissions appear to be well below the threshold. As a result, we characterize this risk as **Low**. We rated our confidence at level **B**.

Based on the manufacturing processes conducted on site, the primary water pollution risk is effluent contaminated with metals, oils, detergents, and surfactants. The regulatory review confirmed a risk of heavy metals, based on the permit limits. However, this facility did not report to TRI or report violations. Therefore, we characterized it as **Low** risk, with a confidence rating of **B**.

Based on the manufacturing processes conducted on site, the primary hazardous waste risks are lead waste from soldering and spent solvent waste from surface treatment and coating. The regulatory review confirms the risk of ignitable waste and solvents, as well as corrosive waste. As one facility reported very large quantities of waste, we rated this as **Medium** with a confidence of **B**; however, this risk is likely dependent on facility size and may be lower.

4.2.3 High Voltage Distribution Grid and Transmission Grid Transformers

High voltage transformers ensure reliable transmission and distribution of electricity across great distances. Distribution grid transformers operate between transmission and distribution lines, stepping down voltage from high voltage transmission levels to lower sub-transmission or distribution levels (e.g., a power substation near a population center) (DOE, 2024). Transmission grid transformers, by contrast, operate between transmission grid circuits, stepping up voltage for long-distance bulk power transfer (Communications with UC Berkeley Labor Center, 2026). High voltage transformers require sophisticated, custom manufacturing, and are made in facilities that only make transformers (Communications with UC Berkeley Labor Center, 2026).

4.2.3.1 High Voltage Distribution Grid and Transmission Grid Transformers Manufacturing Process Literature Findings

Functionally, distribution and transmission grid transformer manufacturing follow extremely similar processes. Each transformer consists of a laminated steel core with a conductor wound around it, housed inside a steel tank filled with transformer oil (Communications with UC Berkeley Labor Center, 2026). It is supported by several ancillary components that are responsible for cooling, monitoring, protecting, and electrically connecting the transformer to the grid.

The manufacturing process for a transformer may consist of five general categories: 1) tank fabrication, 2) steel core assembly, 3) oil filling, 4) electrical assembly, and 5) final testing, which are described below.

1. Tank Fabrication: The steel tank is first fabricated through mechanical machining and thermal cutting (Minhaz, 2014). Then, the tank surfaces are pretreated with solvents before surface coatings and paint are applied to the inner and outer surfaces.
2. Steel Core Assembly: Steel sheets are cut using mechanical machining and thermal cutting and stacked to form the laminated core (Minhaz, 2014). Conductors are then wound around the core and insulated with paper insulation. A high-strength epoxy resin is applied to the ends of the core before it is placed inside the fabricated steel tank.
3. Vacuum Drying & Oil Filling: Once the core is placed inside the tank, the tank undergoes vacuum drying to eliminate moisture (Minhaz, 2014). The tank is then filled with transformer oil under vacuum to ensure complete oil impregnation (Nanayakkara, 2019).

4. Electrical Assembly: The transformer is integrated with its ancillary components, such as radiators and fans (Minhaz, 2014).
5. Final Testing: Finally, the completed transformer undergoes testing and quality assurance before it is transported off-site (Minhaz, 2014).

Risks from the general manufacturing processes listed above, namely mechanical machining, thermal cutting, pretreatment, and surface coating, are described in detail in **Section 3**.

Additionally, there are specific risks posed by the oil filling process that are unique to transformer manufacturing. Transformer oils serve two primary functions: electrical insulation and heat dissipation. Mineral oils, derived from petroleum, are the industry standard; however, natural and synthetic esters are increasingly used as alternatives due to their superior biodegradability and fire safety properties (Noqueira et al., 2022).

The primary risk pathways from oil filling are soil and water contamination from leaks or spills, and fire (Noqueira et al., 2022). Spills can leach into groundwater, impacting waterways and ecosystems. Fires can release $PM_{2.5}$ and other air pollutants that affect nearby communities and pose direct safety risks to workers. These risks are greatest with mineral oils; natural and synthetic esters present a lower risk profile given their biodegradability and higher fire resistance (Noqueira et al., 2022).

While the manufacturing processes for distribution and transmission grid transformers are extremely similar, the scale of each transformer type presents a notable distinction. Because transmission grid transformers are much larger than distribution grid transformers, we anticipate that all manufacturing activities, and their associated risks, are amplified.

4.2.3.2 High Voltage Distribution Grid Transformer Regulatory Findings

We investigated the regulatory permitting for 10 distribution grid transformer manufacturing facilities around the U.S. Among the 10 distribution grid transformer manufacturing facilities, we found that seven had CAA permits, seven had CWA permits, and eight had RCRA permits.

For the seven facilities with CAA permits, three were minor facilities, and four were 80% synthetic minor facilities. Only two reported emissions publicly. Delta Star, in Virginia, reported less than one ton of emissions for all contaminants except for VOCs (~9 tons). The VOC emissions represent less than 20% of the major source threshold, and just under the BAAD significance threshold of 10 tpy. Hitachi, in Virginia, reported less than one ton in emissions for all contaminants except CO, NO_2, and VOCs. For CO (2 tpy) and NO_2 (3 tpy), this is still well below the BAAD significance threshold. However, VOC emissions were reported at 20 tpy, which is 40% of the major source threshold and double the significance threshold. Additionally, there were a number of hazardous air pollutants that may be emitted by these facilities, including xylene, glycol ethers, and chlorofluorocarbons; however, they do not report toxics to the TRI. No emissions amounts were reported. Two had informal notices of violations.

All seven facilities with CWA permits were listed as non-major sources. None had to report discharge monitoring reports, permit limits, effluent charts, or violations. None had toxic water releases reported in TRI. This may indicate that the water pollution concerns are low compared to other regulated facilities.

Of the eight facilities with RCRA permits, only five reported the amount of hazardous waste shipped per year. Two reported over 14,000 kg/year, making them Large Quantity Generators. Three reported over 1,200 kg/yr, making them Small Quantity Generators. The three that did not report hazardous waste shipped were classified as Very Small Quantity Generators, meaning they generate less than 100 kg per month (equivalent to less than 1,200 kg per year). Six of the facilities reported ignitable waste, five reported spent non-halogenated solvents, three reported methyl ethyl ketone, two reported benzene, and one reported corrosive, reactive, metals, and tetrachloroethylene. Three facilities showed at least one violation in the last five years, as well.

4.2.3.3 High Voltage Distribution Grid Transformer Risk Summary

Based on the manufacturing processes conducted on site, the primary air pollution risks are VOC and metal particulate emissions. The regulatory findings support this and reveal that VOCs from distribution transformer manufacturing facilities may exceed significance thresholds.

Based on this, the nearly consistent air permit requirement, the minor violations, and the classification of 80% synthetic minor sources, we rate the risk from these facilities as **Medium** with a confidence rating of **B**.

Based on manufacturing processes conducted on site, the primary water pollution risk is effluent contaminated with metals and solvents. However, due to the near consistent non-major source classification, no TRI reporting requirements, and no other water quality monitoring requirement, we classify this risk as **Low**, with a confidence rating of **B**.

Based on manufacturing processes conducted on site, the primary hazardous waste risk is sludge contaminated with spent solvents and metals. The regulatory review found that, in addition to spent solvents, the hazardous waste generated onsite typically includes ignitable waste, with some risk of corrosive and reactive waste as well. Due to the large quantity of waste generated by some facilities, the near consistent permitting of these facilities, and the kinds of waste found onsite, we rate this risk as **High**, with a confidence rating of **B**.

4.2.3.4 High Voltage Transmission Grid Transformer Regulatory Findings

We investigated the regulatory permitting for four distribution grid transformer manufacturing facilities around the U.S. Among the four transmission grid transformer facilities, two had CAA permits, all four had CWA permits, and three had RCRA permits.

For the two facilities with CAA permits, one was an 80% synthetic minor, and one was a major source. The major source, Hitachi in Jefferson City, Missouri, reported 250 tons of VOCs in a single year, which is 2.5 times the major source threshold and 25 times the BAAD significance threshold. This facility reports no other emissions. The 80% synthetic minor facility reports less than 1 ton of CO and SO_2, around 2 tons of PM_{10}, 3 tons of VOCs, and 3.5 tons of NO_2. These are less than the BAAD significance threshold. One facility reported emissions while being exempt from a CAA permit. This facility reports less than 1 tpy of SO_2, PM_{10}, $PM_{2.5}$, total PM, and NH_3 but reports 1.2 tpy of CO, 1.4 tpy of NO_2, and 6 tpy of VOCs, all well under the BAAD significance threshold. This indicates that VOCs pose the largest risks but that emissions are not consistent across all facilities. Additionally, the major source reported HAP emissions at major source thresholds but did not specify which HAPs or in what quantities. Two facilities reported air emissions to the TRI, including chromium, cobalt, copper, manganese, and nickel. One also reported toxic air emissions of glycol ethers and lead. In the last five years, one facility had one formal enforcement violation and two informal notices of violation.

All four facilities with CWA were listed as non-major sources. While three of the facilities were not required to report discharge monitoring reports, permit limits, effluent charts, or violations, one facility had discharge monitoring reports that showed violations. This included 99 significant noncompliance violations for the effluent, meaning that there was > 40% above the effluent limit or chronic violations. These violations were for pollutants including cancer-linked combustion chemicals, industrial solvents, toxic contaminants used in manufacturing, heavy metals that damage the brain and nervous system, and oily residues that harm aquatic life; most of these pollutants are regulated because even small amounts can pose health or environmental risks. One facility also reported toxic water releases of chromium, copper, manganese, and nickel; however, these were in very small quantities (<3 tons).

All three facilities with RCRA permits reported the amount of hazardous waste shipped per year. One was a Large Quantity Generator reporting between 58,000 and 98,000 kg/yr, one reported just shy of 12,000 kg/yr but still was classified as a Large Quantity Generator, and one was a Small Quantity Generator reporting between 5,500-11,000 kg/yr. Three facilities reported ignitable waste and methyl ethyl ketone, two reported benzene and spent non-halogenated solvents, and one reported corrosive waste, barium, cadmium, chromium, and lead.

4.2.3.5 High Voltage Transmission Grid Transformer Risk Summary

Based on the manufacturing processes conducted on site, the primary air pollution risks are anticipated to be VOC and metal particulate emissions. Due to the major source and 80% synthetic minor source classification, the potential to emit high quantities of VOCs and HAPs, and the CAA violations, we characterized the risk from these facilities as **High**; however, only half of the facilities had CAA permits; therefore, we classify the confidence as **B**.

Based on the manufacturing processes conducted on site, the primary water pollution risk is effluent contaminated with metals and solvents. For one facility, this was evident through the reporting requirements and significant noncompliance violations of solvents, metals, and other toxics. As this was the case for only one facility, and all facilities with CWA were still listed as non-major, we classify this risk as **Medium**, with a confidence rating of **B**.

Based on the manufacturing processes conducted on site, the primary hazardous waste risk is sludge contaminated with spent solvents and metals. As with the distribution grid transformers, we found that ignitable waste was a risk from the regulatory review, in addition to spent solvents, corrosive, and reactive waste. Due to the large quantity of waste generated by some facilities, the near consistent permitting of these facilities, and the kinds of waste found onsite, we rate this risk as **High**, with a confidence rating of **B**.

4.2.4 Medium Voltage and High Voltage Switchgear

Switchgears are an essential technology to ensure grid safety. They control the flow of electrical power, deenergizing certain components during faults or during maintenance. Medium voltage (MV) switchgears are used for facilities like data centers or in distribution grids, while high voltage (HV) switchgears are more commonly used for power transmission networks (G&W Electric, 2026).

A switchgear is generally composed of a collection of circuit breakers, relay and control systems, fuses, and switches, mounted inside a metal structure (G&W Electric, 2026). MV switchgears are typically insulated with air, although other insulation materials may be used (Eaton, n.d.). HV switchgears may be insulated with air or other gas to avoid breakdown (Communications with UC Berkeley Labor Center, 2026).

4.2.4.1 Medium Voltage and High Voltage Switchgear Manufacturing Process Literature Findings

The manufacturing process for a switchgear typically consists of five general categories: 1) enclosure fabrication, 2) component installation, wiring and assembly, 3) testing and quality assurance, and 4) finishing and painting, which are described below.

1. Enclosure Fabrication: Medium voltage switchgears are enclosed in metal structures, typically of steel or aluminum alloy (Eaton, n.d.). To fabricate the enclosure, metal sheets are thermally cut, bent, mechanically machined, and welded together (Communications with UC Berkeley Labor Center, 2026; Electrical Business Review, 2025).
2. Component Installation, Wiring and Assembly: Busbars, circuit breakers, relay and control systems, and other electrical components are mounted and installed. These items are typically fabricated offsite (Electrical Business Review, 2025). All components are then wired together precisely.
3. Testing and Quality Assurance: The switchgear goes through insulation resistance testing, dielectric withstand testing, and functional testing to ensure it meets safety and performance standards (Electrical Business Review, 2025).
4. Painting and Surface Coating: The enclosure surface is treated and painted to enhance its corrosion resistance, make it visually appealing, and enhance its lifespan (Electrical Business Review, 2025).

Risks from the general manufacturing processes listed above, namely mechanical machining, thermal cutting, pretreatment, and surface coating, are described in detail in **Section 3**.

The manufacturing process for high voltage switchgears is similar to that of medium voltage switchgears, with two notable exceptions. The first is that high voltage switchgears are much larger and often custom made for site specific purposes and therefore require more advanced machining and assembly (Communications with UC Berkeley Labor Center, 2026). The second is that some high voltage switchgears are insulated with gas, meaning that facilities require advanced fluid handling capabilities. Historically, gas-insulated switchgears used sulfur hexafluoride (SF_6) due its strong insulating properties (National Grid, 2025). SF_6 is non-toxic and non-flammable, meaning its public health risk is low (EPA, 2002); however, it is an incredibly potent greenhouse, with a global warming potential nearly 24,000 that of carbon dioxide EPA, 2026b. During the manufacturing process, SF_6 gas can inadvertently leak, posing climate risks (EPA, 2025c); as a result, there is growing interest in using alternative insulating gases (EPA, 2026b). The risks of SF_6 leaks to climate are not accounted for directly in our risk assessment; however, this is a potential additional environmental impact to consider in addition to the risks we assess more explicitly.

4.2.4.2 Medium Voltage Switchgear Regulatory Findings

We investigated the regulatory permitting for six medium voltage switchgear manufacturing facilities around the U.S. Among the six transmission grid transformer facilities, one had a CAA permit, three had CWA permits, and four had RCRA permits.

The one facility with a CAA permit was classified as a minor source for PM_{10} emissions, although the quantity of PM_{10} emissions was not reported. The facility did report HAP emissions, specifically chromium IV and II, manganese, and nickel; however, these emissions totaled less than 0.03 tpy.

All three facilities with CWA permits were listed as non-major sources. Two facilities did not report discharge monitoring reports, permit limits, effluent charts, or violations. One facility did show discharge monitoring reports but reported zero pounds of pollutants. This facility had effluent limits for oil and grease and was required to monitor for heavy metals (arsenic, nickel, silver, zinc, aluminum, cadmium, lead, chromium, copper, mercury), nitrogen, solids, pH, and total toxic organics. However, it reported water discharges only for chromium, copper, manganese, and nickel, all below 4 tpy.

For the four facilities with RCRA permits, two were classified as Very Small Quantity Generators, one as a Small Quantity Generator, and one as Other. The amount of hazardous waste generated onsite ranged from ~30 kg/yr to 2,300 kg/yr, which corresponds to emission levels allowable for very small quantity generators. Three facilities reported ignitable waste, one reported corrosive, and one reported lead.

4.2.4.3 Medium Voltage Switchgear Risk Summary

Based on manufacturing processes conducted on site, the primary air pollution risks are VOC emissions from pretreatment and surface coating, heavy metal particulate emissions from machining and thermal cutting of the steel enclosure, and potential NO_x emissions from thermal cutting. The regulatory review confirmed the risks from $PM_{2.5}$ and heavy metal particulates, although this risk was considered classified as minor and represented by small quantities of emissions. As such, we classify the air pollution risk from MV switchgear manufacturing as **Low**, with a confidence rating of **B** due to data availability for three of the six facilities.

Based on the manufacturing processes conducted on-site, the primary water pollution risks are oils, metal particulates, and solvents. The regulatory research confirmed the risk of oils and grease and heavy metals. We classify this risk as **Low** due to the minor permitting status, limited effluent requirements, and small toxic water releases. This was rated a confidence of **B** due to data availability for three of the six facilities.

Based on the manufacturing processes conducted on-site, the primary hazardous waste risks are spent solvents and sludge; however, the regulatory research indicated that the waste amounts were likely very small and that the waste generated on-site was mostly ignitable, with the possibility of lead and corrosive waste. As a result, we rated this as a **Low** risk, with a confidence rating of **B** due to data availability for four of the six facilities.

4.2.4.4 High Voltage Switchgear Regulatory Findings

We investigated the regulatory permitting for two high-voltage switchgear manufacturing facilities around the U.S. Among the two facilities, none had CAA permits, both had CWA permits, and one had an RCRA permit.

Both facilities with CWA permits were listed as non-major sources. One facility did have to produce discharge monitoring reports; however, it reported zero pounds per year of pollutant discharge across all years of reported data. There were no violations at either facility. No toxics were reported for these facilities.

The facility with an RCRA permit was classified as a Very Small Quantity Generator and reported generating under 100 kg/yr of hazardous waste. The type of waste generated at this facility included ignitable waste, toxic heavy metal waste (barium, cadmium, chromium, and lead), and methyl ethyl ketone.

4.2.4.5 High Voltage Switchgear Risk Summary

The risk profile for high voltage switchgears is very similar to that of medium voltage switchgears, and we assign the same risk classification of **Low** to the air pollution, water pollution, and hazardous waste pathways. However, very few facilities were evaluated, and no data were available for these facilities, and we assign confidence ratings of **C** to all three pathways.

4.3 Heat Pumps

4.3.1 Heat Pump Water Heaters

Heat pump water heaters heat water by transferring heat using electricity, rather than by generating it through burning fossil fuels (U.S. Department of Housing and Urban Development [HUD], 2024). This process is more efficient, and little additional capacity is required to switch from conventional gas water heater manufacturing to heat pump water heater manufacturing, as companies often produce both (Communications with UC Berkeley Labor Center, 2026). Therefore, most production of heat pump water heaters is expected to be from established companies, and not new players. The focus of this analysis is on facilities performing final assembly, where we assume that key components that fit well in a storage container are likely to be imported (Communications with UC Berkeley Labor Center, 2026).

4.3.1.1 Heat Pump Water Heaters Manufacturing Process Literature Findings

Heat pump water heaters consist of the heat pump, the hot water tank, the control system and ancillary electronics, and the enclosure that houses everything. The heat pump consists of a condenser, compressor, evaporator, and expansion valve (HUD, 2024).

While there are commercial and residential heat pump water heater models on the market, the primary difference between them is that commercial models are designed to handle more demand (Lowe's, 2024). This means that they have a higher capacity. Still, they can be assumed to use the same types of components, and the primary difference in their manufacturing risk profile is likely the volume of emissions. There are also split units where the heat exchanger can be placed separately from the water tank, and integrated units where they are part of the same assembly (National Laboratory of the Rockies, n.d.).

For integrated units, the tank (Communications with UC Berkeley Labor Center, 2026) and smaller components such as the compressor, condenser, evaporator, and expansion valve are primarily imported from overseas (Communications with UC Berkeley Labor Center, 2026), while the enclosure fabrication and assembly occur on-site. The manufacturing process for heat pump water heaters may consist of five general steps: 1) enclosure fabrication, 2) thermal circuit integration, 3) tank insulation, 4) electrical and electronics integration, 5) refrigerant charging.

1. Enclosure Fabrication: The enclosure that houses the unit, commonly made from steel, is fabricated, and the tank and structural components are mounted. This is done using machining, thermal cutting, and welding to create and shape parts (OpenPR, 2026).
2. Thermal Circuit Integration: The heat pump components are joined into a single unit using brazing to connect them with copper pipes (Gradient, 2022).
3. Tank Insulation: The open space between the tank and enclosure walls is insulated by injecting polyurethane foam to fill it (Cannon, 2023). This step carries similar risks to polyurethane coatings.
4. Electrical and Electronics Integration: The control board and ancillary electronics are assembled and wired into the unit with connections created using soldering (OpenPR, 2026).
5. Refrigerant Charging: Depending on the end-use, the system is charged with refrigerant. This step is sometimes done during installation rather than at the manufacturing facility (Gradient, 2022).

Risks from the manufacturing processes, namely machining, thermal cutting, welding, surface pretreatment, and surface coating, are described in detail in **Section 3**. Most refrigerants used in heat pumps are non-toxic and refrigerant leaks do not pose risks to public health, but may pose climate risks (Mitchell, 2021). Current-generation refrigerants have more moderate, but still non-zero, global warming potential than legacy refrigerants such as hydrofluorocarbons (Delforge, 2022). These risks are not explicitly accounted for in our assessment, but are another potential environmental impact to consider.

4.3.1.2 Heat Pump Water Heaters Regulatory Findings

We investigated regulatory permitting for four heat pump water heater manufacturing facilities around the U.S. Among the four facilities, one had a CAA permit, two had CWA permits, and two had RCRA permits.

The facility with a CAA permit was classified as a minor source for CO, SO_2, NO_2, VOCs, $PM_{2.5}$, and PM_{10}. The facility did report HAP emissions, including metals and diisocyanates; however, these emissions were generally less than 1 tpy. This facility did not have any CAA compliance violations.

Both facilities with CWA permits were classified as non-major sources. One of these facilities did show a discharge monitoring report but reported zero pounds of pollutants. This facility had effluent limits for oil and grease and was required to monitor for heavy metals (arsenic, nickel, silver, zinc, aluminum, cadmium, lead, chromium, copper, mercury), nitrogen, solids, pH, and total toxic organics. This facility had six minor pH limit violations from 2023–2026. No further data is available for the other facility with a CWA permit.

For the facilities with RCRA permits, one facility was classified as a Small Quantity Generator and one as a Very Small Quantity Generator. The amount of hazardous waste generated onsite ranged from 100 kg/yr to nearly 5,000 kg/yr. One facility reported ignitable waste and benzene, and one facility reported lead.

4.3.1.3 Heat Pump Water Heaters Risk Summary

Based on the manufacturing processes conducted on site, the primary air pollution risk is emissions of metal particulate matter from machining, thermal cutting, welding, and brazing during enclosure fabrication and unit assembly. There are also risks from NO_x emissions from thermal cutting and isocyanate emissions from polyurethane foam injection. We classify the air pollution risk for heat pump water heater manufacturing as **Low** due to the minor permitting status and reported TRI emissions. We assigned a confidence rating of **C** as data was only available for one of four facilities.

Based on the manufacturing process conducted on site, the primary water pollution risks are rinse water from surface pretreatment and coating and effluent contaminated with MWF used during machining. Wastewater from the surface pretreatment, machining, water-curtain booths, and equipment cleaning may contain metals, pigments, phosphates, surfactants, oil and grease, and other pollutants. The regulatory findings confirm the risk of metals in the effluent, and one facility was found to violate the pH limit. We classify the water pollution risk as **Low** due to the non-major permitting status and limited environmental releases. We rate this with a confidence level of **B**, as data was available for two of four facilities.

Based on the manufacturing process conducted on site, the primary hazardous waste risk is likely spent solvents and pretreatment chemicals, as well as paint sludge. The regulatory research supports this, with one facility reporting the generation of ignitable waste and benzene. We classify the hazardous waste risk as **Medium** based on the amounts of hazardous waste generated on site. We rate this with a confidence level of **C** because while data was available for two of four facilities, the facility that produced the most hazardous waste is a vertically integrated manufacturer who likely produces more than just heat pump water heaters on site.

4.4 Electrolyzers

4.4.1 Catalyst, Stack, and Module Assembly

Electrolyzers use electricity to split water into its constituent components, hydrogen and oxygen. They are primarily used to produce green hydrogen from excess clean electricity (DOE, 2026). Alkaline water electrolyzers are legacy technology (Nikolić et al., 2026); this study focuses on new types of electrolyzers such as Proton Exchange Membrane (PEM), Anion Exchange Membrane (AEM), and Zero Gap Alkaline Water Electrolyzer (ZAWE) (Communications with UC Berkeley Labor Center, 2026). The key component of electrolyzer modules is the stack, where a catalyst and membrane split water molecules. As these types of electrolyzers are new, companies are often vertically integrated and do not procure the core components from third parties in order to protect their intellectual property. This study examined companies producing at the commercial pilot scale or greater.

4.4.1.1 Electrolyzer Manufacturing Process Literature Findings

Electrolyzers consist of the electrolyzer stack and the supporting balance of plant. The stack is a repeating sequence of cells and is the core of the electrolyzer. A cell consists of an anode and cathode separated by an electrolyte, which may be a solid or liquid, with porous layers and bipolar plates on either side. Cells are connected in series with gaskets, frames, and plates to create stacks (CIC energiGUNE, 2022). The balance of plant consists of supporting equipment such as pumps, pipes, heat exchangers, gas separators, water treatment components, and power electronics (Mayyas et al., 2019).

The electrolyzer variants this analysis focuses on are PEM, AEM, and ZAWE types. The catalyst, stack, and module are IP-sensitive and therefore typically manufactured on-site, while membranes and other components are likely externally sourced (Communications with UC Berkeley Labor Center, 2026). The manufacturing process can consist of four general steps: 1) catalyst ink preparation, 2) catalyst coating, 3) cell and stack assembly, 4) module assembly.

1. <u>Catalyst Ink Preparation</u>: The catalyst ink is prepared by dispersing metal catalyst powders into a solvent along with an ionomer binder (Murugaiah & Shahgaldi, 2024). For PEM systems, the commonly used ionomer is Nafion, which is classified as a PFAS material (Nafion 117, 2026), but there are emerging alternatives (PatSnap, 2026). Metal catalysts are frequently platinum or iridium oxide, while the solvent may be propanol or n-butanol (Murugaiah & Shahgaldi, 2024; Ouimet et al., 2022).
2. <u>Catalyst Coating</u>: The catalyst ink is then applied to the membrane or porous transport layer by spraying, slot-die coating, or decal transfer (Mayyas et al., 2019; Koch et al.,

2023). Decal transfer is accomplished by thermally pressing a pre-coated catalyst layer onto the membrane (Koch et al., 2023). The coated layers are then dried using ovens.

3. Cell and Stack Assembly: The transport layers, coated membrane, electrolyzer or separator, and bipolar plates are then assembled into repeating units and compressed together into a stack held together with tie rods and end plates (Badgett et al., 2024). Cell and stack assembly is assumed to be a largely mechanical process and likely presents minimal public health risk.
4. Module Assembly: One or more stacks are then integrated with the balance of plant (CIC energiGUNE, 2022; Mayyas et al., 2019). This is assumed to be primarily accomplished through mechanical fasteners and electrical wiring, and likely presents limited public health or environmental risk. For ZAWE, the stack is charged with the liquid potassium hydroxide electrolyte (Kumar & Lim, 2022).

4.4.1.2 Electrolyzer Regulatory Findings

We investigated the regulatory permitting for four electrolyzer manufacturing facilities around the U.S. Among the four facilities, one had a CAA permit, none had CWA permits, and three had RCRA permits.

The one facility with a CAA permit did not have a source type classification and did not report any publicly available emissions.

For the three facilities that had RCRA permits, only two reported hazardous waste quantities: one reported 400-800 kg/yr, corresponding to the levels for a Very Small Quantity Generator (although it was classified as Other), and the other reported ~2,700-3,700 kg/yr, corresponding to the levels for a Small Quantity Generator. Only one facility reported the kind of waste generated on site; this included ignitable waste, corrosive waste, reactive waste, and spent non-halogenated solvents.

4.4.1.3 Electrolyzer Risk Summary

Based on the manufacturing processes that occur on site, the primary air pollution risks are associated with VOC emissions during the catalyst ink preparation and application steps. These may be released as overspray or while in the drying ovens. We classify the air pollution risk associated with electrolyzer manufacturing as Very Low with a confidence rating of C due to the lack of permitting or emissions data.

Based on the manufacturing processes that occur on site, the primary water pollution risks are rinse water from cleaning the equipment used to prepare and apply the catalyst, which may be contaminated with PFAS, catalyst metals, and solvents. We classify the water pollution risk as **Very Low** with a confidence rating of **C** due to the lack of permitting required for these facilities.

Based on the manufacturing processes that occur on site, the primary hazardous waste risks are spent solvents, sludge from cleaning operations, and off-spec or expired catalyst ink. The regulatory findings support this, with one facility reporting ignitable, corrosive, and reactive waste, and spent non-halogenated solvents. We classify the hazardous waste risk as **Medium** due to the quantity of waste generated onsite, with a confidence rating of **B,** as two of four facilities reported hazardous waste quantities, despite three of four having RCRA permits.

4.5 EV Charger

As EV infrastructure continues to grow in the commercial sector, demand for EV charging products is expected to keep pace. Direct current fast chargers (DCFC), also known as Level 3 chargers, can charge battery electric vehicles to 80% in under an hour, making them ideal for servicing commercial vehicles along heavy-traffic corridors (U.S. Department of Transportation [DOT], 2025). Due to their larger size and end use, they are more likely to be manufactured domestically than other EV charging types, and were therefore selected as the most viable EV charging technology to be manufactured in the GEZ (Communications with UC Berkeley Labor Center, 2026).

4.5.1.1 EV Charger Manufacturing Process Literature Findings

DCFCs consist of power conversion hardware, control and communications electronics, a thermal management system, the charge cable and connector, wire harnesses, and the enclosure and structural hardware (Peak Nano, 2025). The power conversion hardware includes the power modules, capacitor banks, transformers, and other electrical and electronic components to convert AC grid power to DC output (Energispot, 2025). The control and communications systems use PCBs that control the unit and integrate with other electronics to provide communication capabilities (Ring PCB Technology, 2025). The thermal management system uses fan-based or liquid cooling systems to manage the temperature of the power unit, and a separate liquid cooling loop often serves the charging cable at higher power outputs (Energispot, 2025). The enclosure is a sheet metal cabinet along with all mounting and ancillary hardware (Weber, 2021). The charge cable is the connection between the unit and the vehicle. The wire harness is the internal wiring between all components.

The manufacturing process for DCFCs can be broken down into four general categories: 1) enclosure and busbar fabrication, 2) PCBA assembly, 3) power module integration, 4) mechanical and thermal integration.

1. Enclosure Fabrication: The enclosure that houses the assembly is fabricated from sheet metal, commonly steel, and mounting hardware and gaskets are installed (Weber, 2021). This may involve machining, thermal cutting, and welding. Surface treatments for outdoor electrical enclosures commonly include a sequence of degreasing, derusting, phosphating, and coating with paint or a powder coat (Mulan Group, 2025). The busbar, a solid copper (or aluminum) bar that distributes power between electrical components, is also fabricated and involves machining, surface pretreatment, and coating (Fuspan, 2025).
2. PCB Assembly: PCBAs are assembled by mounting electronic and electrical components onto the PCB and fixing them in place by soldering. PCBA assembly commonly uses wave, reflow, and manual soldering methods (MacroFab, 2024).
3. Power Module Integration: Power modules that convert AC to DC current and regulate the electrical power (Elinta Charge, n.d.) are assembled from components. Components include the power device (such as IGBTs or MOSFETs), the busbar, and conductive cooling structures, among others (Zeconex, 2026). Power components are typically bolted on, while control components may be soldered or attached with other connectors such as crimps (Rusche, 2013).
4. Mechanical and Thermal Integration: The final assembly steps include mounting and connecting the cooling systems, fitting the charge cables and connectors, and connecting everything with the wiring harness. Mounting and connecting the cooling systems largely involves mechanical fasteners and fittings. For liquid-cooled systems, brazing can be used at copper joints, but press fittings are more commonly used. Wire harness connections are typically done with crimp terminations rather than solder (LCSC, 2026).

4.5.1.2 EV Charger Regulatory Findings

We investigated the regulatory permitting for three DCFC manufacturing facilities around the U.S. Among the three facilities, none had CAA or CWA permits, and only one had an RCRA permit. However, this permit reported only 3 kg of hazardous waste in 2024 and did not report the type of hazardous waste generated on-site.

4.5.1.3 EV Charger Risk Summary

Based on the manufacturing processes conducted on site, the primary air pollution risk is metal particulate matter emissions from machining, thermal cutting, welding, and brazing during enclosure and busbar fabrication, with minor risks from solder fumes and thermal cutting NO_x emissions. We classify the air pollution risk associated with DCFC manufacturing as **Very Low** with a confidence rating of **C** due to the lack of permitting required for these facilities.

Based on the manufacturing processes conducted on site, the primary water pollution risks are rinse water from surface pretreatment and coating, as well as effluent contaminated with MWF used during machining. Rinse water and effluent may contain metals, phosphates, pH excursions, surfactants, chelating agents, and other pollutants. We classify the water pollution risk as **Very Low** with a confidence rating of **C** due to the lack of permitting required for these facilities.

Based on the manufacturing process conducted on site, the primary hazardous waste risk is likely spent solvents and pretreatment chemicals, as well as paint sludge. We classify the hazardous waste risk as **Very Low** with a confidence rating of **C**, as only one of three facilities had a RCRA permit, and that facility reported only 3 kg of hazardous waste.

4.6 Zero Emissions Vehicles

Zero emissions vehicles are vehicles that do not produce exhaust or tailpipe emissions locally, typically because they are all-electric (Alternative Fuels Data Center, n.d.). For the GEZ, light- to medium-duty ZEVs, drones, powertrains, and electric ferries were considered the most viable technologies to manufacture. They are described below.

4.6.1 Light to Medium Duty Vehicles, Final Assembly

This analysis focuses on smaller-scale manufacturing facilities that assemble light-duty vehicles (LDVs, e.g., passenger vehicles) and medium-duty vehicles (MDVs, e.g., delivery vans, fire trucks, and school buses). Specifically, we examine final assembly operations that produce finished or near-finished vehicles at low- to medium-scale production facilities.

4.6.1.1 Light to Medium Duty Vehicles Manufacturing Process Literature Findings

LDVs and MDVs generally consist of the body structure, the powertrain and transmission, the chassis and suspension, the battery pack and electrical system, the thermal management and charging system, the braking system, and the exterior and interior trim and fittings (Communications with UC Berkeley Labor Center, 2026).

For final assembly facilities, most components will be externally sourced (Communications with UC Berkeley Labor Center, 2026) with the exception of the frame, which may be manufactured on site (Communications with UC Berkeley Labor Center, 2026). The main difference between manufacturing processes for LDVs vs. MDVs at this stage is that LDV chassis fabrication is more complex, requiring heat treating and stamping the metal, while MDV chassis fabrication is largely bending and welding sheet metal (Communications with UC Berkeley Labor Center, 2026). The manufacturing process for LDVs and MDVs breaks down into five general steps: 1) body fabrication, 2) surface preparation and coating, 3) parts integration, 4) battery installation and wiring, and 5) final assembly.

1. Body Fabrication: The body of the vehicle is fabricated from sheet steel or aluminum. Manufacturing processes that may be involved include machining, welding, and stamping to shape and form the metal, as well as potentially adhesive bonding to join body parts (DOE, 2008; Giampieri et al., 2020). Risks from these processes are described in **Section 3**. The resulting body-in-white assembly is then ready to be treated and painted (DOE, 2008).
2. Surface Preparation and Coating: The surface of the body-in-white is prepared using baths to remove oils and particulates, followed by phosphating to improve the frame's corrosion resistance and improve paint adhesion (Giampieri et al., 2020). Once the surface is prepared, the body is electrocoated, cured in an oven, then sanded before applying primer, the base coat, and the clear coat (Giampieri et al., 2020). Between applying the clear coat, solvent from the base coat and primer is allowed to evaporate (Giampieri et al., 2020).
3. Chassis Assembly: The powertrain, brake system, steering and suspension, and other mechanical systems are mounted on a steel frame by pressing (Giampieri et al., 2020). These components are expected to be externally sourced or fabricated in separate facilities (Communications with UC Berkeley Labor Center, 2026).
4. Battery Installation and Wiring: The battery is installed along with the power electronics module and wired up to the powertrain (Eddy, 2026). Note that this may occur during chassis assembly. At this stage, the battery may also be potted with polyurethane foam for vibration dampening and fire retardancy (Adhesives & Sealants Industry, 2023).
5. Final Assembly: During final assembly, the vehicle body is integrated with the chassis and final components, and trim is installed (DOE, 2008; Giampieri et al., 2020). There appear to be minimal risks associated with this step.

4.6.1.2 Light to Medium Duty Vehicle Regulatory Findings

We investigated the regulatory permitting for four LDV/MDV manufacturing facilities around the U.S. Among the four LDV/MDV manufacturing facilities, none had CAA permits, none had

CWA permits, and two had an RCRA permit. The only facility with an RCRA permit that reported hazardous waste reported ~3,300 kg/yr in 2025, making it a Small Quantity Generator. The facility reports a mix of ignitable waste, reactive waste, methyl ethyl ketone, and spent non-halogenated solvents.

4.6.1.3 Light to Medium Duty Vehicle Risk Summary

Based on the manufacturing processes, the primary air pollution risks are from metal air particulate emissions from machining, thermal cutting, and welding during frame fabrication, as well as VOC emissions from surface treatment and coating. There are also secondary risks from isocyanate emissions from applying the clear coat and battery potting if polyurethane is used. We classify the air pollution risks associated with LDV/MDV manufacturing as **Very Low** with a confidence rating of **C** due to the lack of permitting required for these facilities.

Based on the manufacturing processes conducted on site, the primary water pollution risks are rinse water from surface pretreatment and coating. Rinse water from vehicle frame surface pretreatments may contain metals, phosphates, high or low pH, surfactants, oil and grease, and other pollutants. Water-curtain booths that capture overspray and equipment cleaning associated with surface coating operations can generate wastewater with metal-containing pigments, resin emulsions, surfactants, and other coating additives. We classify the water pollution risks as **Very Low** with a confidence rating of **C** due to the lack of permitting required for these facilities.

Based on the manufacturing process, the primary hazardous waste risk is likely spent solvents and pretreatment chemicals, as well as paint sludge and spent or off-spec batteries that must be disposed of. This is supported by the regulatory findings where the facility with a RCRA permit reported ignitable waste, reactive waste, methyl ethyl ketone, and spent non-halogenated solvents. We classify the hazardous waste risk as **Medium** due to the quantity of waste generated. We assign this a confidence rating of **C** as only one of four facilities required a hazardous waste permit.

4.6.2 Drone Manufacturing

Drones are autonomous vehicles and have a wide variety of end uses, from delivery services to military applications. The types of drones most viable for manufacturing in the GEZ include small, electrically powered remotely or autonomously controlled craft, ranging from handheld drones to drones capable of carrying packages and even cargo, and electric vertical takeoff and landing vehicles (eVTOLs), specifically autonomous or piloted craft that can take human passengers non-trivial distances (Communications with UC Berkeley Labor Center, 2026).

4.6.2.1 Drone Manufacturing Process Literature Findings

Drones and eVTOLs consist of a structural frame or fuselage, propulsion system, a battery, and onboard electronics. The propulsion system may include motors, an electronic speed controller, and propellers or rotors. The electronics may include a PCB controller, GPS unit, camera, and other sensors (Curti, 2025).

The focus of this analysis is on facilities that do final assembly. While there may be some frame or fuselage work onsite, most of the components are externally sourced. The manufacturing of drones and eVTOLS may consist of five general steps: 1) structural fabrication and/or assembly, 2) eVTOL-specific surface coatings, 3) propulsion system integration, 4) electrical and electronics integration (Communications with UC Berkeley Labor Center, 2026). There is a range of scales under consideration, ranging from smaller defense or hobbyist drones to mid-scale delivery drones to large eVTOLs. The risk profile is largely similar across all types, but there is some variation.

1. Structural Fabrication and/or Assembly: The frame or fuselage is first fabricated or assembled. Drones may be assembled from parts made of carbon fiber, aluminum, or other materials with mechanical fasteners or adhesives such as epoxy or methacrylate (Ebadi, 2019). This step may involve some minor machining and solvent degreasing of mating surfaces. eVTOLS are assembled from large carbon-fiber composite structures (Luthada, 2025) that may be cured as a single unit (CompositesWorld, 2023) and then machined to tolerance.
2. eVTOL-Specific Coatings: For eVTOLs, the surface treatment likely follows typical aerospace practices to coat composite materials. The surface is first sanded, then wiped down with a solvent. Then a polyurethane base coat is applied to both act as a primer and fill in voids in the composite weave (Rowbotham, 2012). This is followed by a topcoat that is a clear or high-gloss pigmented polyurethane coat (Rowbotham, 2012; Aviation Pros, 2015).
3. Propulsion System Integration: The propulsion system components are then integrated into the frame. Some electronic components may be potted or encapsulated with epoxies, urethanes, or silicones at this step (Ebadi, 2019).
4. Electrical and Electronics Integration: The PCB controller, battery, and remaining electronics are mounted and wired, with electrical connections completed using soldering (Communications with UC Berkeley Labor Center, 2026).

4.6.2.2 Drone Manufacturing Regulatory Findings

We investigated the regulatory permitting for six drone manufacturing facilities around the U.S. Among the six facilities, none had a CAA permit, only one had a CWA permit, and three had RCRA permits. We found no reported air emissions or water discharges. Only one facility reported hazardous waste amounts (~400 kg/yr) and was listed as "Other." The other two facilities with RCRA permits were listed as "Other" and "SQG" and did not report waste amounts. However, the small quantity generator noted that the hazardous waste included ignitable waste.

4.6.2.3 Drone Manufacturing Risk Summary

Based on the manufacturing processes that occur on site, the primary air pollution risks are associated with VOCs and diisocyanates from the surface coating step of eVTOLs, depending on the type of coating used. There are minimal air pollution risks associated with drone manufacturing based on the manufacturing processes. We classify the air pollution risk associated with drones and eVTOLs as **Very Low** with a confidence rating of **C** based on the lack of permitting required for these facilities.

Based on the manufacturing processes that occur on site, the primary water pollution risks are solvent and oil contamination during the surface treatment and coating step. However, these risks are very minimal and do not apply to drones, as they are not typically coated. We classify the water pollution risk as **Very Low** with a confidence rating of **C** based on the lack of permitting required for these facilities.

Based on the manufacturing processes that occur on site, the primary hazardous waste risks are spent solvent and damaged or off-spec batteries that must be disposed of. We classify the hazardous waste risk as **Very Low** with a confidence rating of **C** based on the lack of permitting required for these facilities.

4.6.3 Electric Ferry Manufacturing

Electric ferries are ships that use battery-powered electric propulsion in place of conventional diesel-powered engines. The focus of this analysis is on the final assembly of the ferry, which typically would occur in shipyards.

4.6.3.1 Electric Ferry Manufacturing Process Literature Findings

An electric ferry consists of the hull, the electric propulsion system, a battery bank, electrical systems, and trim such as passenger seats, rails, etc (Communications with UC Berkeley Labor Center, 2026). The primary difference between a conventional ferry and an electric ferry is the use of electric motors rather than a diesel drivetrain; the main structure of the ferry is not necessarily different (Communications with UC Berkeley Labor Center, 2026).

A facility focused on final assembly may fabricate the hull, but the propulsion system, batteries, and other parts are likely to be externally sourced (All American Marine, 2024; Communications with UC Berkeley Labor Center, 2026). The manufacturing process for electric ferries can be broken down into five general steps: 1) hull fabrication, 2) surface preparation, 3) surface coating, 4) propulsion, battery, and electrical integration, and 5) outfitting and finishing.

1. Hull Fabrication: The hull of the ferry is fabricated from marine-grade aluminum using cutting, bending, and welding processes (All American Marine, n.d.)
2. Surface Preparation: The surface of the hull is then degreased and prepared for painting using abrasive blasting, mechanical abrasion, or chemical etching. This strips the aluminum oxide layer from the aluminum, making it ready for the immediate application of primer (International Yacht Paint, n.d.).
3. Surface Coating: Coatings are applied to the hull in three layers: an anti-corrosive primer, an intermediate coat, and a topcoat. The primer is typically either an epoxy layer, often zinc phosphate epoxy, or an etch/conversion primer. The intermediate coat is an additional epoxy layer that provides a thicker protective film between the primer and topcoat. The topcoat is often a polyurethane layer (Chen, 2025). An additional antifouling layer may be included below the water line, which is often a copper-free paint for aluminum vessels (Better Boat, 2026).
4. Propulsion, Battery, and Electrical Integration: The propulsion and electrical system is then installed. This includes installing the battery bank, the motors and drivetrain, and the controls and power management system, as well as wiring everything together (Communications with UC Berkeley Labor Center, 2026). This step is mostly accomplished through bolting, crimping, and other mechanical connections and fasteners (ToolGrit, 2026) and therefore presents minimal risks.
5. Outfitting and Finishing: The final outfitting and finishing step involves installing trim such as seats, rails, and windows and applying any interior or trim painting (Communications with UC Berkeley Labor Center, 2026). This may involve the use of spray polyurethane foam insulation (Fomicom, n.d.), adhesives and sealants, and solvents in smaller quantities to prepare surfaces.

4.6.3.2 Electric Ferry Regulatory Findings

We investigated the regulatory permitting for two electric ferry manufacturing facilities; however, only one was located within the U.S. This facility had no CAA, CWA, or RCRA permits reported. This indicates the presumed environmental and health implications from these facilities fell below regulatory thresholds.

4.6.3.3 Electric Ferry Risk Summary

Based on the manufacturing processes conducted on site, the primary air pollution risks are metal particulate matter emissions from the hull fabrication step, as well as VOCs and diisocyanates from the surface treatment and coating steps. Abrasive blasting is known to produce particulate matter emissions, but these may be mostly or totally controlled through the use of shrouding or vacuum blasting (San Diego County Air Pollution Control District, 2026). The final outfitting and finishing step may have associated diisocyanate emissions from the use of polyurethane foam as well as minor VOC emissions from coatings or solvent-based adhesives, if used. We classify the air pollution risk associated with electric ferry manufacturing as **Very Low** with a confidence rating of **C** due to the lack of permitting required for the facility.

Based on the manufacturing processes conducted on site, the primary water pollution risk is associated with the surface treatment stage. Rinsewater from degreasing and phosphating the surface of the hull may be contaminated with oils and grease, metals, and solvents. Booths or bays that capture overspray and equipment cleaning associated with surface coating operations can also generate wastewater with metal-containing pigments, resin emulsions, surfactants, and other coating additives. We classify the water pollution risk as **Very Low** with a confidence rating of **C** due to the lack of permitting required for the facility.

Based on the manufacturing processes conducted on site, the primary hazardous waste risk is likely spent solvents, paint sludge, and damaged or off-spec batteries that must be disposed of. We classify the hazardous waste risk as **Very Low** with a confidence rating of **C** due to the lack of permitting required for the facility.

4.6.4 Electric Powertrain Manufacturing

Electric powertrains are the EV equivalent of a combustion engine drivetrain in a conventional gas vehicle. They convert the energy stored in batteries into the energy required to move an EV. The focus of this analysis is on smaller to mid-scale manufacturing facilities as they are considered more viable for the GEZ (Communications with UC Berkeley Labor Center, 2026).

4.6.4.1 Electric Powertrain Manufacturing Process Literature Findings

Electric powertrain facilities may produce standalone powertrains and powertrain components, such as motors and inverters, or full vehicle electrification systems that integrate the powertrain with the power and control system (Cascadia Motion, n.d.; Wrightspeed, n.d.). An electric powertrain consists of the motor, inverter, gearbox, and housing that contains them. A full electrification system includes the powertrain, batteries, and power control modules. Components of the motor include the stator, rotor, shaft, bearings, and the housing. The inverter is composed of power semiconductors, a control board, and the housing (Eddy, 2025).

Facilities that conduct the final assembly of either technology typically source most components, such as the motor subcomponents, externally (Communications with UC Berkeley Labor Center, 2026). Some facilities do manufacture the product housing and some components onsite, and we have included those risks in the analysis. Powertrain and electrification system manufacturing breaks down into four general steps: 1) component fabrication, 2) motor and inverter assembly, 3) battery pack assembly, and 4) powertrain integration.

1. Component Fabrication: The component housings, shaft, brackets, and gears are fabricated. This is accomplished through machining operations such as milling (Origin Basis, 2026). Some facilities may source these components externally, and that surface treatment and coating are often done offsite.
2. Motor and Inverter Assembly: The motor and inverter are sub-assembled. The stator is wound, impregnated with an epoxy or alkyd varnish (MG Chemicals, 2021), then cured. The rotor is fitted to the shaft and PCBs may be populated by soldering in components.
3. Battery Pack Assembly: Facilities that produce electrification systems may assemble battery cells and modules into packs that are incorporated into the final assembly. This is accomplished using epoxy or polyurethane adhesives, fillers, and potentially polyurethane foam for vibration dampening and fire retardance (H.B. Fuller, n.d.; Graco, n.d.). The power control unit, battery banks, and powertrain are then ready to be wired together when they are installed in the vehicle.
4. Powertrain Integration: The motor, inverter, and gearbox are mated into a single unit on an assembly line that uses presses and mechanical fasteners (Comau, n.d.). Solvents may be used to clean mating surfaces at this step. The gearbox is filled with oil, coolant loops are filled, and wiring is connected.

4.6.4.2 Electric Powertrain Regulatory Findings

We investigated the regulatory permitting for three electric powertrain manufacturing facilities around the U.S. Among the three facilities, none had CAA or CWA permits, and only one had an RCRA permit. However, this permit did not specify the amount or the type of hazardous waste generated onsite.

4.6.4.3 Electric Powertrain Risk Summary

Based on the manufacturing processes that occur on site, the primary air pollution risks are metal particulate emissions from machining components. For facilities that produce full electrification systems, there are additional risks from diisocyanate emissions associated with the use of polyurethane adhesives and foam. We classify the air pollution risk associated with electric powertrain manufacturing as **Very Low** with a confidence rating of **C** due to the lack of permitting required for these facilities.

Based on the manufacturing processes that occur on site, the primary water pollution risks are contamination from rinse water with MWF, spilled gear oil, or spilled coolant. We classify the water pollution risk as **Very Low** with a confidence rating of **C** due to the lack of permitting required for these facilities.

Based on the manufacturing processes that occur on site, the primary hazardous waste risks are spent solvents and damaged or off-spec batteries that must be disposed of. We classify the hazardous waste risk as **Very Low** with a confidence rating of **C** due to the lack of permitting required for these facilities, and the lack of further information on the single facility with a RCRA permit.

4.7 Offshore Wind

4.7.1 Floating Offshore Wind Steel Semi-Submersible Platforms

California has massive offshore wind potential off its coastline, and is actively pursuing floating offshore wind energy to diversify its electricity grid while also providing high-paying jobs (California Energy Commission, 2024). While it is unlikely that full wind turbines will be manufactured in the GEZ, there may be feasibility in producing steel and semi-submersible platforms in full fabrication shipyards at port sites (Communications with UC Berkeley Labor Center, 2026).

4.7.1.1 Floating Offshore Wind Steel Semi-Submersible Platforms Manufacturing Process Literature Findings

Floating offshore wind turbine platforms primarily involve steel or concrete (sometimes a hybrid of both). We focus on steel semi-submersible platforms, as these are most likely to be deployed off the West Coast. The manufacturing process will then be predominantly steel-focused and therefore require mostly steel fabrication and construction, including processes like steel cutting, welding, blasting and surface preparation, and surface coating. Steel cutting can generate toxic metal particulates, and welding can release metal fumes.

Steel blasting in particular traditionally uses coal furnaces and emits significant amounts of $PM_{2.5}$ (Indiana University ERI, 2026). Surface coating can release HAPs and VOCs. Details on these processes as well as their health impacts are covered in **Section 3** on Core Manufacturing Processes and **Table A1**.

4.7.1.2 Floating Offshore Wind Steel Semi-Submersible Platforms Regulatory Findings

Most floating-platform offshore wind manufacturers operate outside of the U.S., mostly in Europe, with companies like Principle Power constructing wind farms off the coasts of Portugal, England, Scotland, and France (Principle Power, 2026). There were no comparable domestic floating platform offshore wind companies in the U.S. to pull detailed facility reports on.

4.7.1.3 Floating Offshore Wind Steel Semi-Submersible Platforms Risk Summary

Based on the manufacturing processes conducted on site, the primary air pollution risks are metal particulate and VOC emissions from cutting, welding, and blasting, as well as VOC emissions from surface pretreatment and coating. Due to the lack of domestic manufacturers producing offshore wind platforms, there is no regulatory permit data available. Despite this, we classify the air pollution risk as **Medium** based on the scale of manufacturing and types of processes used, and assign a confidence rating of **C**.

Based on the manufacturing processes conducted on site, the primary water pollution risk is effluent contaminated with metals and solvents. Due to the lack of data availability and the nature of manufacturing, we classify water pollution risk as **Very Low** with a confidence rating of **C**.

Based on the manufacturing processes conducted on site, the primary hazardous waste risk may be slag containing manganese or hexavalent chromium. Due to the lack of data availability and the nature of manufacturing, we classify hazardous waste risk as **Very Low** with a confidence rating of **C**.

4.7.2 High Voltage Direct Current Subsea Cables

Electricity generated from offshore wind turbines is transmitted via subsea cables. High voltage direct current (HVDC) subsea cable manufacturing will require new, custom facilities built for these massive specialty cables (Communications with UC Berkeley Labor Center, 2026).

4.7.2.1 High Voltage Direct Current Subsea Cables Manufacturing Process Literature Findings

Limited information could be gathered about possible subsea cable impacts. Cross-linked polyethylene (XLPE) and other polymers are used for wire coating (Kristech, n.d.). XLPE itself is not toxic, but it is flammable, and combustion of polyethylene-based substances can release CO, olefinic and paraffinic compounds, or trace amounts of organic acids, ketones, and alcohols, which could cause difficulty breathing if inhaled (Worldwide Foam GHS Safety Sheet, 2018). Carbon black powder is also used as an insulator (Birla Carbon, 2021), and can be a fine particulate matter risk as well (Saputra, et al., 2014).

4.7.2.2 High Voltage Direct Current Subsea Cables Regulatory Findings

LS Cable & Systems (LS Greenlink) is the example company for this category, having broken ground on a massive undersea cable factory in Chesapeake, VA. No permit or emissions data were available for this facility; however, the facility began operations in 2025, so this data may not yet be available through federal or state reporting programs.

4.7.2.3 High Voltage Direct Current Subsea Cables Risk Summary

Regulatory data and information on manufacturing processes used for high voltage direct current subsea cable manufacturing is limited. Based on the limited available information, we classify this subtechnology as **Very Low** risk with a confidence rating of **C** across all three pathways.

4.8 Comparison To Existing Operations

To contextualize the regulatory findings for each technology subcategory, we assessed 45 existing industrial operations in Contra Costa County for their air emissions, water releases, and hazardous waste production, as well as their permit compliance. These 45 facilities are categorized in broad groups – Manufacturing, Chemical, and Oil and Gas Refining. Many smaller-scale manufacturing facilities did not have permit information available; however, several larger operations had significant air, water, and hazardous waste emissions, and frequent major permit violations resulting in financial penalties. A few examples of such facilities include:

- Criterion Catalyst and Technologies – A chemical manufacturer that releases up to 13 tons of air emissions and 200 lbs of water discharges of TRI chemicals, and generates 60,000 kg of hazardous waste as an LQG under the RCRA. This facility is a major source under the CAA and has High Priority CAA permit violations for 12/12 quarters assessed, resulting in a $26,500 penalty.

- Henkel Corporation – A manufacturing facility with 0.5 tons of TRI chemical air emissions and up to 100,000 kg of hazardous waste generated as an LQG under the RCRA. This facility is a synthetic minor source with High Priority CAA violations (12/12 quarters) and RCRA violations (4/12 quarters).
- USS-POSCO – A now-idle steel manufacturer with up to 40 tons of NO_x emissions, 0.3 tons of TRI chemical air emissions, and 700 lbs of TRI chemical water discharges, and up to 600,000 kg of hazardous waste generated. This facility is a major source under the CAA, an LQG under the RCRA, and a major discharger under the CWA, with CWA permit violations for 3/12 quarters assessed.
- Dow Chemical – A chemical facility that emits up to 16 tons of VOCs, 11 tons of TRI chemicals to the air, and ships up to 2,000,000 kg of hazardous waste per year. This facility is a major source under the CAA, has had 12/12 quarters of High Priority CAA violations, and is a Significant RCRA noncomplier for 12/12 quarters.

All oil and gas refinery operations in Contra Costa, like Chevron Richmond and Shell Martinez, are major sources under the CAA, with high-priority violations, and major dischargers under the CWA. They each have hundreds of thousands to millions of pounds of air emissions, water discharges, and hazardous waste production. While not every legacy operation in the county has this level of impact, many of these example facilities rank above our risk classifications, as highlighted in **Table 3**, with **High** risk with a confidence rating **of A** due to the availability of regulatory data and community experience.

Table 3: Risk Classification for Existing Industrial Operations in Contra Costa County.

Category	Air Pollution Risk (Confidence)	Water Discharge Risk (Confidence)	Hazardous Waste Risk (Confidence)
Manufacturing	Low (B)	Low (B)	High (B)
Chemical Plants	High (B)	Low (B)	Very High (A)
Oil & Gas Refining	> Very High (A)	> Very High (A)	> Very High (A)

Direct comparisons between new GEZ facility impacts and legacy industrial facility impacts cannot be readily made, as these technologies require different manufacturing processes and are at different scales of development. However, this exercise does provide a reference point for the current situation in Contra Costa County, with two main purposes:

1) Avoid replacing legacy polluting companies with another polluting industry,

2) Understand the cumulative burdens the region has experienced to avoid adding additional health and environmental burdens.

5.0 Risk Mitigation Recommendations

While clean energy manufacturing may carry lower environmental and public health risks than some of the existing legacy industries, it is not without risk. It remains important to implement appropriate controls, practices, and monitoring to minimize the potential for harm to the surrounding community. The following recommendations identify specific practices, control technologies, and considerations that may be implemented to mitigate environmental and public health risks associated with the transition to clean energy manufacturing, both at the regional level and the facility level.

5.1 Regional Mitigation Recommendations

While facility-level controls are essential to managing site-specific risks, some risks are best addressed at a regional scale, where policymakers, the GEZ Board, and regulatory agencies are better positioned to act than any individual facility. The following recommendations identify actions for policymakers and regulators to ensure that regional systems are adequate to protect community health as the sector grows.

Hazardous Waste Infrastructure. Policymakers should ensure that the region has adequate licensed hazardous waste processing capacity and emergency response infrastructure to safely manage increased hazardous waste volumes from new and expanding facilities. Policymakers should assess current regional hazardous waste processing capacity against projected waste volumes from planned and anticipated facilities, and should work with waste management providers to expand licensed processing capacity. This particularly includes expanding specialized capacity for waste streams that require specific handling and cannot be processed at all facilities. Additionally, policymakers should ensure that proper emergency preparedness is in place in the event of an accident at these disposal facilities, including coordination with local authorities on emergency response specific to the hazardous waste expected on site.

Regulatory Framework. As clean energy manufacturing advances in the region, the GEZ Board and policymakers should proactively engage with regulatory agencies to protect public health. Agencies should ensure that permitting and oversight reflect the risks posed by manufacturing each technology and that protective practices and technologies are considered and implemented early.

Cumulative Impacts. Contra Costa County is home to a host of heavily polluting industries in the fossil fuel and chemical sectors, in addition to other emission sources like ports, landfills, a coal train, and traffic-laden highways. Census tracts in the county rank among the highest in California for cumulative environmental and socioeconomic burdens (see **Figure 1** below; Office of Environmental Health Hazard Assessment, 2026). While the risks posed by a single facility may be relatively small, the collective impacts across an influx of multiple small facilities may contribute greater risks to a region already burdened by a legacy of polluting industries. In addition to considering the impacts of individual large, high-risk facilities, it is important to understand the cumulative burden of numerous densely sited small operations to assess the risk these facilities pose.Proper siting of new facilities should be conducted to ensure that additional environmental hazards are not created in historically burdened communities, and that risks are understood at the community scale rather than the scale of an individual facility.

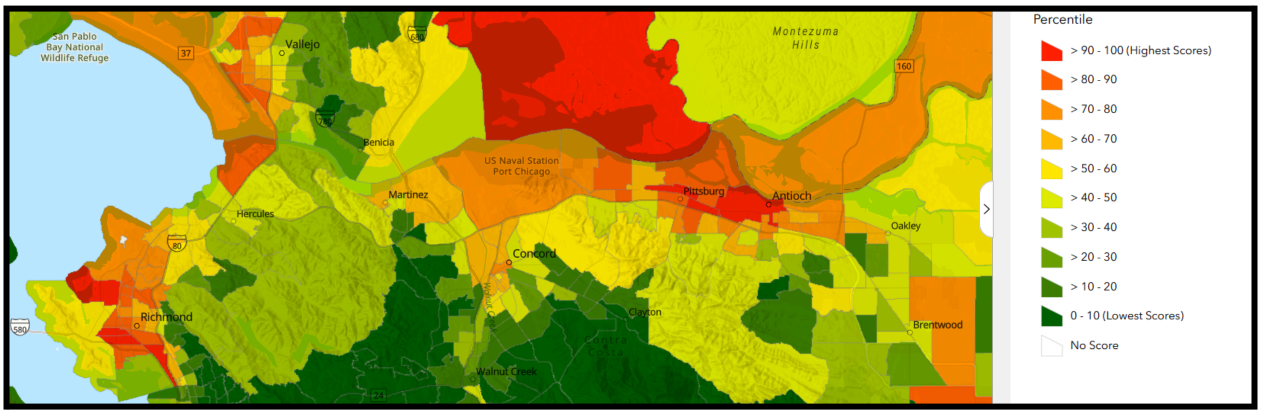

Figure 1: Census tract-level CalEnviroScreen percentile rankings for cumulative burdens based on environmental exposures, socioeconomic indicators, and health vulnerabilities. Many areas in Contra Costa are in the upper 25th percentile of burdened census tracts in the state, representing the importance of community context when planning potential new manufacturing.

Monitoring and Reporting. Monitoring the impacts of manufacturing facilities and reporting the results in a transparent and publicly accessible way are foundational to protecting community health as clean energy manufacturing scales up. Air emissions, water discharges, and hazardous waste can only be managed to the extent that they are measured. Monitoring data should be reported into public databases accessible to residents, researchers, community organizations, and regulators. This allows these groups to identify facilities of concern, track trends over time, evaluate cumulative burdens, and hold operators accountable. As clean energy manufacturing grows in the region, we recommend that monitoring and reporting requirements be established early and applied consistently to minimize risk to the surrounding community.

5.2 Facility-Specific Mitigation Recommendations

Facilities conducting clean energy manufacturing in the GEZ will generate emissions, discharges, and waste across multiple environmental pathways from many of the same underlying manufacturing processes such as surface pretreatments and welding. These processes generate air emissions of concern including VOCs, HAPs such as isocyanates and specific metals (e.g., hexavalent chromium, manganese, nickel, cobalt), and particulate matter. They may contaminate wastewater and stormwater with metals (chromium, copper, nickel, zinc, lead), oils and greases from MWFs and coolants, solvents and surfactants, and acids or bases from pretreatment baths. Furthermore, they may generate hazardous waste streams including spent halogenated and non-halogenated solvents, hexavalent chromium waste, heavy metal-containing sludges, and ignitable wastes such as flammable coatings and adhesives.

Because many of the same source-reduction and control strategies address risks across these pathways, this section organizes recommended mitigation strategies into three tiers that apply across air, water, and hazardous waste: pollution prevention (source reduction), engineering controls, and operational practices.

5.2.1 Pollution Prevention

The most effective way to reduce environmental and public health impacts across all three pathways is to reduce the volume and toxicity of materials at the source, before they become air emissions, water discharges, or hazardous waste. Facilities should prioritize the following source reduction approaches:

Material substitution. Facilities should select coatings, adhesives, sealants, and solvents with low VOC content and without hazardous air pollutants wherever technically feasible. BAAD regulations already require the use of low-VOC coatings for many surface coating operations, and the EPA's Control Techniques Guideline for miscellaneous industrial adhesives likewise recommends low-VOC solvent and adhesive formulations (BAAD, 1991a, EPA, 2008). For degreasing and surface pretreatment operations, lower-hazard aqueous or semi-aqueous cleaners should be evaluated as alternatives to solvent-based degreasers, which provide an opportunity to reduce VOC emissions and hazardous waste generation (EPA, 2016a). For transformer manufacturing, biodegradable natural or synthetic ester-based transformer oils should be prioritized over conventional mineral oils given their biodegradability, higher fire resistance, and reduced persistence and ecotoxicity in the event of a spill or leak (Noqueira et al., 2022). For chromium conversion coatings, trivalent chromium or non-chromium alternatives should be used in place of hexavalent chromium baths, as hexavalent chromium has been identified as a carcinogen and is already being phased out under CARB requirements (CARB, 2023). While not a direct community health concern, switchgear insulating gases with high global warming potential should be substituted for non-SF_6 alternatives (EPA, 2026b) due to their climate impacts (EPA, 2026b). Similarly, alternative refrigerants to hydrofluorocarbons with lower global warming potential should be used for heat pumps (Mitchell, 2021).

Process substitution and optimization. Where technically viable, higher-risk processes should be substituted for lower-risk alternatives, and remaining processes should be optimized to minimize the volume of material lost to emissions or waste. Facilities should use high-efficiency coating technologies such as high-volume, low-pressure spray guns, airless spray, flow coating, or roll coating where feasible (EPA, 2008) to improve the share of material reaching the target surface rather than lost as overspray; these transfer efficiency gains also reduce the volume of waste coatings and solvents requiring disposal. Powder coatings can replace solvent-borne liquid coatings to substantially reduce VOC emissions (EPA, 2007). Plasma or laser cutting may be preferable to other thermal cutting methods, though each carries its own particulate profile (see **Section 3.2**) and proper controls remain necessary regardless. For wave soldering, covering the flux bath when not in use reduces VOC emissions between production runs (BAAD, 1991c).

5.2.2 Engineering Controls

Where pollution prevention measures alone are insufficient to control emissions or contain waste, facilities should implement engineering controls to capture and treat pollutants or contain materials before they can reach the surrounding environment. While worker exposure was not the focus of this analysis, capturing emissions at the source can also improve air quality within the facility, thereby reducing worker exposure to airborne hazards and protecting the surrounding community.

Air capture systems. Effective capture is a prerequisite for effective control. Emissions should be captured at or near the point of generation using appropriately designed enclosures, spray booths, local exhaust ventilation, hoods, and filters before being routed to a downstream control device. For surface coating operations, enclosed spray booths with exhaust capture are standard practice (BAAD, 1991b). For soldering operations, BAAD guidance specifies that wave soldering operations should be fully enclosed with collection systems that vent to a carbon adsorber or afterburner (BAAD, 1991c). For adhesive application and curing, local exhaust ventilation at both application and cure stations, combined with enclosed cure ovens with exhaust capture, are recommended standard controls (EPA, 2008). For thermal cutting, emissions can be mitigated using downdraft tables, water tables, or portable collection devices that collect metal fume emissions close to the source before directing them through a filtration system (SCAQMD, 2024).

Air pollution control devices. Captured emissions must be routed through appropriate air pollution control devices before being discharged from the facility. The appropriate control technology depends on the pollutant. For VOCs and HAPs, carbon adsorbers are widely used and are recommended by both BAAD and EPA guidance for operations such as wave soldering, surface coating, and adhesive application (BAAD, 1991c; EPA, 2008). Thermal oxidizers and regenerative thermal oxidizers are used to control VOC/HAP emission volumes (EPA, 2016b). Catalytic incinerators can achieve approximately 95% VOC destruction efficiency and are widely used by surface coating and printing operations; their particulate destruction efficiency is more variable (25-99.9%) depending on particulate composition (EPA, 2003). Afterburners are another option for facilities generating VOCs or HAPs from soldering or coating operations (BAAD, 1991c). For particulate matter, fabric filters (baghouses) are the standard control technology, including for fine metal particulates generated by machining, thermal cutting, and welding. For metal fume emissions specifically from thermal cutting, collected emissions should be directed through a filtration system to remove particulates, consistent with SCAQMD Rule 1445 requirements for facilities conducting these operations near communities (SCAQMD, 2024).

Storage and containment. All hazardous liquids and hazardous waste — including solvents, coatings, adhesives, MWFs, pretreatment chemicals, and waste awaiting disposal — should be kept in properly labeled, sealed containers when not in use to prevent evaporative emissions and spills, and stored on impervious surfaces within secondary containment structures (2021b). Storage areas should be covered or located indoors to prevent contact with precipitation and stormwater runoff (EPA, 2021a). Additionally, ignitable and reactive waste must be kept away from potential ignition sources, including open flames, heat sources, and sparks (40 C.F.R. § 264.17, 2026), and all waste must be stored in containers made of or lined with materials that will not react with the waste (40 C.F.R. § 264.172, 2026). Powders, granular materials, and other nonsolid substances that can be transported by wind or stormwater should similarly be stored and handled in enclosed or contained areas to prevent them from reaching stormwater conveyances or nearby waterways (California Stormwater Quality Association [CASQA], 2019). This includes metal powders used in battery cathode manufacturing and abrasive blasting media.

Stormwater infrastructure. Because the manufacturing activities described in this report are predominantly conducted indoors, stormwater contamination risk is lower than at facilities with significant outdoor operations. The primary residual stormwater risk is typically from parking lots, loading docks, and outdoor material staging areas. Where outdoor storage of raw materials, finished goods, or waste is unavoidable, these areas should be covered or bermed to prevent contact with precipitation (CASQA, 2019).

5.2.3 Operational Practices

Good operating practices complement pollution prevention and engineering controls and reduce the risk of uncontrolled releases across all three pathways.

Preventative maintenance. Spray booths and ventilation systems should be maintained on a regular schedule to ensure proper capture efficiency. More broadly, facilities should implement a routine preventative maintenance schedule for all equipment that handles liquids, including tanks, pipes, valves, pumps, and fittings. Regularly inspecting equipment and quickly repairing leaks prevents chronic low-level contamination of floor drains and stormwater conveyances (CASQA, 2019).

Spill prevention and response. Written procedures should be established for handling spills and leaks, and spill containment and cleanup equipment should be readily accessible throughout the facility (CASQA, 2019). Spills should be cleaned up promptly using dry methods (e.g., absorbent materials) wherever possible, avoiding wash-down to drains and preventing secondary contamination of stormwater conveyances or floor drains (CASQA, 2019).

Stormwater Pollution Prevention Planning. Facilities should develop and implement a Stormwater Pollution Prevention Plan (SWPPP) consistent with their permit requirements under the California Industrial General Permit (California State Water Resources Control Board, 2014). Key elements include mapping all stormwater drainage areas and conveyances, identifying any potential stormwater contact with outdoor material storage or loading/unloading areas, and inspecting stormwater conveyances regularly for evidence of contamination and addressing sources promptly (CASQA, 2019). For facilities that are predominantly indoor operations, a well-maintained SWPPP may be relatively straightforward.

Regulatory compliance and disposal. Facilities must determine their hazardous waste generator status under RCRA and California law, and comply with applicable requirements for accumulation time limits, manifesting, and recordkeeping (DTSC, n.d.-a; 40 C.F.R. § 262).

Waste must be disposed of through licensed hazardous waste transporters and treatment, storage, and disposal facilities (TSDFs). All hazardous waste accumulation areas should be inspected on a regular schedule consistent with generator status requirements to identify leaks, damaged containers, or labeling deficiencies before they result in releases.

Worker Voice and Training. Facilities should encourage occupational health and safety best practices in collaboration with workers. In particular, worker voice should be elevated as an essential element of occupational health and safety, including encouraging worker participation in joint employee-management occupational health and safety committees, and protecting workers' rights to refuse unsafe tasks and report safety hazards without retaliation (Moore, 2026). Additionally, facilities should provide opportunities for training staff on proper material handling, application techniques, and equipment operation to minimize fugitive emissions and ensure that engineering controls are used correctly and consistently. Workers involved in operations that generate wastewater — including equipment cleaning, pretreatment baths, spray booth washdown, and solvent handling — should be trained in proper wastewater handling and disposal procedures. This includes understanding which drains are connected to the sanitary sewer, which are connected to stormwater conveyances, and which materials must never be discharged to either without pretreatment. Workers involved in generating, handling, or storing hazardous waste should be trained in proper waste identification, container management, emergency procedures, and spill response.

Emergency Preparedness and Community Communication. Facilities should maintain an up-to-date emergency response plan and coordinate with local emergency responders. In addition, direct communication with the surrounding community should be treated as an essential part of emergency preparedness (Notes from GEZ Research Environmental & EJ Stakeholder Briefing, 2026). Facilities should ensure that channels are in place to reach not only local authorities but also the community at large during an emergency. Guidance in the event of an emergency should be preemptively developed that is tailored to the community it serves, considering language, accessibility, and the needs of vulnerable residents.

6.0 Recommendations for Future Work

This report only encompassed impacts associated with specific manufacturing stages of the different subtechnologies. There are several environmental risks associated with each subtechnology that were out of scope for this review, but still important to consider moving forward. These include emissions from truck traffic, impacts from facility construction, and, where applicable, upstream/downstream impacts. Many of these impacts were flagged by community stakeholders during stakeholder engagement sessions in December 2025 and June 2026.

Truck Traffic. Emissions from the transportation sector are the second-largest contributor to $PM_{2.5}$-attributable mortality in the U.S., second to the industrial and commercial sector (Thakrar et al., 2020). The addition of new manufacturing facilities to the GEZ may introduce additional heavy diesel truck activity to the region to ship in raw materials and pre-fabricated components, and ship out finished products. Diesel trucks are a particular concern as they generate diesel particulate matter (DPM), a known carcinogen to humans (CARB, n.d.-b). It is estimated that 70% of total known cancer risk related to air toxics in California is attributable to DPM (CARB, n.d.-b). Trucks driving in and out of or idling in warehousing facilities may be significant sources of NO_x emissions, which can lead to the formation of additional particulate matter and ozone, pollutants that are hazardous to human health (Kerr et al., 2024). Additional research is needed to assess the transportation health impacts from the facilities proposed in the GEZ.

Facility Development. Depending on the land selected to house the facilities selected for the GEZ, additional land use, water, and environmental impacts associated with constructing the facilities pose their own risks. Further work to understand the risks from construction and land use change impacts is needed.

Upstream and Downstream Supply Chain Impacts (where applicable). The extraction and processing of raw materials, the manufacturing of base or intermediary components used for the final product, and the downstream assembly, deployment (i.e., for use in grid applications, vehicles, or power generation), and end-of-life treatment of waste each have associated emissions, contamination, public health, and accident risks. To the extent that these activities happen in the GEZ, these additional risks should be considered.

Noise. Industrial operations, as well as associated construction and truck traffic, can produce a significant amount of noise, which is a concern shared by many community stakeholders

(Notes from GEZ Research Environmental & EJ Stakeholder Briefing, 2026). Noise impacts were outside the scope of this review; however, future work should assess noise impacts from potential GEZ technologies and ensure practices that minimize noise are used.

Table A1. Health Risks from Relevant Hazards

Hazard	Health Risk	Source
Aluminum	Chronic exposure to aluminum has been associated with Alzheimer's disease.	Gonser & Hogan, 2011
Acid mists (sulfuric, hydrochloric, phosphoric, chromic)	Chronic exposure to strong inorganic acid mists causes respiratory and mucous-membrane irritation. Mists containing sulfuric acid are an IARC Group 1 carcinogen linked to laryngeal cancer.	IARC, 1992
Acrolein	Chronic and short-term exposure to acrolein, a potent respiratory and mucous-membrane irritant, causes eye, nose, and throat irritation; IARC classifies it as probably carcinogenic to humans (Group 2A).	CARB, 2026; IARC, 2021
Benzene	Chronic exposure to benzene has been linked to leukemia and other blood and bone-marrow disorders such as aplastic anemia and reduced blood-cell counts.	EPA, 2012
Bisphenol-A (BPA)	Chronic exposure to BPA has been linked to endocrine disruption and potential carcinogenic risks.	Seachrist et al., 2016
Cadmium	Cadmium dust or fumes are classified as a Group 1 human carcinogen by IARC, associated with increased lung cancer risk, and chronic exposure can also cause obstructive lung disease and bronchitis.	Agency for Toxic Substances and Disease Registry, 2012; UK Health Security Agency, 2024
Cobalt	Chronic exposure to cobalt is a probable human carcinogen (IARC Group 2A).	IARC, 2023
Crystalline silica	Chronic inhalation of respirable crystalline silica causes respiratory irritation and is linked to silicosis and lung cancer.	Air Systems, Inc., 2026
Cyanide	Chronic exposure to low levels of cyanide has been linked to thyroid dysfunction and neurological effects.	Agency for Toxic Substances and Disease Registry, 2006
Fluoride	Chronic exposure to fumes containing fluoride has been linked to asthma sensitization.	Gonser & Hogan, 2011
Formaldehyde	Chronic exposure to formaldehyde, an IARC Group 1 human carcinogen, has been linked to nasopharyngeal cancer and leukemia; it is also a respiratory and mucous-membrane irritant	CARB, 2020; IARC 2006

Hazard	Health Risk	Source
	and can trigger or worsen asthma.	
Glycol ethers	Chronic exposure to glycol ethers has been linked to fatigue, nausea, tremor, anemia, and other neurological and blood effects. Acute exposure may result in narcosis, pulmonary edema, and severe liver and kidney damage.	EPA, 2000a
Ground-level ozone	Chronic and short-term exposure to ground-level ozone has been linked to coughing, chest tightness, respiratory irritation, shortness of breath, and asthma.	EPA, 2015-b; CARB, n.d.-c
Hexavalent chromium	Chronic and short-term exposure to hexavalent chromium has been linked to lung, nasal, and sinus cancer, as well as respiratory irritation and damage, and allergic sensitization.	OSHA, 2009; Office of Environmental Health Hazard Assessment, 2011
Isocyanates	Chronic and short-term exposure to isocyanates and diisocyanates has been linked to asthma, wheezing, shortness of breath, decreased lung function, respiratory sensitization, and cancer.	Agency for Toxic Substances and Disease Registry, 2018; NIOSH, 2018
Lead	Lead is a potent neurotoxicant linked to neurological and developmental harm.	Agency for Toxic Substances and Disease Registry, 2020
Manganese	Chronic exposure to manganese has been linked to nervous system damage and a Parkinson-like condition that impairs motor and cognitive function.	NIOSH, 2026
Metalworking Fluids (MWFs)	Chronic exposure to metalworking fluids and their aerosolized mist has been linked to skin disorders, respiratory conditions, and elevated cancer risk.	OSHA, n.d.
Methacrylate monomer and cyanoacrylate vapors	Methacrylate and cyanoacrylate are irritants to the skin, eyes, and mucous membranes and may cause allergic sensitization.	EPA, 2000c; Australian Department of Health and Aged Care, 2024
Methyl Ethyl Ketone (MEK)	Chronic and short-term exposure to MEK irritates the eyes, nose, and throat and can depress the central nervous system.	NIOSH, 2019a
Methyl Isobutyl Ketone (MIBK)	Chronic and short-term exposure to MIBK irritates the eyes, nose, and throat and can cause headache, dizziness, and other central-nervous-system effects.	EPA, 2000b
Nickel	Nickel compounds are a known human carcinogen and metallic nickel is a probable human	National Toxicology Program,

Hazard	Health Risk	Source
	carcinogen. Chronic exposure has been linked to cancer.	2021
Nitrogen oxides (NOx)	Chronic and short-term exposure to nitrogen oxides has been linked to respiratory irritation and reduced lung function; NOx is also a precursor to ground-level ozone and fine particulates.	NIOSH, 2019b
Particulate matter (PM_{10}, $PM_{2.5}$, ultrafine)	Chronic and short-term exposure to particulate matter—including PM_{10}, $PM_{2.5}$, and ultrafine particles (<300 nm)—has been linked to bronchitis, asthma, respiratory symptoms, reduced lung function, cardiovascular morbidity, and premature death; smaller particles penetrate deeper into the lungs and carry greater risk.	CARB, n.d.-a
Per- and Polyfluoroalkyl Substances (PFAS)	Health impacts associated with PFAS exposure are not well understood and are an ongoing topic of research, but available evidence has linked PFAS to kidney and testicular cancer, changes in liver enzymes, potential reproductive effects, and increases in cholesterol levels.	Agency for Toxic Substances and Disease Registry, 2025
Powder coating powder	Chronic exposure to powder coating powder (containing crystalline silica, heavy-metal pigments, and triglycidyl isocyanurate) has been linked to silicosis, nerve damage, and cancer.	Air Systems, Inc., 2026
Rosin-based flux fumes	Chronic and short-term exposure to rosin-based flux fumes is a common cause of occupational asthma and can cause skin and respiratory irritation.	HSE, 2015; NIOSH, 2019
Toluene	Chronic and short-term exposure to toluene can cause central nervous system dysfunction, irritate the eyes and respiratory tract, and may cause reproductive harm.	Agency for Toxic Substances and Disease Registry, 2017
Volatile Organic Compounds (VOCs)	VOCs and hazardous air pollutants form ground-level ozone and fine particulates (PM2.5); acute exposure can cause eye, nose, and throat irritation, headaches, and dizziness while chronic exposure can exacerbate lung disease and contribute to the development of allergies.	American Lung Association, 2023
Welding fume	Welding fumes are an IARC Group 1 carcinogen and chronic and short-term exposure has been linked to lung and kidney tract cancer as well as respiratory irritation, nausea, chronic bronchitis, sarcoid-like lung disease, increased susceptibility to infection, and cardiotoxicity. These risks are in addition to those carried by the PM2.5 fraction.	IARC, 2018; Gonser & Hogan, 2011

Hazard	Health Risk	Source
Xylene	Chronic and short-term exposure to toluene may depress the central nervous system, irritates the eyes and respiratory tract, and may cause reproductive harm.	Agency for Toxic Substances and Disease Registry, 2007
Zinc oxide	Short-term exposure to zinc oxide can cause metal fume fever, a flu-like illness marked by fever, chills, muscle aches, nausea, and fatigue.	American Welding Society, 2002
1-bromopropane	Exposure to 1-bromopropane can cause skin, lung, and intestinal cancer; damage to the liver, kidneys, and nervous system; and effects on the reproductive systems that lead to reduced fertility.	EPA, 2020a
1-methyl-2-pyrrolidone (NMP)	Chronic and short-term exposure to NMP causes developmental toxicity, including fetal loss, and reduced fertility; EPA has determined that NMP presents an unreasonable risk to human health.	EPA, 2020b

Table A2. Regulatory Violations by Facility

Category	Sub-Category	Facility Name	Facility Location	FRS ID	CAA Violation	CWA Violation	RCRA Violation
Batteries	Solid State Battery	Anthro Energy	Alameda, CA	--	--	--	--
		Blue Current	Hayward, CA	110070633314	--	--	None Identified
		Factorial Energy	Billerica, MA	110071423865	--	--	None Identified
		Lyten	San Jose, CA	110070849251	--	--	None Identified
		Lyten	San Leandro, CA	110072040055	--	--	None Identified
		PolyPlus Battery	Berkeley, CA	110064925121	--	--	None Identified
		QuantumScape	San Jose, CA	110061055940	--	None Identified	None Identified
		Sepion	Alameda, CA	110071455098	--	--	None Identified
		SolidPower	Louisville, CO	110070124800	FRV (2023)	None Identified	262.A (2022)
		SolidPower	Thornton, CO	110071312823	None Identified	--	--
		Sonocharge	Mountain View, CA	110055074887	--	--	None Identified
	Non-Vanadium Flow Battery	EOS	Turtle Creek, PA	110028054272	None Identified	--	262.A, 262.C, XXS (2017)
		EOS	Edison, NJ	110070121942	--	--	None Identified
		ESS	Wilsonville, OR	110070208014	None Identified	--	262.A, XXS (Open)
		Inlyte	SF Bay Area, CA	110071675405	--	--	None Identified
		Noon Energy	Mountain View, CA	110071414169	--	--	None Identified
		Primus Power	Hayward, CA	110055378577	--	--	None Identified
		Quino	San Leandro, CA	110002845912	--	--	None Identified

Category	Sub-Category	Facility Name	Facility Location	FRS ID	CAA Violation	CWA Violation	RCRA Violation
	Thermal Batteries	Antora Energy	Sunnyvale, CA	110049220735	--	--	262.C (2025)
		Calectra	Oakland, CA	--	--	--	--
		Stasis Energy Group	Rancho Cucamonga, CA	--	--	--	--
	Module Assembly	Archer	San Jose, CA	110071350057	--	--	None Identified
		Boxpower	Grass Valley, CA	--	--	--	--
		Lithos	Hayward, CA	--	--	--	--
		Onyx Power	Ontario, CA	--	--	--	--
		Smartville	Sacramento, CA	--	--	--	--
		Viridi (formerly Moxion)	Richmond, CA	110071350098	--	--	None Identified
		We Build Machines	Richmond, CA	--	--	--	--
	Cathode Material	Mitra Chemicals	Mountain View, CA	--	--	--	--
		Sparkz	Sacramento, CA	--	--	--	--
		Sylvatex	Alameda, CA	--	--	--	--
		Wildcat Technologies	San Diego, CA	110070485938	--	--	None Identified
Electric Grid Components	Electronics Manufacturing Services	Applied Engineering	San Jose, CA	110065372778	--	--	None Identified
		Benchmark Electronics	Concord, CA	110038058883	--	--	262.A (Open), 262.D (3/2022-11/2022), 262.A (2/2022-7/2022)
		Flex Electronics	Milpitas, CA	110071745239	--	--	--
		Green Circuits	San Jose, CA	110070680379	--	--	None Identified
		Jabil	San Jose, CA	110002790551	--	NOV (2022) NOV (2021)	None Identified

Category	Sub-Category	Facility Name	Facility Location	FRS ID	CAA Violation	CWA Violation	RCRA Violation
		Naprotek	San Jose, CA	110069394364	--	--	None Identified
		Sanmina	Fremont, CA	110070094888	--	None Identified	--
		SMTC	Fremont, CA	110070097590 110070421741	--	NOV (2022) NOV (2021)	None Identified
		We Build Machines	Richmond, CA	--	--	--	--
	Power Electronic Module Assembly	AMSC	Ayer, MA (Jackson St)	110024333853	None Identified	--	None Identified
		AMSC	Ayer, MA (Main St)	110071046564 110070628550	--	--	None Identified
		Calex	Concord, CA	110013944321	--	--	None Identified
		Dynapower	South Burlington, VT	110001916062 110070319297	--	--	262.A (2024), 268.A, 262.C, 265.B, 265.C, 265.I, 273.B, XXS (2018)
		Eaton	El Paso, TX	110070600069	--	None Identified	--
		Eaton	Nacogdoches, TX	110071661683	--	None Identified	--
		Enphase	Arlington, TX	110071942606	--	None Identified	--
		S&C Electric	Chicago, IL	110000434833	None Identified	--	None Identified
		S&C Electric	Palatine, IL	110071655058 110072043840	None Identified	--	None Identified
		SMTC	Fremont, CA	110070421741 110070097590	--	NOV (2022), NOV (2021)	None Identified
		Delta Star	Lynchburg, VA	110001895897 110067128806	None Identified	None Identified	262.A, 268.A, 273.B, 279.C (2023)
		Delta Star	San Carlos, CA	110001181998	--	--	None Identified

Category	Sub-Category	Facility Name	Facility Location	FRS ID	CAA Violation	CWA Violation	RCRA Violation
	High Voltage Distribution Grid Transformers	Hitachi	South Boston, VA	110000344100 110070718819 110071824813	None Identified	None Identified	262.A, 279C, 262.M (2019)
		Hubbell Power Systems	Cuba, MO	110070547653	--	None Identified	--
		Maddox Transformer	Batavia, OH	110071456378 110072129312	None Identified	--	None Identified
		Maddox Transformer	Dyersberg, TN	110072104675	--	None Identified	--
		Maddox Transformer	Greer, SC	110071193565	FRV (2023)	None Identified	None Identified
		Maddox Transformer	Simpsonville, SC	110038445126 110071436504	FRV (2023)	None Identified	None Identified
		Prolec GE	Goldsboro, NC	110007120178	None Identified	None Identified	262.A (2026)
		Pennsylvania Transformer	Raeford, NC	110001492901	None Identified	None Identified	None Identified
	High Voltage Transmission Grid Transformers	GE Prolec	Waukesha, WI	110000417932	--	None Identified	None Identified
		Hitachi	Jefferson City, MO	110001448675	None Identified	None Identified	None Identified
		Hyundai Power Transformers	Montgomery, AL	110070257762	--	None Identified	--
		Pennsylvania Transformer	Canonsburg, PA	110069727889 110000329886	NOV (2021), Formal Enforcement (2022), Formal Enforcement (2021)	Significant Noncompliance (Effluent - Monthly Average Limit)	None Identified

Category	Sub-Category	Facility Name	Facility Location	FRS ID	CAA Violation	CWA Violation	RCRA Violation
	Medium Voltage Switchgears	Butcher Power Products	Sacramento, CA	--	--	--	--
		Eaton	El Paso, TX	110070600069	--	None Identified	--
		Hubbell Power Systems	Leeds, AL	110039493287	--	NOV (2025)	None Identified
		S&C Electric	Palatine, IL	110072043840 110071655058	None Identified	--	None Identified
		Siemens	Wendell, NC	110057653427	--	None Identified	None Identified
		Trayer	San Leandro, CA	110070439974	--	--	None Identified
	High Voltage Switchgears	GE	Charleroi, PA	110032937080	--	None Identified	None Identified
		Hitachi	Mt. Pleasant, PA	110071160122	--	None Identified	--
Heat Pumps	Commercial and Residential Heat Pump Water Heaters, Final Assembly	Colmac WaterHeat	Colville, WA	110042012684	--	None Identified	None Identified
		HTEC	Half Moon Bay, CA	--	--	--	--
		Nyle Water Heating	Bangor, ME	110070289975	--	--	--
		Rheem	Montgomery, AL	110000368735	None Identified	Limit Violation (2023, 2025, 2026)	None Identified
Electrolyzers	Catalyst, Stack, and Module Assembly, PEM/AEM/ZAWE	Electric Hydrogen	Devans, MA	110071531341	None Identified	--	None Identified
		Electric Hydrogen	San Jose, CA	110071422145	--	--	None Identified
		Nel Hydrogen	Wallingford, CT	--	--	--	--
		Verdagy	Newark, CA	110072012346	--	--	None Identified

Category	Sub-Category	Facility Name	Facility Location	FRS ID	CAA Violation	CWA Violation	RCRA Violation
EV Chargers	DC Fast Charger (DCFC), Final Assembly	BTC Power	Irvine, CA	--	--	--	--
		Chargepoint	Campbell, CA	110071134866	--	--	None Identified
		Chargepoint	Milpitas, CA	--	--	--	--
Zero Emissions Vehicles	Light to Medium Duty Vehicles, Final Assembly	Drako Motors	San Jose, CA	110070631677	--	--	None Identified
		Monarch Tractors	Lordstown, Ohio	--	--	--	--
		Phoenix Motorcars	Anaheim, CA	--	--	--	--
		Zoox, Autonomous Taxis	Hayward, CA	110071845694	--	--	None Identified
	Drone Manufacturing, Final Assembly	Airspace Systems	Los Altos, CA	--	--	--	--
		Archer Aviation, Electric Taxis	Covington, GA	110071399679	--	None Identified	None Identified
		Pivotal, Electric Vertical Takeoff and Landing	Palo Alto, CA	110070800223	--	--	None Identified
		Skydio	Hayward, CA	110071844743	--	--	None Identified
		Vantage Robotics	San Leandro, CA	--	--	--	--
		Zipline	South San Francisco, CA	--	--	--	--
	Electric Ferry Manufacturing, Final Assembly	All American Marine	Bellingham, WA	110070299139	--	--	--
	Electric Powertrain Manufacturing	Cascadia Motion	Wilsonville, OR	--	--	--	--
		Motiv Power Systems	Hayward, CA	--	--	--	--
		Wrightspeed	Alameda, CA	110070418650	--	--	None Identified

Category	Sub-Category	Facility Name	Facility Location	FRS ID	CAA Violation	CWA Violation	RCRA Violation
Offshore Wind	HVDC Subsea Cable Manufacturing	LS Cable & Systems	Chesapeake, VA	--	--	--	--

Table A3. Air Permit Data and Emissions by Facility

Technology	Sub-Technology	Facility Name	Facility Location	Classification	PM_{10}	$PM_{2.5}$	NO_2	SO_2	CO	VOC	Total HAPs	HAP List	Source
					tpy								
Batteries	Solid State Battery	Anthro Energy	Alameda, CA	--	--	--	--	--	--	--	--	--	--
		Blue Current	Hayward, CA	--	--	--	--	--	--	--	--	--	--
		Factorial Energy	Billerica, MA	--	--	--	--	--	--	--	--	--	--
		Lyten	San Jose, CA	--	0	0	0	0	0	0	--	--	CEIDARS 2024
		Lyten	San Leandro, CA	--	--	--	--	--	--	--	--	--	--
		PolyPlus Battery	Berkeley, CA	--	--	--	--	--	--	--	--	--	--
		QuantumScape	San Jose, CA	--	0	0	0	0	0	0	0	DPM	CEIDARS 2024
		Sepion	Alameda, CA	--	--	--	--	--	--	--	--	--	--
		SolidPower	Louisville, CO	Synthetic Minor	--	--	--	--	--	0	0	Xylenes	NEI 2021
		SolidPower	Thornton, CO	Minor	--	--	--	1	--	10	8	Benzene, Toluene, Ethylbenzene, Xylenes	CO APCD 2022
		Sonocharge	Mountain View, CA	--	--	--	--	--	--	--	--	--	--
	Non-Vanadium Flow Battery	EOS	Turtle Creek, PA	Synthetic Minor	--	--	--	--	--	--	0	Chromium III, Chromium (VI), Lead,	NEI 2021

Technology	Sub-Technology	Facility Name	Facility Location	Classification	PM_{10}	$PM_{2.5}$	NO_2	SO_2	CO	VOC	Total HAPs	HAP List	Source
					tpy								
												Manganese, Nickel	
		EOS	Edison, NJ	--	--	--	--	--	--	--	--	--	--
		ESS	Wilsonville, OR	No Classification	--	--	--	--	--	--	--	--	--
		Inlyte	SF Bay Area, CA	--	--	--	--	--	--	--	--	--	--
		Noon Energy	Mountain View, CA	--	--	--	--	--	--	--	--	--	--
		Primus Power (+Sanmina Fremont)	Hayward, CA	--	0	0	0	0	0	0	0	toluene, xylenes, fluoranthene, chrysene, formaldehyde, benz[a]anthracene, benzene, acetaldehyde, naphthalene	NEI 2021
		Quino	San Leandro, CA	--	--	--	--	--	--	--	--	--	--
	Thermal Batteries	Antora Energy	Sunnyvale, CA	--	0	0	--	--	--	0	0	HCl, HF, Phosphoric Acid	CEIDARS 2024

Technology	Sub-Technology	Facility Name	Facility Location	Classification	PM_{10}	$PM_{2.5}$	NO_2	SO_2	CO	VOC	Total HAPs	HAP List	Source
					tpy								
		Calectra	Oakland, CA	--	--	--	--	--	--	--	--	--	--
		Stasis Energy Group	Rancho Cucamonga, CA	--	--	--	--	--	--	--	--	--	--
	Module Assembly	Archer	San Jose, CA	--	--	--	--	--	--	--	--	--	--
		Boxpower	Grass Valley, CA	--	--	--	--	--	--	--	--	--	--
		Lithos	Hayward, CA	--	--	--	--	--	--	--	--	--	--
		Onyx Power	Ontario, CA	--	--	--	--	--	--	--	--	--	--
		Smartville	Sacramento, CA	--	--	--	--	--	--	--	--	--	--
		Viridi (formerly Moxion)	Richmond, CA	--	--	--	--	--	--	--	--	--	--
		We Build Machines	Richmond, CA	--	--	--	--	--	--	--	--	--	--
		Mitra Chemicals	Mountain View, CA	--	--	--	--	--	--	--	--	--	--
		Sparkz	Sacramento, CA	--	--	--	--	--	--	--	--	--	--
		Sylvatex	Alameda, CA	--	--	--	--	--	--	--	--	--	--

Cathode Material

Technology	Sub-Technology	Facility Name	Facility Location	Classification	PM_{10} (tpy)	$PM_{2.5}$ (tpy)	NO_2 (tpy)	SO_2 (tpy)	CO (tpy)	VOC (tpy)	Total HAPs (tpy)	HAP List	Source
		Wildcat Technologies	San Diego, CA	--	0	0	0	0	0	0	0	1,3-Butadiene Acetaldehyde Acrolein As cmpd(inorg) Benzene Cadmium Chlorobenzene Chromium Copper Cr(VI) DieselExhPM Ethyl Benzene Formaldehyde HCl Hexane Lead cmp(inorg) Manganese Mercury Naphthalene Nickel PAHs-w/o Propylene Selenium Toluene	CEIDARS 2024

Technology	Sub-Technology	Facility Name	Facility Location	Classification	PM_{10}	$PM_{2.5}$	NO_2	SO_2	CO	VOC	Total HAPs	HAP List	Source
					tpy								
												Xylenes Zinc	
Electric Grid Components	Electronic Manufacturing Services	Applied Engineering	San Jose, CA	--	--	--	--	--	--	--	--	--	--
		Benchmark Electronics	Concord, CA	--	--	--	--	--	--	1	--	--	CEIDARS 2024
		Flex Electronics	Milpitas, CA	--	0	0	0	0	0	1	0	Toluene, Xylenes, Chromium (VI), Fluoranthene, Chrysene, Formaldehyde, Benz[a]Anthracene, Benzene, Manganese, Mercury, Nickel, Arsenic, Beryllium, Cadmium, Acetaldehyde, Naphthalene	CEIDARS 2024
		Green Circuits	San Jose, CA	--	--	--	--	--	--	--	--	--	--

Technology	Sub-Technology	Facility Name	Facility Location	Classification	PM_{10}	$PM_{2.5}$	NO_2	SO_2	CO	VOC	Total HAPs	HAP List	Source
					tpy								
		Jabil	San Jose, CA	--	--	--	--	--	--	1	--	--	CEIDARS 2024
		Naprotek	San Jose, CA	--	--	--	--	--	--	--	--	--	--
		Sanmina	Fremont, CA	--	0	0	0	0	0	3	1	Benzene, EGBE, Formaldehyde, Styrene, Toluene	CEIDARS 2024
		SMTC	Fremont, CA	--	--	--	--	--	--	--	--	--	--
		We Build Machines	Richmond, CA	--	--	--	--	--	--	--	--	--	--
	Power Module Electronic Assembly	AMSC	Ayer, MA (Jackson St)	Synthetic Minor	--	--	SMI	--	SMI	SMI	--	--	ICIS-Air
		AMSC	Ayer, MA (Main St)	--	--	--	--	--	--	--	--	--	--
		Calex	Concord, CA	--	0	0	0	0	0	0	--	--	CEIDARS 2024
		Dynapower	South Burlington, VT	--	--	--	--	--	--	--	--	--	--
		Eaton	Nacogdoches, TX	--	--	--	--	--	--	--	--	--	--
		Eaton	El Paso, TX	--	--	--	--	--	--	--	--	--	--
		Enphase	Arlington, TX	--	--	--	--	--	--	--	--	--	--

Technology	Sub-Technology	Facility Name	Facility Location	Classification	PM_{10}	$PM_{2.5}$	NO_2	SO_2	CO	VOC	Total HAPs	HAP List	Source
					tpy								
		S&C Electric	Chicago, IL	Major	1	1	4	0	4	4	0	Arsenic, Benzene, Beryllium, Cadmium, Chromium VI, Chromium III, Cobalt, Fluoranthene, Fluorene, Formaldeyde, Hexane, Lead, Manganese, Napthalene, Nickel, Phenanthrene, Pyrene, Selenium, Toluene)	NEI 2021
		S&C Electric	Palatine, IL	Minor	--	MIN	--	--	--	--	0	Chromium (VI), Chromium III, Manganese, Nickel	ICIS-Air
		SMTC	Fremont, CA	--	--	--	--	--	--	--	--	--	--
	Distribution Grid Transformer	Delta Star	Lynchburg, VA	80% Synthetic Minor	2	1	2	0	1	11	SMI	--	DEQ 2025 (CAP)

Technology	Sub-Technology	Facility Name	Facility Location	Classification	PM_{10}	$PM_{2.5}$	NO_2	SO_2	CO	VOC	Total HAPs	HAP List	Source
					tpy								
		Delta Star	San Carlos, CA	--	0	0	--	--	--	6	0	Toluene	CEIDARS 2024
		Hitachi	South Boston, VA	80% Synthetic Minor	0	0	0	0	0	24	0	Chromium III, Chromium (VI), Manganese, Nickel	DEQ 2025 (CAP), NEI 2021 (HAP)
		Hubbell Power Systems	Cuba, MO	--	--	--	--	--	--	--	--	--	--
		Maddox Transformer	Batavia, OH	Minor	--	--	--	--	--	--	--	--	--
		Maddox Transformer	Dyersberg, TN	--	--	--	--	--	--	--	--	--	--
		Maddox Transformer	Greer, SC	80% Synthetic Minor	SMI	SMI	SMI	SMI	SMI	SMI	SMI	Xylene	ICIS-Air
		Maddox Transformer	Simpsonville, SC	80% Synthetic Minor	SMI	SMI	--	--	--	SMI	SMI	Glycol Ethers	ICIS-Air
		Pennsylvania Transformer	Raeford, NC	Minor	MIN	--	MIN	--	--	MIN	MIN	--	ICIS-Air
		Prolec GE	Goldsboro, NC	Minor	MIN	--	--	--	--	MIN	MIN	--	ICIS-Air
	Transmission Grid Transformer	GE Prolec	Waukesha, WI	--	0	0	2	0	1	0	0	Ammonia, arsenic, barium, benzene, benzo(jk)fle,	WDNR 2025

Technology	Sub-Technology	Facility Name	Facility Location	Classification	PM_{10}	$PM_{2.5}$	NO_2	SO_2	CO	VOC	Total HAPs	HAP List	Source
					tpy								
												cadmium, chromium met, cobalt, copper, formaldehyde, hexane, manganese, mercury, molybdenum, naphthalene, nickel, pentane, toluene	
		Hitachi	Jefferson City, MO	Major	1	1	5	0	4	101	18	Ethyl Benzene, Formaldehyde, Glycol Ethers, Naphthalene, Xylenes	MOEIS 2024 (via EIP)
		Hyundai Power Transformers	Montgomery, AL	--	--	--	--	--	--	--	--	--	--
		Pennsylvania Transformer	Canonsburg, PA	80% Synthetic Minor	2	--	3	0	1	3	2	Propanol, ethanol, ethyl acetate, ethyl benzene, glycol ethers,	PDEP 2024

Technology	Sub-Technology	Facility Name	Facility Location	Classification	PM_{10}	$PM_{2.5}$	NO_2	SO_2	CO	VOC	Total HAPs	HAP List	Source
					tpy								
												isopropylbenzene, manganese, methanol, methyl ethyl ketone, nickel, phosphorus, toluene, xylenes	
	MV Switchgear	Butcher Power Products	Sacramento, CA	--	0	0	0	0	0	0	0	Barium, Benzene, Cadmium, Chromium, Cr(VI), DiClBenzenes, Ethyl Benzene, Formaldehyde, Hexane, Lead, Mercury, Molybd TriOxide, Naphthalene, Nickel, Propylene,	CEIDARS 2024

Technology	Sub-Technology	Facility Name	Facility Location	Classification	PM_{10}	$PM_{2.5}$	NO_2	SO_2	CO	VOC	Total HAPs	HAP List	Source
					tpy								
												Toluene, Vanadium, Xylenes, Zinc	
		Eaton	El Paso, TX	--	--	--	--	--	--	--	--	--	--
		Hubbell Power Systems	Leeds, AL	--	--	--	--	--	--	--	--	--	--
		S&C Electric	Palatine, IL	Operating Minor	--	MIN	--	--	--	--	0	Chromium (VI), Chromium III, Manganese, Nickel	ICIS-Air
		Siemens	Wendell, NC	--	--	--	--	--	--	--	--	--	--
		Trayer	San Leandro, CA	--	0	0	0	0	0	0	0	Benzene, EGBE, Formaldehyde, Toluene	CEIDARS 2024
	HV Switchgear	GE	Charleroi, PA	--	--	--	--	--	--	--	--	--	---
		Hitachi	Mt. Pleasant, PA	--	--	--	--	--	--	--	--	--	---
Heat Pumps	Commercial and Residential Heat Pump Water Heaters, Final Assembly	Colmac WaterHeat	Colville, WA	--	--	--	--	--	--	--	--	--	--
		HTEC	Half Moon Bay, CA	--	--	--	--	--	--	--	--	--	--

Technology	Sub-Technology	Facility Name	Facility Location	Classification	PM_{10}	$PM_{2.5}$	NO_2	SO_2	CO	VOC	Total HAPs	HAP List	Source
					tpy								
		Nyle Water Heating	Bangor, ME	--	--	--	--	--	--	--	--	--	--
		Rheem	Montgomery, AL	No Classification	MIN	MIN	MIN	MIN	MIN	MIN	--	--	ICIS-Air
Electrolyzers	Catalyst, Stack, and Module Assembly, PEM/AEM/ZAWE	Electric Hydrogen	Devens, MA	No Classification	--	--	--	--	--	--	--	--	--
		Electric Hydrogen	San Jose, CA	--	--	--	--	--	--	--	--	--	--
		Nel Hydrogen	Wallingford, CT	--	--	--	--	--	--	--	--	--	--
		Verdagy	Newark, CA	--	--	--	--	--	--	--	--	--	--
EV Chargers	DC Fast Charger, Final Assembly	BTC Power	Irvine, CA	--	--	--	--	--	--	--	--	--	--
		Chargepoint	Campbell, CA	--	--	--	--	--	--	--	--	--	--
		Chargepoint	Milpitas, CA	--	--	--	--	--	--	--	--	--	--
Zero Emissions Vehicles	Light to Medium Duty Vehicles, Final Assembly	Drako Motors	San Jose, CA	--	--	--	--	--	--	--	--	--	--
		Monarch Tractors	Lordstown, OH	--	--	--	--	--	--	--	--	--	--
		Phoenix Motorcars	Anaheim, CA	--	--	--	--	--	--	--	--	--	--
		Zoox, Autonomous Taxis	Hayward, CA	--	--	--	--	--	--	--	--	--	--

Technology	Sub-Technology	Facility Name	Facility Location	Classification	PM_{10}	$PM_{2.5}$	NO_2	SO_2	CO	VOC	Total HAPs	HAP List	Source
					tpy								
	Drone Manufacturing, Final Assembly	Airspace systems	Los Altos, CA	--	--	--	--	--	--	--	--	--	--
		Archer Aviation, Electric Taxis	Covington, GA	--	--	--	--	--	--	--	--	--	--
		Pivotal, Electric Vertical Takeoff and Landing	Palo Alto, CA	--	--	--	--	--	--	--	--	--	--
		Skydio	Hayward, CA	--	--	--	--	--	--	--	--	--	--
		Vantage Robotics	San Leandro, CA	--	--	--	--	--	--	--	--	--	--
		Zipline	South San Francisco, CA	--	--	--	--	--	--	--	--	--	--
	Electric Ferry, Final Assembly	All American Marine	Bellingham, WA	--	--	--	--	--	--	--	--	--	--
	Electric Powertrain Manufacturing	Cascadia Motion	Wilsonville, OR	--	--	--	--	--	--	--	--	--	--
		Motiv Power Systems	Hayward, CA	--	--	--	--	--	--	--	--	--	--
		Wrightspeed	Alameda, CA	--	--	--	--	--	--	--	--	--	--
Offshore Wind	HVDC Subsea Cable Manufacturing	LS Cable & Systems	Chesapeake, VA	--	--	--	--	--	--	--	--	--	--

Table A4. Water Permit Data by Facility

Technology	Sub-Technology	Facility Name	Facility Location	Permit Type	Discharge Type	Classification	DMR?	Exceeds?	Permit Limits?	Permit Pollutants	Source
Batteries	Solid State Battery	Anthro Energy	Alameda, CA	--	--	--	--	--	--	--	--
		Blue Current	Hayward, CA	--	--	--	--	--	--	--	--
		Factorial Energy	Billerica, MA	--	--	--	--	--	--	--	--
		Lyten	San Jose, CA	--	--	--	--	--	--	--	--
		Lyten	San Leandro, CA	--	--	--	--	--	--	--	--
		PolyPlus Battery	Berkeley, CA	--	--	--	--	--	--	--	--
		QuantumScape	San Jose, CA	NPDES General Permit Covered Facility	Industrial Stormwater	Non-Major	None	None	None	None	CAZ458674
		Sepion	Alameda, CA	--	--	--	--	--	--	--	--
		SolidPower	Thornton, CO	--	--	--	--	--	--	--	--
		SolidPower	Louisville, CO	NPDES General Permit Covered Facility Individual IU (Non-NPDES)	Industrial Stormwater Discharge to POTW	Non-Major	None	None	None	None	CONOX0996 COPIU001Z

Technology	Sub-Technology	Facility Name	Facility Location	Permit Type	Discharge Type	Classification	DMR?	Exceeds?	Permit Limits?	Permit Pollutants	Source
		Sonocharge	Mountain View, CA	--	--	--	--	--	--	--	--
	Non-Vanadium Flow Battery	EOS	Turtle Creek, PA	--	--	--	--	--	--	--	--
		EOS	Edison, NJ	--	--	--	--	--	--	--	--
		ESS	Wilsonville, OR	--	--	--	--	--	--	--	--
		Inlyte	SF Bay Area, CA	--	--	--	--	--	--	--	--
		Noon Energy	Mountain View, CA	--	--	--	--	--	--	--	--
		Primus Power (+Sanmina Fremont)	Hayward, CA	--	--	--	--	--	--	--	--
		Quino	San Leandro, CA	--	--	--	--	--	--	--	--
	Thermal batteries	Antora Energy	Sunnyvale, CA	--	--	--	--	--	--	--	--
		Calectra	Oakland, CA	--	--	--	--	--	--	--	--
		Stasis Energy Group	Rancho Cucamonga, CA	--	--	--	--	--	--	--	--
	Module assembly	Archer	San Jose, CA	--	--	--	--	--	--	--	--
		Boxpower	Grass Valley, CA	--	--	--	--	--	--	--	--
		Lithos	Hayward, CA	--	--	--	--	--	--	--	--

Technology	Sub-Technology	Facility Name	Facility Location	Permit Type	Discharge Type	Classification	DMR?	Exceeds?	Permit Limits?	Permit Pollutants	Source
		Onyx Power	Ontario, CA	--	--	--	--	--	--	--	--
		Smartville	Sacramento, CA	--	--	--	--	--	--	--	--
		Viridi (formerly Moxion)	Richmond, CA	--	--	--	--	--	--	--	--
		We Build Machines	Richmond, CA	--	--	--	--	--	--	--	--
	Cathode material	Mitra Chemicals	Mountain View, CA	--	--	--	--	--	--	--	--
		Sparkz	Sacramento, CA	--	--	--	--	--	--	--	--
		Sylvatex	Alameda, CA	--	--	--	--	--	--	--	--
		Wildcat Technologies	San Diego, CA	--	--	--	--	--	--	--	--
Electric Grid Components	Electronic Manufacturing Services	Applied Engineering	San Jose, CA	--	--	--	--	--	--	--	--
		Benchmark Electronics	Concord, CA	--	--	--	--	--	--	--	--
		Flex Electronics	Milpitas, CA	--	--	--	--	--	--	--	--
		Green Circuits	San Jose, CA	--	--	--	--	--	--	--	--
		Jabil	San Jose, CA	NPDES General Permit Covered Facility	Industrial Stormwater	Non-Major	None	None	None	None	CAZ184335

Technology	Sub-Technology	Facility Name	Facility Location	Permit Type	Discharge Type	Classification	DMR?	Exceeds?	Permit Limits?	Permit Pollutants	Source
		Naprotek	San Jose, CA	--	--	--	--	--	--	--	--
		Sanmina	Fremont, CA	NPDES General Permit Covered Facility	Industrial Stormwater	Non-Major	None	None	None	None	CAZ459 986
		SMTC	Fremont, CA	NPDES General Permit Covered Facility	Industrial Stormwater	Non-Major	None	None	None	None	CAZ486 454
		We Build Machines	Richmond, CA	--	--	--	--	--	--	--	--
	Power Module Electronic Assembly	AMSC	Ayer, MA	--	--	--	--	--	--	--	--
		AMSC	Ayer, MA	--	--	--	--	--	--	--	--
		Calex	Concord, CA	--	--	--	--	--	--	--	--
		Dynapower	South Burlington, VT	--	--	--	--	--	--	--	--
		Eaton	El Paso, TX	NPDES General Permit Covered Facility	Industrial Stormwater	Non-Major	None	None	None	None	TXRNEB G96 TXRNEB M57
		Eaton	Nacogdoches, TX	NPDES Construction Stormwater	Construction Stormwater	Non-Major	None	None	None	None	TXR154 2OY

Technology	Sub-Technology	Facility Name	Facility Location	Permit Type	Discharge Type	Classification	DMR?	Exceeds?	Permit Limits?	Permit Pollutants	Source
		Enphase	Arlington, TX	NPDES General Permit Covered Facility	Industrial Stormwater	Non-Major	None	None	Yes	Arsenic, Barium, Cadmium, Chromium, Copper, Lead, Manganese, Mercury, Selenium, Silver, Zinc	TXR05GR69
		S&C Electric	Chicago, IL	--	--	--	--	--	--	--	--
		S&C Electric	Palatine, IL	--	--	--	--	--	--	--	--
		SMTC	Fremont, CA	NPDES General Permit Covered Facility	Industrial Stormwater	Non-Major	None	None	None	None	CAZ486454
	Distribution Grid Transformer	Delta Star	Lynchburg, VA	NPDES General Permit Covered Facility	Industrial Stormwater	Non-Major	None	None	None	None	VAR050173
		Delta Star	San Carlos, CA	--	--	--	--	--	--	--	--
		Hitachi	South Boston, VA	NPDES General Permit	Industrial Stormwater	Non-Major	None	None	None	None	VAR050602

Technology	Sub-Technology	Facility Name	Facility Location	Permit Type	Discharge Type	Classification	DMR?	Exceeds?	Permit Limits?	Permit Pollutants	Source
				Covered Facility							
		Hubbell Power Systems	Cuba, MO	NPDES Individual	Discharge to Waterways	Non-Major	None	None	None	None	MONX00622
		Maddox Transformer	Batavia, OH	--	--	--	--	--	--	--	--
		Maddox Transformer	Dyersberg, TN	NPDES General Permit Covered Facility	Construction Stormwater	Non-Major	None	None	None	None	TNR123105
		Maddox Transformer	Greer, SC	NPDES General Permit Covered Facility	Industrial Stormwater	Non-Major	None	None	None	None	SCR006357
		Maddox Transformer	Simpsonville, SC	NPDES General Permit Covered Facility	Industrial Stormwater	Non-Major	None	None	None	None	SCR005652
		Pennsylvania Transformer	Raeford, NC	NPDES General Permit Covered Facility	Industrial Stormwater	Non-Major	None	None	None	None	NCG030763

Technology	Sub-Technology	Facility Name	Facility Location	Permit Type	Discharge Type	Classification	DMR?	Exceeds?	Permit Limits?	Permit Pollutants	Source
		Prolec GE	Goldsboro, NC	NPDES General Permit Covered Facility	Industrial Stormwater	Non-Major	None	None	None	None	NCS000303
	Transmission Grid Transformer	Hitachi	Jefferson City, MO	NPDES General Permit Covered Facility	Industrial Stormwater	Non-Major	None	None	None	None	MOR203024
		Hyundai Power Transformers	Montgomery, AL	NPDES Construction Stormwater	Construction Stormwater	Non-Major	None	None	None	None	ALR10C7AD
		GE Prolec	Waukesha, WI	NPDES General Permit Covered Facility	Industrial Stormwater	Non-Major	None	None	None	None	WIG005790
		Pennsylvania Transformer	Canonsburg, PA	NPDES Individual	Discharge to Waterways	Non-Major	Yes	Yes	Yes	Analytes included metals, PAHs, PCBs, chlorinated solvents, VOCs, phenols, nitrogen-co	PA0001937

Technology	Sub-Technology	Facility Name	Facility Location	Permit Type	Discharge Type	Classification	DMR?	Exceeds?	Permit Limits?	Permit Pollutants	Source
										ntaining organics, cyanide, fluoride, sulfate, oil and grease, pH, and fecal coliform.	
	MV Switchgear	Butcher Power Products	Sacramento, CA	--	--	--	--	--	--	--	--
		Eaton	El Paso, TX	NPDES General Permit Covered Facility	Industrial Stormwater	Non-Major	None	None	None	None	TXRNEB G96 TXRNEB M57
		Hubbell Power Systems	Leeds, AL	Individual IU (Non-NPDES) NPDES General Permit Covered Facility	Discharge to POTW; Industrial Stormwater	Non-Major	Yes	No	Yes	Total Toxic Organics, BOD, Cadmium, Chromium, Copper, Cyanide, Lead, Nickel, Oil & Grease, pH, Silver, Solids, Zinc	ALP000 446 ALR10C 77M ALG120 744

Technology	Sub-Technology	Facility Name	Facility Location	Permit Type	Discharge Type	Classification	DMR?	Exceeds?	Permit Limits?	Permit Pollutants	Source
		S&C Electric	Palatine, IL	--	--	--	--	--	--	--	--
		Siemens	Wendell, NC	NPDES General Permit Covered Facility	Industrial Stormwater	Non-Major	None	None	None	None	NCG030668 NCC242271
		Trayer	San Leandro, CA	--	--	--	--	--	--	--	--
	HV Switchgear	GE	Charleroi, PA	NPDES Construction Stormwater	Construction Stormwater	Non-Major	None	None	None	None	PAC630197
		Hitachi	Mt. Pleasant, PA	NPDES General Permit Covered Facility	Industrial Stormwater	Non-Major	Yes	No	Yes	Nitrogen, Oil & Grease, Chemical Oxygen Demand, Phosphorus, Solids, pH	PAG036397
Heat Pumps	Commercial and residential heat pump water heaters	Colmac WaterHeat	Colville, WA	NPDES General Permit Covered Facility	Industrial Stormwater	Non-Major	None	None	None	None	WAR000037
		HTEC	Half Moon Bay, CA	--	--	--	--	--	--	--	--

Technology	Sub-Technology	Facility Name	Facility Location	Permit Type	Discharge Type	Classification	DMR?	Exceeds?	Permit Limits?	Permit Pollutants	Source
		Nyle Water Heating	Bangor, ME	--	--	--	--	--	--	--	--
		Rheem	Montgomery, AL	Individual IU (Non-NPDES); NPDES General Permit Covered Facility	Discharge to POTW; Industrial Stormwater	Non-Major	Yes	Yes	Yes	Total Toxic Organics, Aluminum, Arsenic, Cadmium, Total Organic Carbon, Chromium, Copper, Cyanide, Lead, Mercury, Nickel, Nitrogen, Oil & Grease, pH, Silver, Solids, Zinc, PFAS (multiple)	ALP000289 ALG120073
Electrolyzers	Catalyst, Stack, and Module Assembly, PEM/AEM/ZAWE	Electric Hydrogen	Devens, MA	--	--	--	--	--	--	--	--

Technology	Sub-Technology	Facility Name	Facility Location	Permit Type	Discharge Type	Classification	DMR?	Exceeds?	Permit Limits?	Permit Pollutants	Source
		Electric Hydrogen	San Jose, CA	--	--	--	--	--	--	--	--
		Nel Hydrogen	Wallingford, CT	--	--	--	--	--	--	--	--
		Verdagy	Newark, CA	--	--	--	--	--	--	--	--
EV Chargers	DC Fast Charger (DCFC), Final Assembly	BTC Power	Irvine, CA	--	--	--	--	--	--	--	--
		Chargepoint	Campbell, CA	--	--	--	--	--	--	--	--
		Chargepoint	Milpitas, CA	--	--	--	--	--	--	--	--
Zero Emissions Vehicles	Light (passenger vehicles) to Medium Duty (delivery vans), Final Assembly	Drako Motors	San Jose, CA	--	--	--	--	--	--	--	--
		Monarch Tractors	Lordstown, OH	--	--	--	--	--	--	--	--
		Phoenix Motorcars	Anaheim, CA	--	--	--	--	--	--	--	--
		Zoox, Autonomous Taxis	Hayward, CA	--	--	--	--	--	--	--	--
	Drone Manufacturing, Final Assembly	Airspace systems	Los Altos, CA	--	--	--	--	--	--	--	--
		Archer Aviation, Electric Taxis	Covington, GA	NPDES General Permit Covered Facility	Construction Stormwater	Non-Major	None	No	None	None	GAR3930A1

Technology	Sub-Technology	Facility Name	Facility Location	Permit Type	Discharge Type	Classification	DMR?	Exceeds?	Permit Limits?	Permit Pollutants	Source
		Pivotal, Electric Vertical Takeoff and Landing	Palo Alto, CA	--	--	--	--	--	--	--	--
		Skydio	Hayward, CA	--	--	--	--	--	--	--	--
		Vantage Robotics	San Leandro, CA	--	--	--	--	--	--	--	--
		Zipline	South San Francisco, CA	--	--	--	--	--	--	--	--
	Electric Ferry, Final Assembly	All American Marine	Bellingham, WA	--	--	--	--	--	--	--	--
	Electric Powertrain Manufacturing	Cascadia Motion	Wilsonville, OR	--	--	--	--	--	--	--	--
		Motiv Power Systems	Hayward, CA	--	--	--	--	--	--	--	--
		Wrightspeed	Alameda, CA	--	--	--	--	--	--	--	--
Offshore Wind	HVDC Subsea Cable Manufacturing	LS Cable & Systems	Chesapeake, VA	--	--	--	--	--	--	--	--

A5. Toxic Air Emissions by Facility

Technology	Sub-Technology	Facility Name	Facility Location	TRI	Certain Glycol Ethers	Chromium	Cobalt	Copper	Diisocyanates	Lead	Manganese	Nickel	Nitrate	Nitric Acid	Sodium Nitrite	Zinc
					tpy											
Batteries	Solid State Battery	Anthro Energy	Alameda, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Blue Current	Hayward, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Factorial Energy	Billerica, MA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Lyten	San Jose, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Lyten	San Leandro, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		PolyPlus Battery	Berkeley, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		QuantumScape	San Jose, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Sepion	Alameda, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		SolidPower	Louisville, CO	--	--	--	--	--	--	--	--	--	--	--	--	--
		SolidPower	Thornton, CO	--	--	--	--	--	--	--	--	--	--	--	--	--
		Sonocharge	Mountain View, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
	Non-Vanadium Flow Battery	EOS	Turtle Creek, PA	15145 STLD N200 BR	--	--	--	--	--	--	--	--	--	--	--	--
		EOS	Edison, NJ	--	--	--	--	--	--	--	--	--	--	--	--	--
		ESS	Wilsonville, OR	--	--	--	--	--	--	--	--	--	--	--	--	--
		Inlyte	San Leandro, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Noon Energy	Mountain View, CA	--	--	--	--	--	--	--	--	--	--	--	--	--

Technology	Sub-Technology	Facility Name	Facility Location	TRI	Certain Glycol Ethers	Chromium	Cobalt	Copper	Diisocyanates	Lead	Manganese	Nickel	Nitrate	Nitric Acid	Sodium Nitrite	Zinc
					tpy											
		Primus Power (+Sanmina Fremont)	Hayward, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Quino	San Leandro, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
	Thermal Batteries	Antora Energy	Sunnyvale, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Calectra	Oakland, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Stasis Energy Group	Rancho Cucamonga, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
	Module Assembly	Archer	San Jose, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Boxpower	Grass Valley, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Lithos	Hayward, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Onyx Power	Ontario, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Smartville	Sacramento, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Viridi (formerly Moxion)	Richmond, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		We Build Machines	Richmond, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
	Cathode Material	Mitra Chemicals	Mountain View, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Sparkz	Sacramento, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Sylvatex	Alameda, CA	--	--	--	--	--	--	--	--	--	--	--	--	--

Technology	Sub-Technology	Facility Name	Facility Location	TRI	Certain Glycol Ethers	Chromium	Cobalt	Copper	Diisocyanates	Lead	Manganese	Nickel	Nitrate	Nitric Acid	Sodium Nitrite	Zinc
					tpy											
		Wildcat Technologies	San Diego, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
Electric Grid Components	Electronic Manufacturing Services	Applied Engineering	San Jose, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Benchmark Electronics	Concord, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Flex Electronics	Milpitas, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Green Circuits	San Jose, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Jabil	San Jose, CA	95119JBLCR3GREA	--	--	--	--	--	--	--	--	--	--	--	--
		Naprotek	San Jose, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Sanmina	Fremont, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		SMTC	Fremont, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		We Build Machines	Richmond, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
	Power Module Electronic Assembly	AMSC	Ayer, MA (Jackson St)	01432MRCNS64JAC	--	--	--	--	--	--	--	--	--	--	--	--

Technology	Sub-Technology	Facility Name	Facility Location	TRI	Certain Glycol Ethers	Chromium	Cobalt	Copper	Diisocyanates	Lead	Manganese	Nickel	Nitrate	Nitric Acid	Sodium Nitrite	Zinc
					tpy											
		AMSC	Ayer, MA (Main St)	0143WMRCNS114EM	--	--	--	--	--	0	--	--	--	--	--	--
		Calex	Concord, CA	94520CLXMF241ST	--	--	--	--	--	0	--	--	--	--	--	--
		Dynapower	South Burlington, VT	--	--	--	--	--	--	--	--	--	--	--	--	--
		Eaton	Nacogdoches, TX	--	--	--	--	--	--	--	--	--	--	--	--	--
		Eaton	El Paso, TX	--	--	--	--	--	--	--	--	--	--	--	--	--
		Enphase	Arlington, TX	--	--	--	--	--	--	--	--	--	--	--	--	--
		S&C Electric	Chicago, IL	60626SCLCT6601N	--	0	--	0	--	0	0	0	0	0	0	0
		S&C Electric	Palatine, IL	--	--	--	--	--	--	--	--	--	--	--	--	--
		SMTC	Fremont, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
	Distribution Grid Transformer	Delta Star	Lynchburg, VA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Delta Star	San Carlos, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Hitachi	South Boston, VA	24592WSTN	--	--	--	--	--	--	--	--	--	--	--	--

Technology	Sub-Technology	Facility Name	Facility Location	TRI	Certain Glycol Ethers	Chromium	Cobalt	Copper	Diisocyanates	Lead	Manganese	Nickel	Nitrate	Nitric Acid	Sodium Nitrite	Zinc
					tpy											
				GHIGHW												
		Hubbell Power Systems	Cuba, MO	--	--	--	--	--	--	--	--	--	--	--	--	--
		Maddox Transformer	Batavia, OH	--	--	--	--	--	--	--	--	--	--	--	--	--
		Maddox Transformer	Dyersberg, TN	--	--	--	--	--	--	--	--	--	--	--	--	--
		Maddox Transformer	Greer, SC	--	--	--	--	--	--	--	--	--	--	--	--	--
		Maddox Transformer	Simpsonville, SC	--	--	--	--	--	--	--	--	--	--	--	--	--
		Pennsylvania Transformer	Raeford, NC	--	--	--	--	--	--	--	--	--	--	--	--	--
		Prolec GE	Goldsboro, NC	27530HVDTYHWY11	--	--	--	--	--	--	--	--	--	--	--	--
	Transmission Grid Transformer	GE Prolec	Waukesha, WI	53186BBLCT400SP	--	--	--	--	--	--	--	--	--	--	--	--

Technology	Sub-Technology	Facility Name	Facility Location	TRI	Certain Glycol Ethers	Chromium	Cobalt	Copper	Diisocyanates	Lead	Manganese	Nickel	Nitrate	Nitric Acid	Sodium Nitrite	Zinc
					tpy											
		Hitachi	Jefferson City, MO	65101WSTNG500WE	21	0	0	0	--	0	0	0	--	--	--	--
		Hyundai Power Transformers	Montgomery, AL	--	--	--	--	--	--	--	--	--	--	--	--	--
		Pennsylvania Transformer	Canonsburg, PA	15317MCGRWADAMS 15317NCSNC30CUR	--	1	0	0	--	--	0	1	--	--	--	--
	MV Switchgear	Butcher Power Products	Sacramento, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Eaton	El Paso, TX	--	--	--	--	--	--	--	--	--	--	--	--	--
		Hubbell Power Systems	Leeds, AL	35094SCPWR81CHU	--	0	--	0	--	--	0	0	--	--	--	--
		S&C Electric	Palatine, IL	--	--	--	--	--	--	--	--	--	--	--	--	--

Technology	Sub-Technology	Facility Name	Facility Location	TRI	Certain Glycol Ethers	Chromium	Cobalt	Copper	Diisocyanates	Lead	Manganese	Nickel	Nitrate	Nitric Acid	Sodium Nitrite	Zinc
					tpy											
		Siemens	Wendell, NC	27591SMNSNSR230	--	--	--	--	--	--	--	--	--	--	--	--
		Trayer	San Leandro, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
	HV Switchgear	GE	Charleroi, PA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Hitachi	Mt. Pleasant, PA	--	--	--	--	--	--	--	--	--	--	--	--	--
Heat Pumps	Commercial and Residential Heat Pump Water Heaters, Final Assembly	Colmac WaterHeat	Colville, WA	--	--	--	--	--	--	--	--	--	--	--	--	--
		HTEC	Half Moon Bay, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Nyle Water Heating	Bangor, ME	--	--	--	--	--	--	--	--	--	--	--	--	--
		Rheem	Montgomery, AL	36193RHMMN2600E	--	0	--	0	0	--	0	0	--	--	--	--
Electrolyzers	Catalyst, Stack, and Module Assembly, PEM/AEM/ZAWE	Electric Hydrogen	Devens, MA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Electric Hydrogen	San Jose, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Nel Hydrogen	Wallingford, CT	--	--	--	--	--	--	--	--	--	--	--	--	--
		Verdagy	Newark, CA	--	--	--	--	--	--	--	--	--	--	--	--	--

Technology	Sub-Technology	Facility Name	Facility Location	TRI	Certain Glycol Ethers	Chromium	Cobalt	Copper	Diisocyanates	Lead	Manganese	Nickel	Nitrate	Nitric Acid	Sodium Nitrite	Zinc
					tpy											
EV Chargers	DC Fast Charger, Final Assembly	BTC Power	Irvine, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Chargepoint	Campbell, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Chargepoint	Milpitas, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
Zero Emissions Vehicles	Light to Medium Duty Vehicles, Final Assembly	Drako Motors	San Jose, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Monarch Tractors	Lordstown, OH	--	--	--	--	--	--	--	--	--	--	--	--	--
		Phoenix Motorcars	Anaheim, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Zoox, Autonomous Taxis	Hayward, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
	Drone Manufacturing, Final Assembly	Airspace Systems	Los Altos, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Archer Aviation, Electric Taxis	Covington, GA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Pivotal, Electric Vertical Takeoff and Landing	Palo Alto, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Skydio	Hayward, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Vantage Robotics	San Leandro, CA	--	--	--	--	--	--	--	--	--	--	--	--	--

Technology	Sub-Technology	Facility Name	Facility Location	TRI	Certain Glycol Ethers	Chromium	Cobalt	Copper	Diisocyanates	Lead	Manganese	Nickel	Nitrate	Nitric Acid	Sodium Nitrite	Zinc
					tpy											
		Zipline	South San Francisco, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
	Electric Ferry, Final Assembly	All American Marine	Bellingham, WA	--	--	--	--	--	--	--	--	--	--	--	--	--
	Electric Powertrain Manufacturing	Cascadia Motion	Wilsonville, OR	--	--	--	--	--	--	--	--	--	--	--	--	--
		Motiv Power Systems	Hayward, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
		Wrightspeed	Alameda, CA	--	--	--	--	--	--	--	--	--	--	--	--	--
Offshore Wind	HVDC Subsea Cable Manufacturing	LS Cable & Systems	Chesapeake, VA	--	--	--	--	--	--	--	--	--	--	--	--	--

Table A6. Toxic Water Emissions by Facility

Technology	Sub-Technology	Facility Name	Facility Location	TRI ID	Chromium	Copper	Manganese	Nickel
					lbs/yr			
Batteries	Solid State Battery	Anthro Energy	Alameda, CA	--	--	--	--	--
		Blue Current	Hayward, CA	--	--	--	--	--
		Factorial Energy	Billerica, MA	--	--	--	--	--
		Lyten	San Jose, CA	--	--	--	--	--
		Lyten	San Leandro, CA	--	--	--	--	--
		PolyPlus Battery	Berkeley, CA	--	--	--	--	--
		QuantumScape	San Jose, CA	--	--	--	--	--
		Sepion	Alameda, CA	--	--	--	--	--
		SolidPower	Louisville, CO	--	--	--	--	--
		SolidPower	Thornton, CO	--	--	--	--	--
		Sonocharge	Mountain View, CA	--	--	--	--	--
	Non-Vanadium Flow Battery	EOS	Turtle Creek, PA	15145STLDN200BR	--	--	--	--
		EOS	Edison, NJ	--	--	--	--	--
		ESS	Wilsonville, OR	--	--	--	--	--
		Inlyte	San Leandro, CA	--	--	--	--	--
		Noon Energy	Mountain View, CA	--	--	--	--	--
		Primus Power (+Sanmina Fremont)	Hayward, CA	--	--	--	--	--
		Quino	San Leandro, CA	--	--	--	--	--
	Thermal Batteries	Antora Energy	Sunnyvale, CA	--	--	--	--	--
		Calectra	Oakland, CA	--	--	--	--	--

Technology	Sub-Technology	Facility Name	Facility Location	TRI ID	Chromium	Copper	Manganese	Nickel
					lbs/yr			
		Stasis Energy Group	Rancho Cucamonga, CA	--	--	--	--	--
	Module Assembly	Archer	San Jose, CA	--	--	--	--	--
		Boxpower	Grass Valley, CA	--	--	--	--	--
		Lithos	Hayward, CA	--	--	--	--	--
		Onyx Power	Ontario, CA	--	--	--	--	--
		Smartville	Sacramento, CA	--	--	--	--	--
		Viridi (formerly Moxion)	Richmond, CA	--	--	--	--	--
		We Build Machines	Richmond, CA	--	--	--	--	--
	Cathode Material	Mitra Chemicals	Mountain View, CA	--	--	--	--	--
		Sparkz	Sacramento, CA	--	--	--	--	--
		Sylvatex	Alameda, CA	--	--	--	--	--
		Wildcat Technologies	San Diego, CA	--	--	--	--	--
Electric Grid Components	Electronic Manufacturing Services	Applied Engineering	San Jose, CA	--	--	--	--	--
		Benchmark Electronics	Concord, CA	--	--	--	--	--
		Flex Electronics	Milpitas, CA	--	--	--	--	--
		Green Circuits	San Jose, CA	--	--	--	--	--
		Jabil	San Jose, CA	95119JBLCR3GREA	--	--	--	--
		Naprotek	San Jose, CA	--	--	--	--	--
		Sanmina	Fremont, CA	--	--	--	--	--
		SMTC	Fremont, CA	--	--	--	--	--

Technology	Sub-Technology	Facility Name	Facility Location	TRI ID	Chromium	Copper	Manganese	Nickel
					lbs/yr			
		We Build Machines	Richmond, CA	--	--	--	--	--
	Power Module Electronic Assembly	AMSC	Ayer, MA (Jackson St)	01432MRCNS64JAC	--	--	--	--
		AMSC	Ayer, MA (Main St)	0143WMRCNS114EM	--	--	--	--
		Calex	Concord, CA	94520CLXMF241ST	--	--	--	--
		Dynapower	South Burlington, VT	--	--	--	--	--
		Eaton	Nacogdoches, TX	--	--	--	--	--
		Eaton	El Paso, TX	--	--	--	--	--
		Enphase	Arlington, TX	--	--	--	--	--
		S&C Electric	Chicago, IL	60626SCLCT6601N	--	--	--	--
		S&C Electric	Palatine, IL	--	--	--	--	--
		SMTC	Fremont, CA	--	--	--	--	--
	Distribution Grid Transformer	Delta Star	Lynchburg, VA	--	--	--	--	--
		Delta Star	San Carlos, CA	--	--	--	--	--
		Hitachi	South Boston, VA	24592WSTNGHIGHW	--	--	--	--
		Hubbell Power Systems	Cuba, MO	--	--	--	--	--
		Maddox Transformer	Batavia, OH	--	--	--	--	--
		Maddox Transformer	Dyersberg, TN	--	--	--	--	--
		Maddox Transformer	Greer, SC	--	--	--	--	--
		Maddox Transformer	Simpsonville, SC	--	--	--	--	--

Technology	Sub-Technology	Facility Name	Facility Location	TRI ID	Chromium	Copper	Manganese	Nickel
					lbs/yr			
		Pennsylvania Transformer	Raeford, NC	--	--	--	--	--
		Prolec GE	Goldsboro, NC	27530HVDTYHWY11	--	--	--	--
	Transmission Grid Transformer	GE Prolec	Waukesha, WI	53186BBLCT400SP	--	--	--	--
		Hitachi	Jefferson City, MO	65101WSTNG500WE	--	--	--	--
		Hyundai Power Transformers	Montgomery, AL	--	--	--	--	--
		Pennsylvania Transformer	Canonsburg, PA	15317MCGRWADAMS 15317NCSNC30CUR	0	2	0	0
	MV Switchgear	Butcher Power Products	Sacramento, CA	--	--	--	--	--
		Eaton	El Paso, TX	--	--	--	--	--
		Hubbell Power Systems	Leeds, AL	35094SCPWR81CHU	1	4	4	0
		S&C Electric	Palatine, IL	--	--	--	--	--
		Siemens	Wendell, NC	27591SMNSNSR230	--	--	--	--
		Trayer	San Leandro, CA	--	--	--	--	--
	HV Switchgear	GE	Charleroi, PA	--	--	--	--	--
		Hitachi	Mt. Pleasant, PA	--	--	--	--	--
Heat Pumps	Commercial and Residential Heat Pump Water Heaters, Final Assembly	Colmac WaterHeat	Colville, WA	--	--	--	--	--
		HTEC	Half Moon Bay, CA	--	--	--	--	--
		Nyle Water Heating	Bangor, ME	--	--	--	--	--
		Rheem	Montgomery, AL	36193RHMMN2600E	6	16	--	32

Technology	Sub-Technology	Facility Name	Facility Location	TRI ID	Chromium	Copper	Manganese	Nickel
					lbs/yr			
Electrolyzers	Catalyst, Stack, and Module Assembly, PEM/AEM/ZAWE	Electric Hydrogen	Devens, MA	--	--	--	--	--
		Electric Hydrogen	San Jose, CA	--	--	--	--	--
		Nel Hydrogen	Wallingford, CT	--	--	--	--	--
		Verdagy	Newark, CA	--	--	--	--	--
EV Chargers	DC Fast Charger, Final Assembly	BTC Power	Irvine, CA	--	--	--	--	--
		Chargepoint	Campbell, CA	--	--	--	--	--
		Chargepoint	Milpitas, CA	--	--	--	--	--
Zero Emissions Vehicles	Light to Medium Duty Vehicles, Final Assembly	Drako Motors	San Jose, CA	--	--	--	--	--
		Monarch Tractors	Lordstown, OH	--	--	--	--	--
		Phoenix Motorcars	Anaheim, CA	--	--	--	--	--
		Zoox, Autonomous Taxis	Hayward, CA	--	--	--	--	--
	Drone Manufacturing, Final Assembly	Airspace Systems	Los Altos, CA	--	--	--	--	--
		Archer Aviation, Electric Taxis	Covington, GA	--	--	--	--	--
		Pivotal, Electric Vertical Takeoff and Landing	Palo Alto, CA	--	--	--	--	--
		Skydio	Hayward, CA	--	--	--	--	--
		Vantage Robotics	San Leandro, CA	--	--	--	--	--
		Zipline	South San Francisco, CA	--	--	--	--	--
	Electric Ferry, Final Assembly	All American Marine	Bellingham, WA	--	--	--	--	--

Technology	Sub-Technology	Facility Name	Facility Location	TRI ID	Chromium	Copper	Manganese	Nickel
					lbs/yr			
	Electric Powertrain Manufacturing	Cascadia Motion	Wilsonville, OR	--	--	--	--	--
		Motiv Power Systems	Hayward, CA	--	--	--	--	--
		Wrightspeed	Alameda, CA	--	--	--	--	--
Offshore Wind	HVDC Subsea Cable Manufacturing	LS Cable & Systems	Chesapeake, VA	--	--	--	--	--

Table A7. Hazardous Waste Generation by Facility

Technology	Sub-Technology	Facility Name	Facility Location	Class	Amount (kg/yr) Low	Amount (kg/yr) High	Waste Codes: Ignitable	Corrosive	Reactive	Barium	Cadmium	Chromium	Lead	Silver	Benzene	Chloroform	MEK	PCE	Spent Solvent (Ignitable)	Spent Solvent (Toxic)	Unused Acetone	Other
Batteries	Solid State Battery	Anthro Energy	Alameda, CA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Batteries	Solid State Battery	Blue Current	Hayward, CA	LQG	400	3,800	X	X	X	--	--	--	--	--	--	--	--	--	X	X	--	U009, U067
Batteries	Solid State Battery	Factorial Energy	Billerica, MA	SQG	10	3,900	X	X	X	--	--	--	--	--	--	--	--	--	X	--	--	F002
Batteries	Solid State Battery	Lyten	San Jose, CA	LQG	3,300	5,700	X	X	X	--	--	--	X	--	--	--	--	--	--	X	--	--
Batteries	Solid State Battery	Lyten	San Leandro, CA	LQG	--	10	X	X	X	--	--	--	--	--	--	--	X	--	X	X	X	--
Batteries	Solid State Battery	PolyPlus Battery	Berkeley, CA	Other	100	300	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Batteries	Solid State Battery	QuantumScape	San Jose, CA	LQG	40,000	84,500	X	X	X	--	--	--	--	--	--	--	--	--	X	X	--	--
Batteries	Solid State Battery	Sepion	Alameda, CA	SQG	500	3,900	X	--	X	--	--	--	--	--	--	X	--	--	X	X	--	--
Batteries	Solid State Battery	SolidPower	Thornton, CO	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Batteries	Solid State Battery	SolidPower	Louisville, CO	LQG	35,300	80,000	X	X	X	--	--	--	--	--	--	X	--	--	X	X	--	--

		Sonocharge	Mountain View, CA	VSQG	30	400	X	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Non-Vanadium Flow Battery	EOS	Turtle Creek, PA	LQG	--	--	X	X	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		EOS	Edison, NJ	LQG	200	600	X	X	X	--	--	--	--	X	--	--	--	--	--	--	X	U125, U134
		ESS	Wilsonville, OR	VSQG	--	100	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Inlyte	SF Bay Area, CA	Other	10	10	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Noon Energy	Mountain View, CA	VSQG	--	--	X	X	--	--	--	X	X	--	--	--	--	--	--	--	--	--
		Primus Power (+Sanmina Fremont)	Hayward, CA	LQG	100	100	X	X	--	--	--	--	X	--	--	--	--	--	X	--	--	--
		Quino	San Leandro, CA	SQG	800	3,600	--	X	X	--	--	--	--	--	--	--	--	--	--	--	--	--
	Thermal Batteries	Antora Energy	Sunnyvale, CA	LQG	7,400	13,400	X	X	--	--	--	--	--	--	--	--	--	X	X	X	--	D004
		Calectra	Oakland, CA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Stasis Energy Group	Rancho Cucamonga, CA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Module Assembly	Archer	San Jose, CA	SQG	--	--	X	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Boxpower	Grass Valley, CA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

		Lithos	Hayward, CA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Onyx Power	Ontario, CA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Smartville	Sacramento, CA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Viridi (formerly Moxion)	Richmond, CA	LQG	--	--	X	--	--	--	--	--	--	--	--	--	--	--	X	--	--	--
		We Build Machines	Richmond, CA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Cathode Material	Mitra Chemicals	Mountain View, CA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Sparkz	Sacramento, CA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Sylvatex	Alameda, CA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Wildcat Technologies	San Diego, CA	SQG	1,000	4,200	X	X	X	--	--	X	--	X	X	X	--	--	X	X	X	D010, D038, D040, F002, U012, U056, U117, U147, U154, U165, U193, U196, U213, U220, U404

Electric Grid Components	Electronic Manufacturing Services	Applied Engineering	San Jose, CA	Other	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Benchmark Electronics	Concord, CA	LQG	1,800	2,800	X	--	--	--	--	--	--	--	--	--	--	--	X	X	--	--
		Flex Electronics	Milpitas, CA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Green Circuits	San Jose, CA	Other	100	400	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Jabil	San Jose, CA	SQG	1,000	2,000	X	X	--	--	--	--	X	--	--	--	--	--	X	--	--	--
		Naprotek	San Jose, CA	SQG	1,300	2,500	X	--	--	--	--	--	X	X	--	--	--	--	--	--	--	--
		Sanmina	Fremont, CA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		SMTC	Fremont, CA	Other	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		We Build Machines	Richmond, CA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Power Module Electronic Assembly	AMSC	Ayer, MA (Jackson St)	Other	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		AMSC	Ayer, MA (Main St)	SQG	100	400	X	X	--	X	--	--	--	--	--	--	--	--	X	--	--	--
		Calex	Concord, CA	Other	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Dynapower	South Burlington, VT	SQG	1,200	1,900	X	--	--	--	--	--	--	--	--	--	X	--	X	X	--	--
		Eaton	Nacogdoches, TX	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Eaton	El Paso, TX	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

		Enphase	Arlington, TX	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		S&C Electric	Chicago, IL	LQG	522,200	625,200	X	X	X	X	X	X	X	X	X	--	X	--	X	X	X	D009; D028; D036; LABP; P022; P105; F006; U001; U012; U022; U044; U077; U096; U122; U151; U220; U239
		S&C Electric	Palatine, IL	VSQG	--	30	X	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		SMTC	Fremont, CA	Other	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Distribution Grid Transformer	Delta Star	Lynchburg, VA	SQG	7,800	8,200	X	--	--	X	X	X	X	--	X	--	X	X	X	X	--	--
		Delta Star	San Carlos, CA	Other	3,300	5,300	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Hitachi	South Boston, VA	LQG	19,200	25,700	X	X	--	--	--	--	--	--	X	--	X	--	X	X	--	--

		Hubbell Power Systems	Cuba, MO	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Maddox Transformer	Greer, SC	VSQG	--	--	X	--	--	--	--	--	--	--	--	--	--	--	X	--	--	--
		Maddox Transformer	Simpsonville, SC	VSQG	--	--	X	--	--	--	--	--	--	--	--	--	--	--	X	--	--	--
		Maddox Transformer	Batavia, OH	VSQG	--	--	X	--	--	--	--	--	--	--	--	--	--	--	X	--	--	--
		Maddox Transformer	Dyersberg, TN	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Pennsylvania Transformer	Raeford, NC	Other	1,200	2,000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Prolec GE	Goldsboro, NC	LQG	14,100	15,000	X	--	--	--	--	--	--	--	--	--	X	--	X	X	--	--
	Transmission Grid Transformer	GE Prolec	Waukesha, WI	SQG	5,500	10,800	X	--	--	--	--	--	--	--	--	--	X	--	--	--	--	--
		Hitachi	Jefferson City, MO	LQG	58,400	97,700	X	X	X	X	X	X	X	--	X	--	X	--	X	X	--	--
		Hyundai Power Transformers	Montgomery, AL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Pennsylvania Transformer	Canonsburg, PA	SQG/ LQG	10,400	11,400	X	X	--	X	--	X	--	--	--	--	X	--	X	X	--	--
	MV Switchgear	Butcher Power Products	Sacramento, CA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

		Eaton	El Paso, TX	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Hubbell Power Systems	Leeds, AL	VSQG	800	2,300	X	--	--	--	--	--	X	--	--	--	--	--	--	--	--	--
		S&C Electric	Palatine, IL	VSQG	--	30	X	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Siemens	Wendell, NC	SQG	100	200	X	X	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Trayer	San Leandro, CA	Other	--	200	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	HV Switchgear	GE	Charleroi, PA	VSQG	30	100	X	--	--	X	X	X	X	--	--	--	X	--	--	--	--	--
		Hitachi	Mt. Pleasant, PA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Heat Pumps	Commercial and Residential Heat Pump Water Heaters, Final Assembly	Colmac WaterHeat	Colville, WA	VSQG	200	400	--	--	--	--	--	--	X	--	--	--	--	--	--	--	--	--
		HTEC	Half Moon Bay, CA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Nyle Water Heating	Bangor, ME	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Rheem	Montgomery, AL	SQG	500	4,800	X	--	--	--	--	--	--	--	X	--	--	--	--	--	--	--
Electrolyzers	Catalyst, Stack, and Module Assembly, PEM/AEM/ZAWE	Electric Hydrogen	Devans, MA	VSQG	2,700	3,700	X	X	X	--	--	--	--	--	--	--	--	--	X	X	--	--
		Electric Hydrogen	San Jose, CA	Other	500	800	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Nel Hydrogen	Wallingford, CT	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

		Verdagy	Newark, CA	Other	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
EV Chargers	DC Fast Charger, Final Assembly	BTC Power	Irvine, CA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Chargepoint	Campbell, CA	Other	--	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Chargepoint	Milpitas, CA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Zero Emissions Vehicles	Light to Medium Duty Vehicles, Final Assembly	Drako Motors	San Jose, CA	Other	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Monarch Tractors	Lordstown, OH	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Phoenix Motorcars	Anaheim, CA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Zoox, Autonomous Taxis	Hayward, CA	SQG	--	3,300	X	--	X	--	--	--	--	--	--	--	X	--	X	X	--	--
	Drone Manufacturing, Final Assembly	Airspace Systems	Los Altos, CA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Archer Aviation, Electric Taxis	Covington, GA	SQG	--	--	X	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Pivotal, Electric Vertical Takeoff and Landing	Palo Alto, CA	Other	--	400	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Skydio	Hayward, CA	Other	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Vantage Robotics	San Leandro, CA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

		Zipline	South San Francisco, CA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Electric Ferry, Final Assembly	All American Marine	Bellingham, WA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Electric Powertrain Manufacturing	Cascadia Motion	Wilsonville, OR	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Motiv Power Systems	Hayward, CA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Wrightspeed	Alameda, CA	Other	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Offshore Wind	HVDC Subsea Cable Manufacturing	LS Cable & Systems	Chesapeake, VA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

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