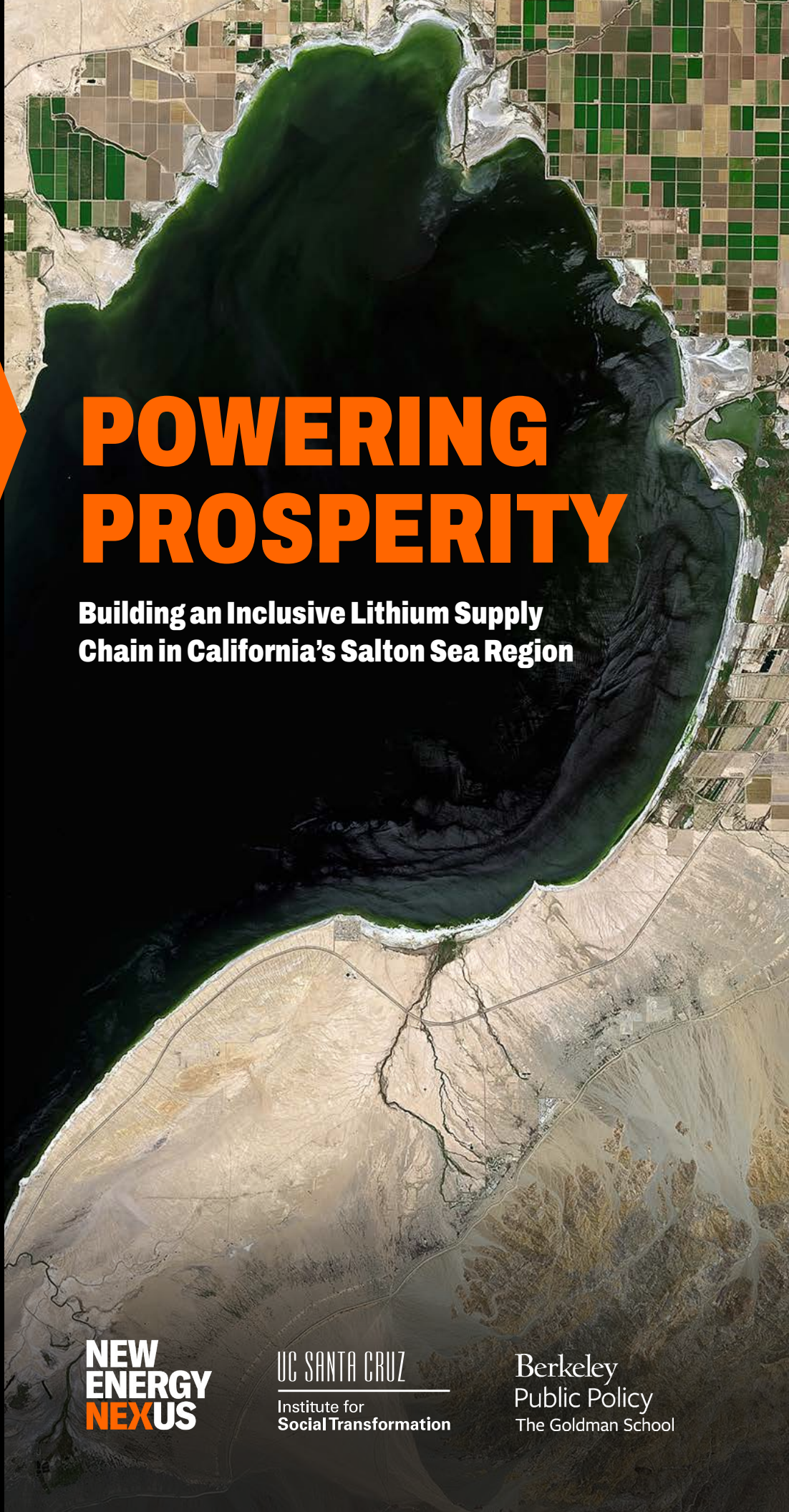

POWERING PROSPERITY

Building an Inclusive Lithium Supply Chain in California's Salton Sea Region

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ACRONYMS

AB	California Assembly Bill
BHER	Berkshire Hathaway Energy Renewables (company)
BIL	Bipartisan Infrastructure Law
CAM	Cathode Active Material
CBA	Community Benefits Agreement
CEQA	California Environmental Quality Act
CTR	Controlled Thermal Resources (company)
CWDB	California Workforce Development Board
DAC	Disadvantaged Community
DLE	Direct Lithium Extraction
DOE	U.S. Department of Energy
DTSC	Department of Toxic Substance Control
EOL	End of Life
ESM	EnergySource Minerals (company)
EV	Electric Vehicle
GWh	Gigawatt Hour
HRTP	High Road Training Partnership
IBEW	International Brotherhood of Electrical Workers
IRA	Inflation Reduction Act
IVC	Imperial Valley College
LCE	Lithium Carbonate Equivalent
LFP	Lithium Ferrous Phosphate
MT	Metric Ton
MWh	Megawatt Hour
NMC	Nickel, Manganese, and Cobalt
pCAM	Precursor Cathode Active Material
PEIR	Programmatic Environmental Impact Report
PLA	Project Labor Agreement
SB	California Senate Bill
STEM	Science, Technology, Engineering, and Mathematics
TRIC	Tahoe Reno Industrial Center
UAW	United Auto Workers
U.S.	United States
ZEV	Zero-Emission Vehicle

EXECUTIVE SUMMARY

Global demand for lithium-ion batteries used in electric vehicles (EVs) and energy storage systems is expected to increase fivefold by 2030 (Arora et al. 2023), anchoring critical minerals[1] as a strategic pillar of national security, energy independence, supply chain resilience, and the United States (U.S.) economy. Securing domestic sources of critical minerals is a national priority, and if managed carefully, the growth of this new industry in the U.S. could provide tremendous economic opportunity that simultaneously uplifts industry, workers, and communities. Onshoring related supply chains could create up to 100,000 direct new jobs in domestic battery industries, and three to four times that in EV manufacturing. Two pivotal pieces of federal legislation, the Bipartisan Infrastructure Law (BIL, 2021) and Inflation Reduction Act (IRA, 2022) have created major financial incentives to drive the buildout of a domestic green manufacturing industry across the U.S., particularly for lithium-ion battery and EV production (Climate Power 2024).

A key domestic site for lithium is near the Salton Sea in California's Imperial County. Located in the Southeastern corner of California, this long underinvested region has some of the highest rates of poverty in the state and nation.[2] Here, lithium deposits exist in hot, mineral-rich brines deep underground that are already brought to the surface for geothermal energy production. This allows for

1 **https://www.energy.gov/cmm/what-are-critical-materials-and-critical-minerals**

2 Much of the county is qualified as disadvantaged according to the federal Justice40 Initiative criteria, including all of the communities surrounding the Salton Sea. **https://www.arcgis.com/apps/mapviewer/index.html?webmap=bdac3e391cd04d2396983fc67c23bf1c**

a direct lithium extraction (DLE) process in which the lithium can be recovered with a much smaller land and energy footprint than the hard rock mining or open evaporation pond methods used in other parts of the world. In recent years, this area in the Salton Sea region has become known as "Lithium Valley" as stakeholders have launched an ambitious development initiative to build out a domestic lithium extraction industry and a broader processing, geothermal, and battery manufacturing ecosystem, with the potential to create good jobs, new business enterprise opportunities and other meaningful benefits for residents.[3] **If realized, this vision would profoundly transform the region, creating an economy rooted in shared prosperity, technological innovation, environmental protection, and value-added enterprises.**

Inclusive economic development—an approach linking environmental sustainability and social equity to support broad and lasting community wellbeing—has been at the forefront of conversations surrounding Lithium Valley. This inclusive approach is especially critical for a community that has experienced largely extractive economics, seasonal employment, and boom and bust labor cycles for decades. This vision has strong support in California, where policymakers and state agencies have made strides in supporting **high-road** climate action (see **Box**) through policy and regulatory levers that simultaneously advance decarbonization and economic inclusion goals. While there is still work ahead, the state's commitment to this high-road

3 We acknowledge that the term "Lithium Valley" is not embraced by all local residents, for whom the area holds value first and foremost as their home, and regardless of its economic potential or the critical mineral within it now sparking so much interest. Herein, we use the term Lithium Valley not as a geographic place name, but rather in reference to the industrial lithium hub envisioned for this area.

HIGH-ROAD WORKFORCE PRACTICES

In workforce contexts, the high-road approach seeks to create an environment in which firms compete based on quality of product and service, achieved through innovation and investment in their workforce, which allows them to generate good jobs. It is in contrast to the low road, in which firms compete primarily on cost, often at the expense of workers, with negative outcomes in terms of wages, safety, worker voice, inclusive opportunity, and career advancement.

High-road labor practices focus on job quality, with union jobs as the gold standard, because good wages, career pathways, and worker protections are built into them; and job access, to ensure that workers from local communities, including those historically excluded from family-sustaining careers, have access to training and placement in career-track quality jobs.

The high-road markers of good jobs include

JOB QUALITY

- Family-supporting wages and benefits
- High standards for health and safety
- Long-term career pathways
- Worker voice and protections, including the right to organize

JOB ACCESS

- Access and entry-points to good jobs for local workers
- Hiring commitments to ensure inclusion of marginalized communities
- Training to support advancement

approach (see Zabin et al. 2020) is delivering concrete results, with, for example, about 60% ($19 billion) of California's projected climate investments budget through 2026 including a workforce standard (Appel and Hammerling 2023).

California's solid foundation in marrying climate and equity goals positions it well with regard to current federal priorities. But how does this translate in the real-world business landscape? What do companies across the battery supply chain look at in considering where to set up operations, and how does the Salton Sea region—and more broadly, California—compete? What are the opportunities and challenges for seeding an advanced battery and EV manufacturing supply chain in the region that is centered on shared prosperity? With momentum building in various efforts to advance the Lithium Valley vision, we set out to shed light on these dynamics. We utilize our national analysis of investment locations across the U.S. battery and EV supply chain, and local analysis of lithium extraction and related investments in Imperial County, to do the following:

1. to assess progress and define next steps in order to maximize equitable, high-road development of the **lithium extraction industry** already under development in the region, given the unique context of the Salton Sea region as an active geothermal hub,
2. to identify how to build out more of the **battery supply chain** in the region so that the environmental, job, and community benefits can multiply,
3. to provide concrete recommendations for how to achieve these high-road development goals.

KEY FINDINGS FROM ANALYSIS OF DOMESTIC INVESTMENTS IN THE BATTERY AND EV SUPPLY CHAINS

To analyze employment patterns and trends in the EV battery supply chain, we developed a database and created an interactive online tool, "**Lithium Battery Supply Chains of North America**," that maps EV supply chain jobs with regard to labor standards and a range of climate and economic justice indicators.[4] Based on our analysis, we find that:

- **Almost half of battery supply chain jobs are in auto manufacturing:** Most of the jobs currently associated with the battery supply chain are not in lithium extraction or processing but in manufacturing phases like cell, pack, and vehicle production (see **Figure ES1**). Across the entire value chain, out of over 150,000 existing jobs, 43% are in EV manufacturing, 26% are in battery component, cell, and pack manufacturing, and only 6% of jobs are estimated to be in the mining of critical minerals like lithium.

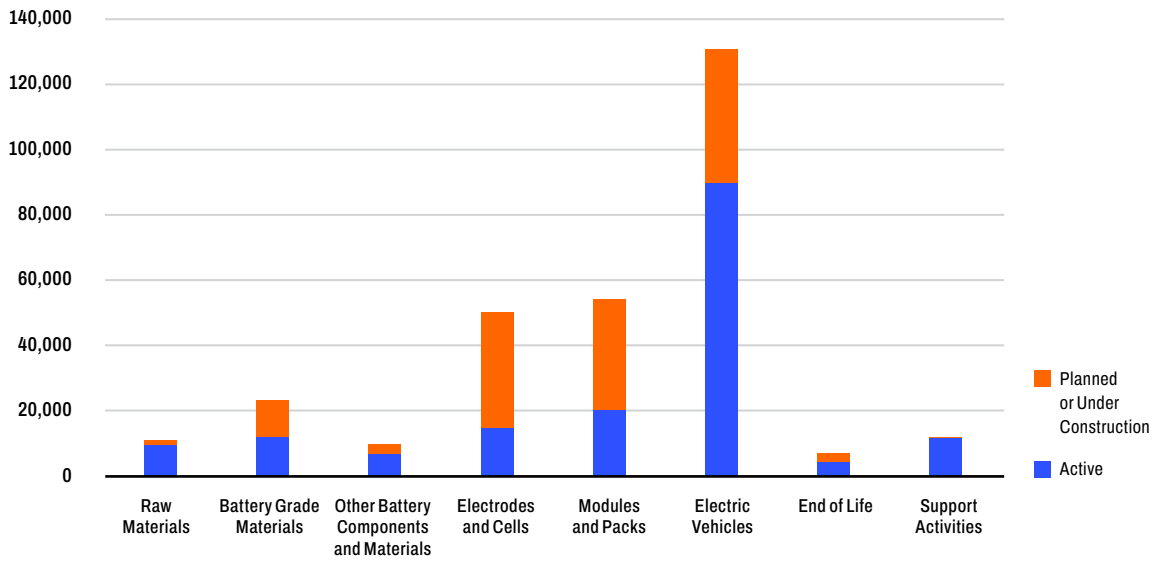


FIGURE ES1.

Estimated employment in the lithium-ion battery and EV supply chain in the U.S., 2023.

SOURCE: Authors' analysis of custom database used in "Lithium Battery Supply Chains of North America."[5]

4 We developed an integrated database, combining a battery value chain database developed by the National Renewable Energy Laboratory and NAATBatt International (a trade association for the battery industry) with data on EV manufacturing facilities from Automotive Manufacturing Solutions' EV database and various news reports and company announcements. (**Figure ES2** maps these operational and planned EV facilities.) We then overlaid this data with state level indicators of labor protection policies gathered in a report by Oxfam America (Henderson 2023) and census tract level indicators that are part of the Federal Government's Climate and Economic Justice Screening tool. To access the complete interactive map, please visit **https://lithium-map.netlify.app/** .

5 **https://lithium-map.netlify.app/**.

- **California is the largest state for lithium supply chain jobs but is currently missing out on new opportunities.** California currently accounts for roughly 19% of existing jobs, by far the highest share of any state (Tennessee is second with 12%). The largest concentration of jobs is at the Tesla electric vehicle plant in Fremont, with an estimated employment of over 22,000 workers. Although California also hosts an ecosystem of innovation and startups that provide valuable opportunities for future growth, **when it comes to new projects, California is lagging behind, with only 2.4% of projected new jobs along the value chain.**
- **Western states provide a strong supply chain ecosystem with good labor policies.** Along with neighboring Nevada and Arizona, California anchors this western cluster that encompasses all steps in the lithium-battery and EV supply chain. In policies to support good jobs and wages, California ranks 1st in the nation, while Arizona places 18th and Nevada 20th (Oxfam, 2023). Together, the three states currently account for nearly a third (31%) of jobs in the full lithium battery and EV value chain, but only 10% of planned new investment.
- **New battery and EV production sites are concentrating in the Southern U.S.** (see Figure ES2), driven by cheap land and energy costs, short permitting timelines, and a suite of incentives being offered by state and local governments. But we do not see evidence that the jobs generated will be high-quality. Kentucky, Tennessee, Alabama, and Georgia currently account for approximately 16% of total existing employment along the value chain, but represent nearly 34% of projected jobs in new sites. In contrast to California, these states are low-to-bottom ranked in terms of labor protection, worker health and safety, and wages. Kentucky is ranked 38th, Tennessee 45th, Alabama 48th, and Georgia 50th.
- **Traditional auto industry states also have strengths in the lithium supply chain.** The Midwest also remains a key region for EV development due to its deep bench of physical and human infrastructure in the automobile industry. The recent landmark contract negotiations between the United Auto Workers (UAW) and the Big Three automakers (Ford, General Motors, and Stellantis) may ensure that this region solidifies its high-road history. And, if the union is able to expand its organizing throughout the “Battery Belt” (the broad swath of battery facilities stretching from the upper Midwest down through Georgia), better outcomes for workers are possible.

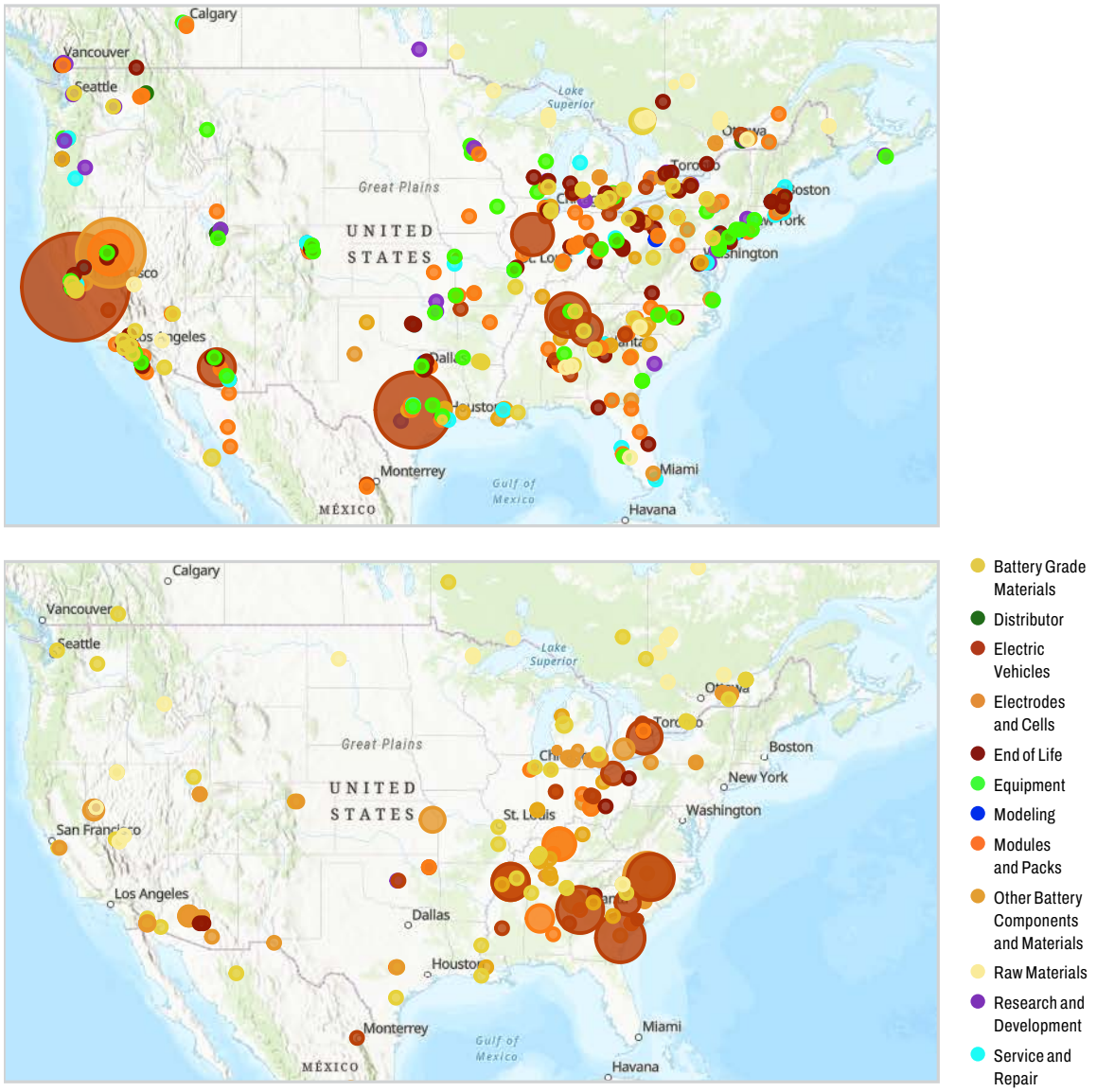


FIGURE ES2.

Facilities in the EV and battery value chain: operational (above) and planned (below); bubble size represents estimated job numbers. Source: "Lithium Battery Supply Chains of North America."[6]

SOURCE: "Lithium Battery Supply Chains of North America."

6 To access the complete interactive map—which allows users to see facility-level details, filter by supply chain step, and add labor policy and environmental justice indicators—please visit **https://lithium-map.netlify.app/**.

- **Through a variety of unprecedented funding requirements and incentives, the federal government is seeking to support a domestic EV battery chain industry that provides good jobs and community benefits.** The huge federal investments in the IRA and the BIL have clearly galvanized private investments in green manufacturing, although not all the investments are leading to good jobs and community benefits. Federal mandates and incentives for high road practices vary by program and industry. For example, in renewable energy construction, federal investments are strongly tied to high-road labor practices that lead to union jobs for local construction trades workers.[7] In other funding, the federal government has embedded incentives for good jobs and community benefits in grant and loan programs by ranking applicants in part on their commitments to locate in disadvantaged communities[8] and to provide good jobs. Applicants for many green federal grant and loan programs are now required to identify their specific plans to provide good jobs and community benefits, which gives high road firms an advantage when they compete for funding.[9] However, because federal support is not the only factor that determines competitiveness, it can sometimes be difficult for EV and battery companies interested in high-road practices to compete in the marketplace, and there are technical gaps in firms' capacities to build in community benefits and develop the necessary partnerships with labor and community to do so.

KEY FINDINGS REGARDING CURRENT LITHIUM VALLEY DEVELOPMENTS

The current landscape in Lithium Valley has clear locational advantages for lithium extraction and potentially for co-location of manufacturing but no guarantees that extraction or manufacturing will lead to high-road jobs or significant community benefits. However, with greater public and private financial support for high-road employment practices, technical assistance for community benefits planning, and improved coordination among local, state, tribal, and federal actors, Lithium Valley could be a model for a just and equitable clean energy transition centered on shared prosperity.

There are many encouraging developments already underway in the region. Three companies (Berkshire Hathaway Energy Renewables, EnergySource Minerals, and Controlled Thermal Resources) are actively pursuing lithium extraction, with commercial scale production first expected by late 2025 or 2026. Controlled Thermal Resources (CTR) broke ground on its Hell's Kitchen Campus, a fully integrated lithium facility and clean energy campus in Imperial Valley, on January 26, 2024.[10] Major automobile companies, including Ford, General Motors, and Stellantis, have invested in these companies, reflecting their confidence in the ability of the developers to secure reliable sources of lithium at mass scale. The State of California has passed a lithium extraction excise tax, to help ensure some portion of the revenue generated from mineral extraction goes to support the communities near

7 https://laborcenter.berkeley.edu/ira-charts-a-path-that-is-both-pro-climate-and-pro-worker/
8 https://www.whitehouse.gov/environmentaljustice/justice40/
9 https://www.energy.gov/infrastructure/about-community-benefits-plans
10 https://www.cthermal.com/projects

where the lithium is extracted. The state also has appropriated funds to help with planning, not just for lithium extraction but for a broader processing and manufacturing ecosystem. This includes providing funding to Imperial County to help prepare a Programmatic Environmental Impact Report (PEIR) and establish a Lithium Valley Development Office, and to community organizations to conduct robust community engagement to promote broader input into the process. Important state and local workforce development initiatives are also in progress, including work by Imperial Valley College to develop a Lithium Industry Force Training (LIFT) program and California state funding to expand San Diego State University's Brawley campus to focus on STEM. The state has also funded a High Road Training Partnership[11] (HRTP) planning grant led by the San Diego & Imperial Counties Labor Council to help promote high-road jobs in lithium recovery and related production. At the same time, challenges still need to be overcome to ensure the Lithium Valley vision delivers good jobs and substantive community benefits. In our locational analysis, we find that:

- **The number of direct jobs expected to be connected with the direct lithium extraction (DLE) is relatively modest and the quality of these jobs remains a concern.** In total, there will be a few hundred jobs initially, rising to roughly two thousand ongoing jobs in lithium extraction at full build-out many years from now. There are currently no agreements in place to ensure these operations jobs are high-quality or will be targeted for local residents, although at least two developers have signed project labor agreements (PLAs) with building trades unions for the construction phase of the projects. Employers have asserted that the operations jobs will pay roughly $25–30/hour, which is still below the living wage of $34.80 for a family of one adult and one child in the county.[12] The vast majority of these jobs are blue-collar jobs, likely to require skills acquired primarily through on-the-job training. The Lithium Valley Community Coalition and others have called for firms involved in lithium extraction to negotiate a Community Benefits Agreement[13] (CBA), to ensure job quality and local access, but to date no concrete agreements have been settled.
- **Most of the jobs associated with this lithium will be created further along the value chain.** We find that if all the lithium that flows through the existing geothermal plants annually were extracted and used to make batteries, it would support roughly 200 GWh of battery production per year—enough for nearly 3 million EVs. This is associated with roughly 1,600 jobs in cathode manufacturing, 20,000 jobs in battery cell and pack manufacturing, and over 100,000 jobs in electric vehicle manufacturing. (**Figure ES3**. See section 2.3 of the report for the methodology of this calculation.). It is not likely that all the lithium will be extracted, nor that these jobs would all be located in Imperial County; depending on where the batteries are produced, they could be distributed throughout the state, country, or internationally. However, these numbers illustrate that the potential for job creation grows almost exponentially as more steps in the value chain are added, so the associated benefits for Imperial County will grow depending on its ability to attract more value-added production capacity.

11 https://cwdb.ca.gov/wp-content/uploads/sites/43/2020/01/HRTP-Essential-Elements_ACCESSIBLE.pdf
12 https://livingwage.mit.edu/
13 https://www.policylink.org/resources-tools/tools/all-in-cities/good-jobs/community-benefits-agreements

- **There are multiple potential economic benefits of co-locating lithium processing and supply chain manufacturing in the region.** One clear advantage is the ethical (environmental and social), reputational, and public funding benefits of firms locating manufacturing in the region. This includes the reputational and marketing benefits of being tied to a clean source of lithium, as well as the potential for companies to tap into federal investments targeted at encouraging investments in disadvantaged communities (such as the Justice40 Initiative) and related high-road incentives.[14] The region also has a number of locational advantages, including: close access to a large environmentally conscious consumer market which remains the largest EV consumer base in the country; linking with the broader California-centric innovation ecosystem in batteries and EVs, particularly EV manufacturing in the Los Angeles area; a relatively low cost of land and energy compared to the rest of California; and proximity to Southern California ports linking to international markets. Locating precursor and cathode material production near a lithium resource could also potentially offer some logistical and environmental benefits; it could reduce the time, cost, and emissions associated with shipping lithium, resulting in more efficient coordination between producers and a lower life cycle carbon footprint. It is important to keep in mind, however, that while lithium is an essential element for battery production, it is still but one of many input materials, and thus presence of lithium is not enough on its own to attract value-added manufacturing. Furthermore, there are clearly untapped opportunities for California and particularly the Salton Sea region to expand battery and EV manufacturing even prior to the start of lithium being extracted at commercial scale. The attention to lithium extraction itself should not draw away from efforts to build the broader lithium battery chain ecosystem.
- **There are direct environmental benefits of lithium extraction, although also environmental concerns that need to be addressed.** The benefits of sourcing lithium from Imperial County are in part environmental: extracting lithium from geothermal brine is expected to have a substantially lower ecological and carbon footprint than alternative processes of hard rock mining or large-scale evaporation ponds. Through the approved excise tax, lithium extraction will be a major source of revenue for ongoing Salton Sea restoration.[15] In addition, using locally generated clean geothermal energy for manufacturing could substantially lower the carbon footprint of battery production. On the other hand, there are important concerns about the disposal of waste streams, the potential of increased localized air pollution, and the responsible use of scarce water resources that remain to be fully addressed. Leading advocacy on these issues, Comité Cívico del Valle and Earthworks have released an in-depth report on the environmental and social impacts of Lithium Valley development (Naimark 2023), and on February 15, 2024 hosted a related webinar open to the public.[16]

14 https://www.whitehouse.gov/environmentaljustice/justice40/

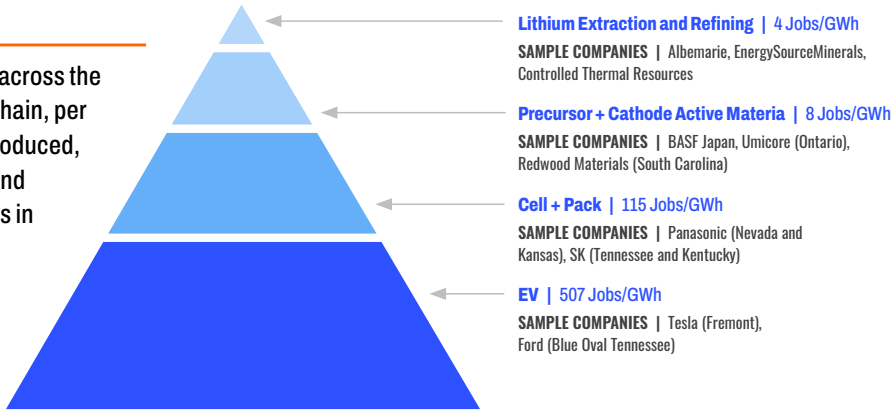
15 https://www.cdtfa.ca.gov/taxes-and-fees/lithium-extraction-excise-tax.htm

16 https://www.facebook.com/photo.php?fbid=767076975469929&set=a.232076875636611&type=3&paipv=0&eav=AfaaLPf_w6T5jga4Bz_SKGLR5ohU2KDxPSXxfLKRsKFMdqnPwFj350Nr5Yl4VXvDbrA&_rdr

- **California can provide a model for inclusive and environmentally friendly economic development strategies.** California built the lithium battery and EV industry, through pioneering legislation promoting zero-emission vehicles (as early as 1990); providing subsidies to early pioneers in the field; and awarding grants, such as those from the California Energy Commission, to companies pursuing clean energy innovations.[17] California continues to be a hub for green tech and automotive innovation, hosting the headquarters and major research and development facilities of dozens of battery technology, EV, and automobile companies. But to survive and prosper, firms in California must gain market edge through quality, innovation, highly skilled workers, and high environmental standards. Policy-makers need to focus on the race to the top as a market differentiator, i.e., a particular strength of California that positions employers favorably for high-road-oriented public incentives, appeals to growing consumer values, and includes workforce benefits that pay dividends in the form of attracting and retaining a skilled and engaged workforce.
- **California labor standards are not driving companies away from the state.** If higher labor costs are a consideration, it is important to remember that labor costs make up only roughly 10% of operating expenses in battery manufacturing (Orangi and Strømman 2022a), and that the marginally higher cost of high-road labor comes with profit-enhancing advantages: a strong pipeline of skilled labor, less turnover, increased manufacturing efficiency and greater eligibility for state and federal incentives in place for high-road employers. The advancement of high-road standards at the federal level by the Biden administration is an opportunity to onshore a critical supply chain that draws high-road industry to the state, aligns with the state's climate goals, and produces a return on investment that maximizes benefits to local communities.

FIGURE ES3.

Breakdown of jobs across the EV battery supply chain, per 1 GWh of battery produced, based on existing and announced facilities in the U.S.



17 Tesla has benefited from over $3.2 billion in direct and indirect California subsidies since 2009, particularly in the form of credits created by California's Zero Emission Vehicle program, as well as from later federal incentives to support EV adoption, and these subsidies amounted to as much as 85% of Tesla's gross margins in 2009 (Niedermeyer 2019:72). Both Controlled Thermal Resources and Berkshire Hathaway Energy have received California state grants to support their lithium extraction development (Chao 2020).

CONCLUSIONS

1. The Lithium Valley vision is an opportunity for California to model a counterweight to low-road economic development in the battery supply chain. Realizing this vision is not without its challenges because although California has been the home of EV innovation, many companies are setting up manufacturing operations to scale their California-grown technology elsewhere. Concentrated public investment and policies are needed to support high-road companies in attracting additional private capital; and to ensure that companies who innovate in California stay in the state, generating family supporting jobs and career pathways in new green industries.

2. The residents of Imperial County can benefit from lithium extraction itself, but this will require commitment by government and industry to ensure community and worker benefits. All too often, communities that have valuable natural resources experience a resource curse, rather than an economic benefit, as companies extract resources without investing in local community benefits or ensuring high-quality jobs. Building a new battery industry in Imperial County provides a unique opportunity to move away from business-as-usual practices and redefine the standards of a resource-based economy—one that is more sustainable, with local jobs offering strong labor standards and family-supporting wages. Residents will benefit from an excise tax on extraction, but more needs to be done. California's well-developed high-road tools must ensure job quality and local job access, starting with the adoption of a **Community Benefits Agreement (CBA)** for the lithium extraction that is already underway. Coalitions in Imperial County are already calling for this, and technical assistance to support companies interested in the high road is needed to ensure the success of these efforts. In addition, infrastructure development to support resource extraction should serve the community and support economic diversification.

3. The vast majority of jobs and revenue from the EV and battery supply chain will be in the value-added enterprises that come after mineral extraction. To help ensure the co-location of some of these value-added enterprises in the Imperial Valley region, significant governmental commitment is needed to attract further investment into Imperial County for production activities that will multiply the job and economic impacts beyond resource extraction. To realize these advantages, cities, the county, and the state must work together to provide substantial public investment for companies committed to high-road pathways, more rigorously coordinated with federal, state, tribal, and local entities, and at the same time condition further public subsidies for companies on the provision of good jobs with career pathways, rigorous training, worker voice, and local hire agreements.

4. The short-term priority is to ensure that lithium extraction jobs are good jobs available to local residents, through robust high-road-oriented funding and technical support to the existing workforce development and community benefits initiatives. In the medium to long term, the

priority is to build the conditions for a broader high-road business ecosystem. The post-pandemic labor landscape has emerged as a "workers' market"; nationwide, businesses are struggling to find skilled workers to meet production timelines. As attracting and retaining a high-quality workforce proves more challenging, investing in workers is not only socially responsible but also sound business strategy. The Lithium Valley vision presents the opportunity to show that high-road models are good for workers, communities and companies alike, and that large-scale climate action can also usher in shared prosperity and greater equity. By pairing these values with tailored, business-friendly measures, California can extend a warm welcome to companies embracing these models of the future at the same time that benefits to frontline and local communities are maximized.

RECOMMENDATIONS

We propose the following recommendations to realize the aims set out in our conclusions.

The first two areas set out below—**supporting high-road workforce development and investing in locally serving infrastructure**—are immediate priorities to secure high-road labor outcomes and concrete community benefits in the emerging lithium extraction phase. However, these levers must be implemented in tandem with medium- and long-term policy planning around the buildout of a high-road battery manufacturing ecosystem in Imperial County and in the state. This entails building on the state's historic incubation of the EV and battery industry, but with a focus on ensuring that there is **an innovation to implementation pipeline,** providing the business benefits and public support for high-road companies who stay and manufacture their technologies in the state. It also means **addressing permitting barriers** to ensure that companies can compete in California while also providing good jobs and career pathways for local workers. Finally, it means ensuring that there are mechanisms in place for **battery supply chain transparency** from extraction to recycling that can monitor, measure, and uphold environmental, labor and air quality standards. These recommendations are the critical steps in ensuring that California can create the high-road ecosystem of businesses innovating and manufacturing in the state, while simultaneously creating economic benefits for the workers who power those industries and the communities that host them.

R.1 Support high-road workforce development

State and local governments are providing significant resources to support lithium extraction in the region, including direct grants and subsidies. The state is also investing in the infrastructure needed to make lithium extraction possible, including in workforce development programs to help ensure a skilled local workforce. Community and public leaders should also help ensure that the jobs that emerge, both in the construction phase of the project and the ongoing operations, are high-quality jobs and that there are enforceable agreements to ensure job access for local residents.

RECOMMENDED ACTIONS

- **Condition public funding for private businesses on the negotiation of Community Benefits Agreements[18] (CBAs) with labor and community groups.** Existing formalized agreements, or commitments to negotiate them, between industry, labor and community organizations, like CBAs, can be used as criteria to evaluate eligibility for, or maximize, funding available for a project. CBAs are tools proven to show that by elevating worker and community voices in project development residents and workers can ensure lasting avenues of ongoing partnership with the company to ensure a project's success. For practical resources on implementing CBAs in an energy development context, see the U.S. Department of Energy's CBA Toolkit.[19] The U.S. Department of Energy also offers guidance on proposal-stage **community benefits planning** during funding application processes, as a precursor to a subsequent CBA.[20]
- **To ensure a robust skilled workforce, deploy the following strategies to address skills and job quality in the following key sets of occupations**:
  - For the **construction trades workers**, including those involved in maintaining equipment once facilities are operational, utilize the state-certified apprenticeship system.
  - For the **blue-collar operations workers**, develop labor management High Road Training Partnerships (HRTPs) that include the key elements found in apprenticeship programs, including agreements on joint labor- and- employer input into training curricula and skill certification, shared funding, wage improvements as skills are acquired, and partnerships with training organizations such as community colleges. These high-road principles should be incorporated into existing workforce development programs in Imperial County, aligning the nascent HRTPs with ongoing investments in workforce training by Imperial Valley College for the blue-collar workforce in both extraction and future operations work.
  - For the **professional and technical workers who need higher-education degrees** at the two-year, four-year, or graduate level, utilize the community colleges and state university for training, developing appropriate curriculum, and articulating degree pathways in consultation with industry. Here it is critical to Incorporate new relevant curricula and internships into the key engineering and related degrees, in consultation and collaboration with industry.

18 https://www.policylink.org/resources-tools/tools/all-in-cities/good-jobs/community-benefits-agreements
19 https://www.energy.gov/diversity/community-benefit-agreement-cba-toolkit
20 https://www.energy.gov/infrastructure/about-community-benefits-plans

R.2 Invest in locally serving infrastructure

Developing new industries requires reliable transportation networks, modern utilities, and access to education and healthcare facilities. Both community and industry need upgrades to the electric grid, roads, and broadband/internet. But there is a danger that infrastructure development will be focused narrowly on what is required to extract lithium and ship it to external markets. Instead, infrastructure investments should be designed to support lithium extraction as well as foster the co-location of a broader supply chain and economic diversification throughout the region.

This includes investments in physical and social infrastructure to improve quality of life for those living and working in the area, such as public health services, public transportation (both within Imperial County and connecting it to other population centers), climate resilient housing, and environmental restoration related to Salton Sea management and air quality. This not only benefits the companies connected to the Lithium Valley vision, who will be able to recruit and retain workers, but is also an important step towards inclusive economic development for the communities in Imperial Valley who are hosting and supporting this new industry.

RECOMMENDED ACTIONS

- **Use county revenue from the lithium extraction excise tax to fund not just infrastructure supporting lithium companies and their extraction and transportation needs, but also infrastructure that will benefit the local community and support diversified economic development (e.g., roads, public transportation, updating electric grid, improving broadband access).**
- **Incentivize companies to support investment in local infrastructure through suggested CBA provisions informed by the needs of Imperial County residents.**
- **Secure more state and federal funding for critical infrastructure to support a high-road advanced battery supply chain.**

R.3 Keep manufacturing in California by supporting an "Innovation to Implementation" pipeline

Building a green manufacturing industry in Imperial County will require significant collaboration across multiple sectors, between federal, state, and local actors, to support high-road companies leading the race to the top. Coordinating multiple policies to support economic development along the full lithium supply chain is critical to create the conditions for high-road development in regions like the Imperial Valley.

RECOMMENDED ACTIONS

- **Increase funding to California clean energy entrepreneur support organizations and accelerator programs that support high-road pathways for startup commercialization in lithium supply chain related enterprises.**
- **Provide public resources and match federal dollars for companies with high-road labor standards that commit to keep lithium supply chain manufacturing in California.**
- **Create statewide workforce standards and condition funding for battery manufacturing companies that receive state dollars on the development of community benefits agreements (CBAs).**
- **Create a "high-road employer accelerator program" to provide technical assistance for companies who are committed to shared prosperity and partnerships with labor and community.**

R.4 Address permitting barriers for manufacturing

Making the permitting process more efficient will be necessary if Imperial County and California are to attract investment in green industries. Expedited permitting, for example, can be made available for projects that have formalized agreements and support from community members and local organizations. Through a CBA, where companies have committed to shared decision making and regular convenings with community stakeholders regarding specific issues of community concern, public agencies can allow for expediting permitting without sacrificing environmental protections, local community concerns, and transparency.

RECOMMENDED ACTIONS

- **Support the creation of a Regulatory Roadmap for companies interested in setting up a manufacturing facility in Imperial County.**
- **Create a regulatory streamlining district for desired project types, building on the outcomes of the Programmatic Environmental Impact Report process (PEIR) and conditional on commitment to high-road standards.**
- **Identify suggested CBA provisions as part of the PEIR process, including proactive permitting discussions, and drawing on some of the recommendations made in reports led by Imperial Valley community organizations (Naimark 2023).**
- **Utilize the CEC's new Opt-in Certification program to streamline permitting for eligible green manufacturing projects. Under Assembly Bill 205, passed in 2022, permit approval time for projects can be shortened significantly when the CEC certifies that the project**

meets specific labor standards and community benefits.[21]

- **Utilize long-range land use planning, and work with Tribal Nations, to identify areas that are desirable for manufacturing, including areas where communities are supportive and do not conflict with tribal cultural resources**.
- **Work with Tribal Nations in the region to explore interest and suitability for tribally led and owned turnkey ready manufacturing sites on tribal lands, similar to the Tahoe Reno Industrial Center but designed to attract and support high-road employers.**

R.5 Support battery supply chain transparency initiatives

Local communities and environmental justice organizations have raised the importance of transparent monitoring and accountability for environmental and public health impacts, particularly related to waste management and water use (Naimark 2023).

Supply chain transparency is an important accountability tool, and a necessary mechanism to reward companies for implementing high-road practices and investing in sustainable manufacturing. Traceability is essential because it facilitates carbon accounting in value chains, which enables California's low-carbon grid and cleaner lithium extraction to be a competitive advantage. This advantage would be significant for lithium or batteries produced in Imperial County using geothermal energy. Traceability mechanisms could also be used to verify domestic and recycled content. If suppliers were also required to report labor metrics, it would be possible to verify and support high-road employment practices along the value chain. The ability to trace the source of minerals and component production along the entire supply chain could also give EV manufacturers a clear marketing advantage with environmentally and socially conscious consumers.

Traceability is also critical to sustainable, safe, and efficient end-of-life (EOL) management. Better access to information supports stakeholders in the reuse and recycling industries who need to know the battery's chemistry and remaining capacity to handle it properly. Batteries can be reused in vehicles as affordable replacement packs, repurposed into stationary storage systems that help facilitate the integration of renewables, or recycled to recover the constituent materials, effectively creating a domestic source for critical mineral supply as more batteries reach the end of their EV service lives.

21 see https://www.energy.ca.gov/programs-and-topics/topics/power-plants/power-plant-licensing.

RECOMMENDED ACTION

- **As the California legislature considers how to institutionalize battery infrastructure, they should actively participate in the development of existing transparency initiatives, such as the Global Battery Passport,[22] and require company-reported data about emissions and labor practices during production.**

With lithium being a critical element in the green transition, the unique resource in Imperial County presents a tremendous opportunity for a California region that has long been left behind. Through investments in the companies actively pursuing lithium extraction in Imperial County, major automakers have shown their interest and confidence in the Lithium Valley vision. With sufficient community mobilization and government stewardship, it is possible for lithium to be recovered in Imperial County with minimal environmental impact, and for Community Benefits Agreements (CBAs) and High Road Training Partnerships (HRTPs) to lead to a just and sustainable manufacturing hub in the region, delivering good jobs for local residents.

The high-road co-location of further battery chain jobs alongside Imperial Valley lithium extraction is ambitious but possible, and can multiply the benefits for local residents and workers across the state. This report discusses the most accessible prospects for co-location, including CAM as well as further possibilities from component production to EV manufacturing. These are strong prospects for the Lithium Valley vision, consistent with its brand as a specialized high-road battery ecosystem, and a pioneering example of sustainable, just, and inclusive new green industry.

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22 https://www.globalbattery.org/battery-passport/

1

INTRODUCTION

1.1 BACKGROUND

In the race to mitigate global warming, decarbonization strategies in California and around the world rely heavily on transportation electrification, requiring lithium batteries at scale. In the United States (U.S.), the latest federal climate goals include bringing the electric share of new vehicle sales to 50% by 2030 (Woody, Keoleian, and Vaishnav 2023). California's ambitious electric vehicle (EV) regulations go even further, requiring all new passenger cars, trucks and SUVs sold in California to be zero-emission vehicles (ZEVs) by 2035. Global demand for lithium-ion batteries used in EVs and energy storage systems is expected to increase fivefold by 2030 (Arora et al. 2023), anchoring critical minerals[23] as a strategic pillar of national security, energy independence, supply chain resilience, and the U.S. economy. Securing domestic sources of critical minerals is a national priority, and if managed carefully, could provide tremendous economic opportunity that simultaneously uplifts industry, workers, and

23 https://www.energy.gov/cmm/what-are-critical-materials-and-critical-minerals

communities. Onshoring the related supply chains could potentially create 100,000 direct new jobs in the U.S. by 2030 in the battery portions of the industry alone, and three to four times that many jobs in electric vehicle manufacturing. Beyond the reduction in greenhouse gas emissions, lithium batteries have other environmental benefits over fossil fuels. Lithium and other materials in lithium-ion batteries are not actually consumed when used, in the way that fossil fuels are; if they are properly reused and recovered, it is possible to develop a closed-loop system, with lithium extracted today being able to power our lives for generations to come. Lithium's importance in a sustainable and prosperous future, and growing momentum in the energy transition, have propelled it to the forefront among critical raw materials, prompting a new lithium "white gold rush."

While market dynamics are important, the growth in demand for lithium-ion batteries is also largely driven by government policy and regulation. Two pivotal pieces of federal legislation, the Bipartisan Infrastructure Law (BIL) and Inflation Reduction Act (IRA), passed in 2021 and 2022, have created major financial incentives to drive the buildout of a domestic green manufacturing industry across the U.S., particularly for lithium-ion battery and EV production (Climate Power 2024). This historic level of public funding is accompanied by clear requirements that federal funding programs ensure that community stakeholders are meaningfully involved in determining program benefits, and a goal that at least 40% of overall investments benefit disadvantaged communities (DACs).[24] The IRA establishes domestic content requirements specifying a percentage of materials that must be sourced domestically for vehicles to be eligible for tax incentives. A 2019 data release from the U.S. Geological Survey inventories some 20 U.S. sites—occurring in Arkansas, California, Nevada, North Carolina, and Utah—identified as having a lithium resource or past lithium metal production of more than 15,000 metric tons.[25]

One of these sites stands out as a resource of particular promise: the U.S. Department of Energy cites the Salton Sea area, in California's Imperial County, as offering "the greatest domestic potential for lithium extraction from brines," utilizing potentially a far safer and more cost-effective method of lithium extraction and refining than is possible at most other sites.[26] Here, the lithium deposits exist in hot brines thousands of feet underground which are already brought to the surface for geothermal energy production. Several companies are developing direct lithium extraction (DLE) technology enabling lithium to be produced with a smaller land and energy footprint than with hard rock mining or open evaporation pond methods (Grant, Deak, and Pell 2020). In Imperial County, DLE could create a symbiotic industrial context, with the lithium and geothermal energy operations existing side by side.

24 https://www.whitehouse.gov/environmentaljustice/justice40/
25 https://www.usgs.gov/data/lithium-deposits-united-states
26 https://www.energy.gov/articles/doe-invests-millions-americas-massive-lithium-production-potential

1.2 THE LITHIUM VALLEY VISION

Although DLE technology is not yet commercially operational, the lithium-rich Salton Sea area has garnered acute interest for its potential value in the California and U.S. energy transitions, and for the economic development that it could bring to Imperial County, a long underserved county with major environmental pollution, leading to some of the highest asthma rates in the state. In recent years, the area has become synonymous with "Lithium Valley," a name coined by state and local leaders envisioning the buildout of not just a lithium extraction industry, but a broader battery supply hub that creates good jobs and meaningfully benefits the surrounding communities.[27] If successful in realizing this vision, Imperial County could provide a model for just and inclusive green economic development, not just for the county and the State of California, but for the whole country and beyond.

This endeavor requires proceeding with great care. All too often throughout history and continuing today, gold rush responses to valuable natural resources have done more harm than good to the places and communities that find themselves at their epicenter. Examples abound wherein, rather than improving local livelihoods and the wellbeing of local populations, the presence of a sought-after commodity proves to be a resource curse, distorting economies, undermining democratic practices, and wreaking environmental damage on resident populations and ecosystems (Ross 1999).

27 We acknowledge that the term "Lithium Valley" is not embraced by all local residents, for whom the area holds value first and foremost as their home, and regardless of its economic potential or the critical mineral within it now sparking so much interest. Herein, we use the term Lithium Valley not as a geographic place name, but rather in reference to the industrial lithium hub envisioned for this area.

HIGH-ROAD WORKFORCE PRACTICES

In workforce contexts, the high-road approach seeks to create an environment in which firms compete based on quality of product and service, achieved through innovation and investment in their workforce, which allows them to generate good jobs. It is in contrast to the low road, in which firms compete primarily on cost, often at the expense of workers, with negative outcomes in terms of wages, safety, worker voice, inclusive opportunity, and career advancement.

High-road labor practices focus on job quality, with union jobs as the gold standard, because good wages, career pathways, and worker protections are built into them; and job access, to ensure that workers from local communities, including those historically excluded from family-sustaining careers, have access to training and placement in career-track quality jobs.

The high-road markers of **good jobs** include

JOB QUALITY

- Family-supporting wages and benefits
- High standards for health and safety
- Long-term career pathways
- Worker voice and protections, including the right to organize

JOB ACCESS

- Access and entry-points to good jobs for local workers
- Hiring commitments to ensure inclusion of marginalized communities
- Training to support advancement

Awareness of these dangers and making sure they are avoided in Imperial County are evident in local and state initiatives around the Lithium Valley vision (Naimark 2023), and are at the core of the vision that this paper seeks to advance. The deposits hold the potential to contribute significantly to the urgent energy transition while also bringing good jobs and strong community benefits to a portion of the state that has been long left behind. But regardless of how many EVs the county's lithium helps power, positive local outcomes will not occur automatically. In fact, without careful design and sustained, intentional **high-road** actions (see **Box**), an Imperial Valley lithium industry risks developing along the low road—failing to benefit local communities, even as companies profit from it, even as it contributes to decarbonization.

1.3 ENSURING AND MULTIPLYING THE INCLUSIVE ECONOMIC BENEFITS OF LITHIUM EXTRACTION

Much is still uncharted in terms of how Lithium Valley development will unfold. In exploring several possibilities, this paper starts from the premise that the lithium resource in Imperial County must not be allowed to be a curse. This report presents concrete recommendations to support the continuing process to shape Lithium Valley as just, equitable, and environmentally sound.

There has already been significant stakeholder engagement, and active labor and community groups are demanding transparency, voice in decision-making, and concrete benefits for local workers and their families. As challenges are identified, as can be expected in a project of this complexity and scale, the solutions to them must be elaborated hand in hand with, and acceptable to, resident communities.

Building a new industry from the ground up provides a unique opening to move away from business-as-usual practices and set new standards for a just green economy—one that is more sustainable, with strong labor standards, living wages, and meaningful community benefits. Creating good jobs for local residents—including marginalized groups—is industry's greatest lever for positively impacting a community. This means that Lithium Valley's potential for positive local impact increases the larger the workforce it

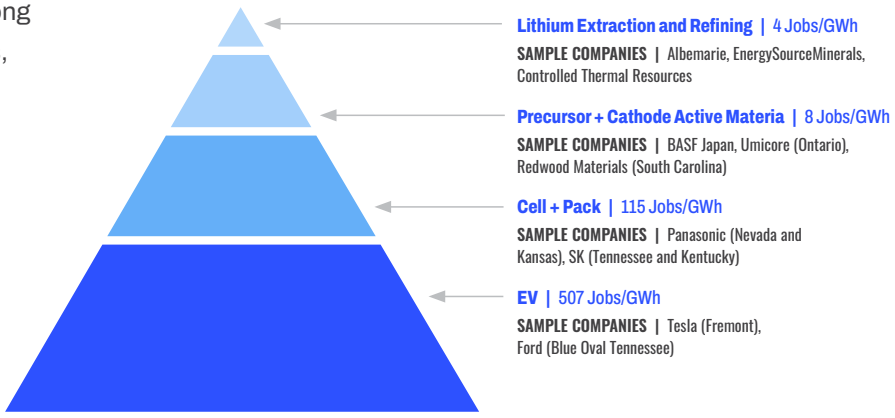

FIGURE 1.

Breakdown of jobs across the EV battery supply chain, per 1 GWh of battery produced, based on existing and announced facilities in North America.

supports, which would be achieved by attracting more value-added steps in the supply chain: using the lithium to make cathode active materials (CAM), battery cells, packs, and potentially electric vehicles. Indeed, as illustrated in **Figure 1**, lithium extraction represents only the tip of the iceberg, i.e., only 0.7% of jobs in the full EV battery value chain, with most jobs concentrated in the manufacturing stages.[28]

At the federal level, the Biden administration has signaled that high-road strategies are a priority in growing green industries. The IRA establishes wage standards and apprenticeship requirements that businesses must meet in order to be eligible for enhanced clean energy tax benefits.[29] However, these requirements are mainly found on incentives geared towards renewable energy projects (e.g., construction of a solar or wind farm). Various public incentives are in place to help level the playing field for high-road employers, with additional benefits available for investments in disadvantaged communities under the Justice40 Initiative.[30] However, navigating these incentives can be daunting, particularly in climate-related sectors, such as the EV chain, that do not fall under the category of renewable energy production. For EV and battery companies interested in operating on the high road, there is a gap in technical assistance that could help them identify and leverage the public incentives designed to support them. Furthermore, many new and planned EV and battery facilities are locating in southeastern states that have limited worker protection policies (e.g., high minimum wage provisions and workers' right to organize). In short, even as the federal government provides clear guidance and incentives for high-road practices in green industries, some battery manufacturers are opting to set up in states where they are held to lower labor standards. In Imperial County, a better way is possible. Lithium Valley's alignment with federal prioritization of equity and economic inclusion in green economies represents an opportunity, as yet not fully tapped, to capture resources that can be instrumental in creating a model of the high-road alternative.

California has been the core of the EV industry since its inception, and still is the home to the largest EV factory in the country, Tesla's Fremont plant. The state remains at the forefront of new technological development in the industry, including in new battery chemistries and sustainable battery life-cycle businesses. California is also an industry leader in its consumer base, with by far the largest number of electric vehicles in the country: more than a third of all EVs nationwide and five times as many EVs as the second-highest state.[31] In 2022, the state represented 19% of all new EV sales nationally, and in the second quarter of 2023, ZEVs had risen to one fourth of all car sales in California.[32] This trend is only expected to grow as the state has crossed 1.5 million cumulative EV sales two years ahead of its

28 Calculations are based on employment data from similar facilities and explained in greater detail in **Section 2.3.1**.

29 Prevailing wage is a combination of hourly wages and fringe benefits that employers must pay at or above, as calculated for specific regions and occupations, and applies to all laborers and mechanics performing construction, alteration, or repair on facilities or energy installations. The apprenticeship requirements specify a minimum percentage of labor hours that must be performed by qualified apprentices, as well as participation requirements stating that a company or contractor with four or more workers must employ at least one qualified apprentice. **https://www.apprenticeship.gov/inflation-reduction-act-apprenticeship-resources**

30 **https://www.whitehouse.gov/environmentaljustice/justice40/**

31 According to the most recent data (2022) from the U.S. Department of Energy Alternative Fuels Data Center: **https://afdc.energy.gov/vehicle-registration**

32 **https://www.energy.ca.gov/data-reports/energy-almanac/zero-emission-vehicle-and-infrastructure-statistics/new-zev-sales**

target.[33] In addition, California has set public fleet greening targets that will continue to make the State itself a major buyer of electric transportation. Recently passed legislation requires 30% zero-emission heavy-duty vehicles in state fleets by 2030 (AB 739)[34] and 50% of light-duty vehicles (12 passengers or less) purchased by the state to be zero-emission by 2025 (SB 498).[35]

However, despite ranking first in EV adoption and being home to the country's first major EV company (Tesla), California is not leading the charge in battery manufacturing: while the state is an incubator for innovations in battery chemistry and other technological advancements, the related manufacturing operations have tended to go elsewhere. Lithium Valley presents an opportunity 1) to help shift the momentum in California away from innovation isolation to a robust lithium-ion battery manufacturing industry, and 2) to position the state as a counterweight against the "race to the bottom" by modeling successful sustainable production and high-road manufacturing. The Biden administration is seeking to support the race to the top through its investment mandates, and has set up scoring systems to ensure that the most competitive applications are those demonstrating high-road practices.[36] Seizing this window of federal support is a priority in advancing California's high-road green industry ambitions.

1.4 SCOPE AND PURPOSE

In this report, we 1) explore how to ensure that the already emerging lithium extraction in Imperial County provides high-quality jobs for local residents and other community benefits, and 2) examine how to build out more of the battery supply chain in Imperial County, and more broadly in California, while ensuring that this expansion takes the high road, and 3) provide concrete recommendations for how to achieve these high-road development goals.

We start by examining the present and future of Lithium Valley, focusing on existing initiatives to create a high-road critical mineral extraction industry, and the possibilities presented by a broader battery hub. Next, we examine the foundational pillars of a high-road supply chain and trends developing in domestic battery manufacturing, to identify why companies are locating in certain locations in the U.S. Based on these insights, we outline the significant challenges and key strengths at play in incubating a high-road, green manufacturing industry in Imperial County and across California. We conclude with a series of concrete recommendations, identifying tools and strategies actionable primarily at the local and state levels to ensure a high-road Lithium Valley.

33 https://www.gov.ca.gov/2023/04/21/california-surpasses-1-5-million-zevs-goal-two-years-ahead-of-schedule/
34 https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180AB739
35 https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201720180SB498
36 https://www.energy.gov/infrastructure/about-community-benefits-plans

2

LITHIUM VALLEY IN THE REGIONAL LANDSCAPE

Located in the far southeast corner of the state, California's Salton Sea region stands as a testament to resilience. The Salton Sea itself, created in the early 1900s by a two-year flood caused by a breached irrigation canal, became a thriving tourist attraction, along with the region's desert ecosystems and captivating landscape. But in recent decades, tourism has declined as the Salton Sea became better known as a site of toxic agricultural run-off and asthma-inducing dust storms. At the same time, irrigation has enabled the region's farmers and farmworkers to turn the fertile soils of Imperial County into a vital hub for the nation's food supply. It supplies a large share of U.S. winter vegetables, particularly lettuce, broccoli, carrots, onions, and spinach, and is California's largest producer of alfalfa and second largest source of cattle (Imperial County Agricultural Commissioner 2022). With an economy highly dependent on agriculture, the region has low union density, starkly low wages, and

high rates of seasonal employment, with county-wide unemployment rates typically three to four times the state-wide average, and regularly exceeding 25% in agricultural off-seasons.[37] Almost a third of the population are foreign born, mostly Mexican, and much of the seasonal agricultural employment is filled by migrant workers from Mexico. A quarter of the total population, and nearly half of the region's Native American population, live below the official poverty line.[38]

State and local leaders began referring to the area as "Lithium Valley" around 2019, proposing the vision of a new industry that would not only support clean energy independence but also bring needed investment and benefits to communities that have been marginalized for decades (Alston et al. 2020; Paz et al. 2022). This vision for a better future in Lithium Valley is best analyzed as two distinct possible trajectories. The more immediate goal is to establish a high-road lithium extraction industry that will provide a secure and environmentally sound source of lithium, create high-quality jobs for local residents, and benefit the local community. This is not easy; it will require sustained community engagement and action, not to mention overcoming difficult technological challenges, but this scenario appears feasible given current political tools and political will. The more ambitious goal for Lithium Valley involves the buildout of a battery supply hub that includes more value-added manufacturing steps, powered by clean energy. This could lead to a profound transformation of the region, moving beyond primary resource dependency to a thriving economy rooted in technology, innovation, and value-added enterprises that link lithium mining with the full battery and EV value chain. Realizing this vision, however, will require significant public investment, sustained political support, and a huge collaborative effort.

A number of initiatives aimed at creating the ambitious vision for Lithium Valley are already underway, led by local and state efforts. In 2020, the California legislature passed AB 1657, which convened a Blue Ribbon Commission on Lithium Extraction in California ("Commission"), known colloquially as the "Lithium Valley Commission." The Commission was tasked with reviewing, investigating, and analyzing eight specific topics related to lithium extraction, including "methods of overcoming technical and economic challenges…" and the potential economic and environmental impacts. It was composed of fourteen commissioners from different backgrounds, who met monthly and released their final report in December 2022 (Paz et al. 2022). Another foundational document is the "Building Lithium Valley" report published by New Energy Nexus in 2020 (Alston et al. 2020). Both reports highlight the existing challenges in the region, and the importance of developing this new industry in a way that benefits the surrounding communities. In the wake of these reports, efforts to build an inclusive Lithium Valley have continued, resulting in important initiatives from community and labor organizations, local government, educational institutions, and the State of California. Geothermal and lithium developments are also progressing, fueled by ongoing public and private sector investment.

37 https://www.labormarketinfo.edd.ca.gov/geography/imperial-county.html
38 https://nationalequityatlas.org/indicators/poverty?geo=04000000000006025

In this section, we give an update on the status of "Lithium Valley," starting with lithium extraction and the progress to date in terms of local benefits. We look at how to leverage current community and government efforts in order to turn the evident will for positive outcomes into concrete measures securing good local jobs and community benefits. We then look at the potential for a broader battery supply hub in the region, first, estimating potential jobs and then considering the merits of setting a high-road course for this industry.

2.1 LITHIUM RESOURCES AND EXTRACTION ACTIVITIES IN THE SALTON SEA REGION

The Salton Sea Region has tremendous energy and mineral resource potential. The area currently hosts eleven geothermal energy plants, with a combined capacity of approximately 432 megawatts (MW), which provide renewable energy to surrounding areas in California and Arizona. These plants use hot brines from a reservoir thousands of feet underground to produce steam, which then generates electricity. The total resource potential is estimated to be 2,950 MW, with plans underway for significant expansion, as California has committed to reaching 100% renewable energy production by 2045 (Kaspereit et al. 2016).

The concentration of lithium in these geothermal brines is high—around 200 parts per million (ppm)—which makes it more economically viable to extract the mineral. The brines also contain other valuable minerals—most importantly zinc with a concentration of 500 ppm, and manganese at 1500 ppm—that could add to the economic attraction of mining lithium in the region (McKibben, Elders, and Raju 2021; Murphy and Haji 2022). A recent DOE-sponsored report estimated that the proven geothermal resource contains 760 thousand metric tons of lithium metal or approximately four million metric tons of lithium carbonate equivalent (LCE),[39] enough to produce batteries for 85 million EVs.[40] Meanwhile, the entire reservoir may contain as much as 3.4 million metric tons of lithium metal (roughly 18 million metric tons of LCE) (Dobson et al. 2023). At present, brine is reinjected into the underground reservoir after electricity generation; however, there is an opportunity to separate out lithium (and potentially other minerals) first, using direct lithium extraction (DLE). DLE promises fewer environmental problems than typical lithium hard rock mining or evaporative operations, and in Imperial County, operations will have to comply with California's comprehensive environmental protection laws. However, as a novel process, there is limited experience with the environmental impacts of DLE, and ongoing monitoring and transparency will be required to validate its sustainability. DLE can be done using a variety of different techniques, including adsorption, ion-exchange, and membrane and electrochemical separation technologies (Stringfellow and Dobson 2021). Whether the technology is viable depends on a variety of factors, including brine chemistry, water temperatures, costs, and, of course, the market prices for lithium.

39 Since there are a wide variety of lithium compounds, it is commonplace to refer to the lithium content in terms of lithium carbonate equivalent (LCE), which is 5.323 times the amount of pure lithium.

40 Assuming 8.9 kg of lithium metal per EV.

There are three companies currently developing plans for lithium extraction in the region: Berkshire Hathaway Energy Renewables (BHER), EnergySource Minerals (ESM), and Controlled Thermal Resources (CTR). BHER, a subsidiary of Berkshire Hathaway Energy (BHE), currently operates 10 distinct geothermal facilities in the region, with a combined capacity of 377 MW (Goodman, Mirick, and Wilson 2022). It also has a lithium recovery demonstration project underway that has been able to extract lithium chloride. As of early 2023, BHER was also developing a pilot project to transform lithium chloride into lithium carbonate, which it expected to have done by the end of the year. The company is waiting on results about the performance of these demonstration projects to make its final decision about developing at commercial scale. Assuming a two-year construction period, it has announced publicly that it expects to deliver its first commercial lithium in 2026 (Weisgall 2023). Three subsidiaries of BHER recently filed applications to construct new geothermal plants in the area, and presumably would also extract lithium from these plants if their DLE technology proves to be commercially viable.[41]

41 https://efiling.energy.ca.gov/GetDocument.aspx?tn=251545

Brine

Brine is water containing dissolved minerals. Brine composition varies widely, which is a complicating factor in direct lithium extraction (DLE) development: a DLE technology perfected for the specific mineral mix of the brine at one site is unlikely to work as well in other sites; thus, even as advances are made for a specific brine, the industry as a whole cannot pursue a single "best technology" (Grant 2020).

The composition of the Salton Sea brines is important to the success of DLE for several reasons. First, these brines have relatively high levels of silica, which must first be removed to avoid silica scaling on equipment (Spitzmüller et al. 2021). They also contain trace concentrations of arsenic and lead, which can be toxic if precipitated and must be carefully managed. Oakland-based DLE company Lilac Solutions, which in 2020 announced a high-profile partnership with Controlled Thermal Resources (CTR) to explore lithium extraction from Salton Sea brines, ended up withdrawing just two years later, citing as one reason the challenges of working with the toxic materials dissolved in Salton Sea brines (Ohnsman 2022; Richter 2020).

Nonetheless, despite these particularities of the Salton Sea brines, DLE cost projections suggest that developing these resources in Imperial County should be profitable. A study by the National Renewable Energy Lab compared proposed DLE projects in the Salton Sea, Arkansas, Utah, Germany, and Alberta, Canada. The production costs for all DLE projects ranged from $3,217 to $4,545 per metric ton of lithium carbonate equivalent (LCE) (Warren 2021). This is substantially more than the direct costs of hard rock mining—a report by S&P Global Market Intelligence estimates that hard rock producers' costs are less than half that of conventional brine operations—but the end-product of hard rock operations is a lithium concentrate, and it received a 57% lower equivalent price than the lithium carbonate produced from the brine operations. As a result, the average profit margins for brine operations were almost double that of hard rock producers (S&P Global 2019).

EnergySource, a privately held company formed in 2006, has been involved in geothermal production in the Salton Sea region since 2012.[42] EnergySource has developed a proprietary and patented DLE technology called Integrated Lithium Adsorption Desorption (ILiAD), based on a lithium-selective adsorbent. It has already licensed this technology to other companies, including Compass Materials in 2022 for use in the brines in the Great Salt Lake. Publicly, EnergySource has set 2025 as the target date for delivery of its first commercial lithium and manganese products from the Salton Sea region (Benson 2023).The company is so confident in its ability to commercialize lithium recovery that it turned over the geothermal side of its operation to Cyrq Energy in July of 2022, retaining exclusive rights to extract minerals from the brine water before it is returned underground (Fudge 2022).

Controlled Thermal Resources (CTR) was established in Australia in 2013 and incorporated in the U.S. in 2022, moving its headquarters to Imperial County. CTR began operating a lithium recovery "optimization plant" in late 2022, with plans for the construction of a 50 MW geothermal energy plant well underway, and subsequent plans to build five more. CTR broke ground on its Hell's Kitchen Campus, a fully integrated lithium facility and clean energy campus, on January 26, 2024.[43] CTR's ambitious plans include integrating their lithium production with a co-located battery gigafactory. In March of 2023, CTR signed a Memorandum of Understanding with Fuji Electric for the delivery of geothermal power equipment worth $1.4 billion and totaling 330 MW capacity, which would rival BHER in energy production. It expects to eventually produce an estimated 150,000 metric tons per year of lithium hydroxide, with the first commercial delivery occurring "in late 2024" according to published sources, although insiders suggest the end of 2025 is more likely and may still be optimistic.[44]

The importance of the lithium resource to the EV battery supply chain is illustrated by significant investment by automakers in the region. For example, CTR has entered into an agreement with Stellantis, the owner of Jeep and Peugeot, to provide up to 65,000 metric tons of lithium hydroxide per year over a ten-year period.[45] CTR also has a Strategic Investment and Collaboration agreement with General Motors to provide lithium hydroxide, including a Definitive Supply Agreement extending supply beyond an initial ten-year agreement. GM was the first company to make a multi-million investment in CTR's Hell's Kitchen development, and secured first rights to purchase lithium from the first stage of the project.[46] While these agreements are simply for the provision of lithium, with no commitment pertaining to manufacturing, they may provide a leverage point for encouraging manufacturing in the state.

42 **https://www.businesswire.com/news/home/20120518005065/en/EnergySource%E2%80%99s-First-Geothermal-Plant-in-Imperial-Valley-Lauded-for-Creating-Jobs-Boosting-the-Economy-Delivering-Clean-Energy-to-50000-Homes-Second-Plant-to-Follow**

43 **https://www.cthermal.com/projects**

44 Interview by authors with Jim Turner, CTR Chief Operating Officer and Director, October 20, 2023; and **https://www.cthermal.com/latest-news/ctr-set-to-tap-fuji-electric-for-delivery-of-multiple-geothermal-power-facilities-at-hells-kitchen**

45 **https://www.stellantis.com/en/news/press-releases/2023/august/stellantis-invests-in-ctr-to-strengthen-low-emission-us-lithium-production**

46 **https://www.cthermal.com/latest-news/gm-secures-sustainable-us-based-lithium-supply-in-part-from-controlled-thermal-resources-for-next-generation-ev-batteries**

2.1.1 Potential Local Jobs

The number of jobs expected to be connected with direct lithium extraction in the region is relatively modest; in total, perhaps a few thousand. BHER expects that its lithium operations will employ 400 full-time workers if fully built out, and CTR anticipates 1,400 permanent jobs at full capacity (Alston et al. 2020). Meanwhile, EnergySource Minerals expects to increase its current workforce by roughly 70–80 people when its lithium recovery facility is fully operational, (Signoratti 2022). The primary occupations will be in lab technician, instrumentation technician, and equipment operator positions. Employers have asserted that these jobs will pay roughly $20–25/hour. This is significantly below the living wage for a family of one adult and one child, which is $34.80 in Imperial County, according to the commonly used MIT living wage calculator.[47] The vast majority of these jobs are blue-collar jobs and do not require higher education, and are likely to require skills mostly acquired through on-the-job training.

2.2 PROGRESS REPORT: LOCAL BENEFITS FROM LITHIUM EXTRACTION

The Lithium Valley Commission and Building Lithium Valley reports identified several opportunities for lithium extraction to benefit communities that surround the resource: (1) locally-invested tax revenue (2) building infrastructure and carrying out environmental remediation that is needed in the region, and (3) the creation of good jobs for local residents. While both reports indicate awareness of the need for intentional action to ensure meaningful local benefits from this new extractive industry, and local stakeholders have been proactive and innovative in their efforts to plan for development while ensuring equity, our assessment is that the current efforts still need to be bolstered.

2.2.1 Lithium Tax, Planning, and Public Engagement

In 2022, California passed a Lithium Extraction Excise Tax ("lithium tax"), a measure that creates a structured means of making sure at least some portion of the revenue generated from mineral extraction stays in the impacted communities. Authored by Assemblymember Eduardo Garcia, this bill represents a major victory for a coalition of labor and community organizations known as the Lithium Valley Community Coalition, which was an important advocate.[48] The bill imposes a tiered tax per metric ton of lithium carbonate equivalent, meaning that companies that produce more lithium have to pay a higher tax. A full 80% of the tax must be paid to the county in which the extraction takes place (in this case, Imperial County), and 20% to the Lithium Subaccount of the Salton Sea Restoration Fund.[49] The bill further specifies that of the amount allocated to Imperial County, 30% must be invested in those frontline communities that are most directly and indirectly impacted by the lithium extraction activities. The California Department of Tax and Fee Administration was tasked with implementing and administering

47 https://livingwage.mit.edu/counties/06025

48 www.lithiumvalleycommunitycoalition.org

49 https://leginfo.legislature.ca.gov/faces/codes_displayexpandedbranchxhtml?tocCode=RTC&division=2.&title=&part=25.&chapter=&article=

the lithium tax, including software configuration, publication creation, training, and other administrative functions.The County of Imperial accepted public comment on how to invest the revenue for 60 days and published the full results on their Lithium Valley website.[50]

The bill creating this tax also appropriated a one-time sum of $5 million to help with planning for lithium extraction. This included $3.85 million to prepare the county's Programmatic Environmental Impact Report (PEIR, discussed further below) and health impact assessment, including supporting community outreach around this work—an effort to identify infrastructure needs within the Lithium Valley Specific Plan Area, help streamline permitting for future developments and support broad public engagement. Another $800,000 was allocated for grants to be distributed by the county directly to community based organizations in Imperial County, for engagement activities related to the PEIR. Among the groups selected were Comité Cívico del Valle ("Comite Civico"),[51] a public health advocacy organization based in Brawley, whose executive director Luis Olmedo participated in the Lithium Valley Commission and spearheaded the Lithium Valley Community Coalition. Comité Cívico was also awarded a $4 million grant by the Waverly Foundation to expand their outreach efforts.[52] Several smaller community-based organizations are participating as well, including Los Amigos de La Comunidad IV, the Imperial Valley Equity and Justice Coalition, Raizes, and the Imperial Valley LGBT Resource Center.[53] All these organizations have been hosting workshops and meetings to inform community members about the developments, soliciting feedback about community concerns and priorities for investment, and sharing information about how to participate in the public comment process. Recent public engagement includes a February 15, 2024 webinar on the impacts of mineral extraction on Imperial Valley communities, hosted by Comité Cívico and Earthworks.[54]

2.2.2 Current Efforts and Next Steps to Secure Concrete Benefits for Local Workers and Communities

There are other notable local efforts already underway in Imperial County, seeking to secure positive outcomes for workers and communities from Lithium Valley extraction. Those listed here strike us as holding particular potential and represent enormous effort by local stakeholders. However, further action is needed for them to deliver broad and concrete high-road outcomes.

Workforce Development Initiatives

Historically, many workforce development initiatives have been unable to ensure job placement in career-track, family-supporting jobs. There is now extensive research showing that workforce

50 https://lithiumvalley.imperialcounty.org/wp-content/uploads/2023/05/Lithium-Tax-Public-Comment-Period-3-1-23-to-4-30-23-Comments-Log2.pdf

51 https://ccvhealth.org/

52 https://calexicochronicle.com/2023/01/13/comite-civico-awarded-4m-grant/

53 https://holtvilletribune.com/2023/04/19/county-awards-720k-for-lithium-valley-outreach-efforts/

54 https://www.facebook.com/photo.php?fbid=767076975469929&set=a.232076875636611&type=3&paipv=0&eav=AfaaLPf_w6T5jga4Bz_SKGLR5ohU2KDxPSXxfLKRsKFMdqnPwFj350Nr5Yl4VXvDbrA&_rdr

development works best for workers and employers when training is carefully calibrated to real-world demand for workers, and when the jobs awaiting trainees are high-quality jobs. California has revolutionized its approach to workforce development by marrying efforts to create good jobs with efforts to prepare workers for them. By designing training to deliver optimal outcomes, this high-road approach improves access to good jobs for workers, including those from marginalized populations, while ensuring employers a reliable pipeline of skilled workers. Imperial Valley has the opportunity to model this approach if partnerships between employers, labor, and educational institutions are structured and roles are clearly defined.

The California Jobs and Climate Action Plan (Zabin et al. 2020) laid out a comprehensive and detailed strategy for workforce development for the low-carbon transition, focusing on the major categories of occupations that are critical to key green industries, including the battery supply chain. This approach has been adopted by the California Workforce Development Board (CWDB), which is responsible for the state's overall Strategic Plan for workforce development and funds workforce development initiatives focused on workers who do not have college degrees. The CWDB has created new funding streams to fill gaps in training infrastructure, most specifically through the High Road Training Partnership (HRTP) and the Construction Careers initiatives.

Based on the industry sectors involved in the green transition, the Jobs and Climate Action Plan identifies strategies for:

- the small minority of professional workers in engineering and related occupations
- the significant number of blue collar workers who work in the construction phase of an extraction or manufacturing development, and who move from project to project as new investments occur
- the majority of workers who are blue collar permanent workers, particularly in extraction and manufacturing occupations

For each of these occupational categories, there are different levels of existing infrastructure and different best practice strategies to ensure both industry-relevant training for incumbent and new workers, as well as strategies to promote diversity and inclusion. Therefore, understanding the specific strategies for these three occupational categories is critical to build upon existing training infrastructure and initiatives and align efforts to maximize the value of training to employers and workers both.

Professional workers generally enter their careers with educational credentials at the associate, bachelor's or graduate level educational degrees. Their general pre-employment training occurs via the higher education system. California has a vast public infrastructure in its community colleges, state universities and the University of California system. In Imperial County, the Imperial Valley College is working on a four-year degree program in Industrial Management to help prepare students for management positions. The new STEM campus in Brawley of San Diego State University is another significant state-funded initiative supporting educational resources and workforce development in Imperial County for the salaried and professional jobs that generally require a college degree. Efforts to

promote diversity and inclusion for professional careers are best carried out through articulation with local high schools and smooth transitions between community colleges and four year institutions.

Construction trades workers generally enter their careers either learning on the job or through California's vast certified apprenticeship system. Apprenticeship is the gold standard in training, ensuring a supply of highly skilled and adaptable trades workers for employers while creating family-supporting careers free of educational debt for workers without a college degree. The critical best practice characteristics of apprenticeship include employer and union partnerships in developing training curricula, industry funding of training, the learn-while-you earn model, wage improvements tied to skill acquisition, and combined on-the-job and classroom training. Historically, apprenticeship has served the construction trades and a small number of other occupations.

Tapping into apprenticeship is clearly the high-road strategy, ensuring both quality work and good middle-class careers for workers. In public works, state and federal law requires the use of apprentices trained in approved apprenticeship programs, in recognition of the importance of supporting a highly skilled workforce and creating good jobs. In the private sector, employers are not required to use this training approach unless they agree to a project labor agreement or community benefits agreement or they receive public funding with apprenticeship standards like the "skilled and trained workforce" requirement found in some California programs.[55]

55 https://laborcenter.berkeley.edu/californias-climate-investments-and-high-road-workforce-standards/

Thus, supporting and encouraging the use of the apprenticeship system for the construction of new extraction and manufacturing facilities is a key priority for policy-makers. To support this effort, the CWDB has funds to support pre-apprenticeship training which has proved extremely successful in ensuring the inclusion of local workers of color, and new programs have been created in many locations across the state.[56]

In Imperial County, the only existing state-approved apprenticeship training center is the International Brotherhood of Electrical Workers (IBEW) Local 569 Electrical Training Institute in the city of Imperial. The IBEW invested in this training center, which has been operational since 2009, in response to the growth of utility scale solar farms in the region. The other trades have training centers in San Diego, but thus far there has not been enough work to justify large permanent investments by their training trusts within Imperial County itself. As more industrial development is planned, this can change, and support for anticipated growth by the state for planning and coordination can help facilitate these industry training investments. Historically, community colleges have sometimes competed with apprenticeships by offering more limited training serving lower wage employers in a particular trade. However, there are also many fruitful and complementary collaborations between community colleges and apprenticeships. By law, the community colleges serve as the administrator of state classroom funds for certified apprenticeships and in practice either they or local adult schools house the actual classroom training. In addition, in a number of areas in California, the community colleges provide pre-apprenticeship training to ensure greater inclusion and diversity in the certified apprenticeship programs. The CWDB, as part of the statewide strategic plan, is promoting collaboration between apprenticeships and community colleges and discouraging competition.

56 https://cwdb.ca.gov/initiatives/hrcc/

Apprenticeship Explained

Source: Adapted from (Luke et al. 2017)

State- or federally-registered apprenticeships are the gold standard in workforce training and certification. Intended to prepare apprentices for a career in a particular trade, those who complete the program graduate with an industry-recognized credential (usually called a journey card) that affirms a journey-level position as a union member (Worker, Owens-Wilson, and Beach 2016). In California, registered apprenticeship programs are regulated by the state Division of Apprenticeship Standards (DAS) and must meet specific minimum training benchmarks and other criteria to ensure quality and accountability.[57] The programs can either be joint, i.e., a partnership between a local union and the employers with whom it has collective bargaining contracts, or unilateral, i.e., run solely by the employer(s) in a non-union work environment. State-approved apprenticeship programs are almost completely privately funded by contractors and workers, who make small payments into a training trust fund for every hour worked. The state government helps fund the classroom portion of the training, which is administered by the community college system and carried out by each apprenticeship's local public educational partner.

Requirements for the attainment of the journey card credential vary by trade, e.g., for the International Brotherhood of Electrical Workers (IBEW) electrical apprenticeship, the minimum state requirements are 8,000 hours of on-the-job training, 640 hours of classroom learning, and competency tests for each level of advancement.[58] The yearly number of openings in each apprenticeship program is determined according to the labor contracts that each local union currently has and to expectations about future work. Such demand driven training ensures that people are trained only if jobs exist for them; unions will not sponsor new apprentices unless there will be enough work for them to finish their three- to five-year training program. Apprenticeship openings, therefore, tend to track cycles in the related sectors with the number of program openings increasing only when the relevant industry expands or unions' share of it grows. By limiting the number of new slots to the capacity of the unionized construction sector, this model avoids the common problem of low job placement rates that has plagued many training programs (Zabin and Chapple 2011).

Apprenticeship provides clear benefits to workers and is one of few pathways to a middle-class career without higher education credentialing (Argyres and Moir 2008). Apprentices receive the same health, pension, and other benefits as journey-level workers, and their training is free. During an apprenticeship, workers receive pay increases on a periodic basis as they acquire new skills, and upon graduation obtain their journey card and receive journey level wages. Apprentice wages vary by trade and sometimes by county. In California Area 4 counties, including San Diego and Imperial, first-year apprentices in the Ironworkers start at $23.10 per hour plus benefits, and after completion of their four-year apprentice program will be paid the journey wage, currently at $43.89 per hour.[59] In lifetime earnings, registered apprenticeship offers greater gains than community college or alternative technical education training (Carnevale, Jayasundera, and Hanson 2012).

Employers also benefit from apprenticeship programs. Because of these direct, strategic investments in their workforce, employers are able to access skilled workers and upgrade their skills quickly as technologies change. Union apprenticeship programs also have been shown to retain skilled workers, amid the ups and downs of an extremely cyclical industry (Bilginsoy 2003). The programs also provide a clear safety benefit: apprenticeship includes comprehensive safety training (Philips 2014), with injury less likely among apprenticeship graduates than non-apprenticeship-trained workers.[60] Apprenticeship programs also offer free skills upgrade programs for journey level workers. This has been critical to the rapid uptake of key competency certifications for new zero carbon technologies. For example, the IBEW invested early in skills upgrading programs such as the Electric Vehicle Infrastructure Training Program for the installation of EV charging stations.[61]

57 https://www.dir.ca.gov/apprenticeship.html; https://www.dol.gov/agencies/vets/employers/apprenticeship
58 https://www.dir.ca.gov/dlse/ecu/ECP_Curriculum_Committee/ECP_ElectricalIndustryContructionTrainingCriteria.pdf
59 https://www.dir.ca.gov/oprl/pwappwage/wage/23238380.html?VarWageId=23237380
60 https://www.lni.wa.gov/safety-health/safety-research/files/2022/75_46_2022_Apprentice_Injuries.docx.pdf
61 https://www.ibew.org/media-center/Articles/22Daily/2208/220804_EVITP

Blue collar permanent operations workers generally learn on the job, are not required to have higher education degrees, and training infrastructure is most effectively built through labor management partnerships at the firm or multi-firm level. This is where the High Road Training Partnership (HRTP) model comes into play. Unlike in construction, there is not an existing comprehensive apprenticeship infrastructure for manufacturing, except in a few isolated small programs sprinkled across the state. There is however, interest in building apprenticeships or similar programs through the HRTP initiative for manufacturing operations workers in a variety of industries across the state (see **https://cwdb.ca.gov/initiatives/high-road-training-partnerships/**).

In Imperial Country, efforts are already underway to develop training for the lithium extraction workforce through partnerships between educational institutions, companies, and the Imperial County Workforce Development Board (ICWDB). The main training initiative at present is offered by Imperial Valley College (IVC), where administrators in the Economic & Workforce Development Division have been in detailed conversations with the lithium companies to develop certification programs in technician and operator positions, using equipment donated by companies in the area. These programs build on existing courses in welding, heating/ventilation/air conditioning (HVAC), and electronics to address the blue-collar occupations that will form the large majority of jobs in extraction. The programs are designed to prioritize accessibility with the aim of enabling access to the training in as much of the county as possible, for example, by offering financial aid, night classes, and streamlined courses to help students finish on a shorter timeline.

In 2022, the California Workforce Development Board (CWDB) funded the Lithium Valley High Road Partnership, a one-year planning partnership proposed by the San Diego & Imperial Counties Labor Council to focus on "creating high road jobs and preparing the local workforce to fill them [with the goal of ensuring] that all new jobs be developed with project labor agreements, job quality standards, job access agreements, and educational pathways." This project is part of the CWDB's **High Road Training Partnership (HRTP)** initiative (see **Box**). The HRTP initiative takes a different approach than traditional workforce development efforts by centering worker voice and knowledge in the development of training programs with workers in explicit partnership with industry. HRTPs are often based on labor-management partnerships codified in collective bargaining agreements. The prerequisite of concrete commitments by employers regarding wages, local hire, and training investments, and the involvement of workers in the design of training, distinguish the high-road approach from the more traditional workforce development initiatives described above. The new state-wide Center for Manufacturing a Green Economy (CMGE), also funded by the CWDB's HRTP initiative, is a UAW-led effort that is also starting work in Imperial County, as part of a strategy to develop training programs supporting a potential battery manufacturing hub near the Salton Sea.

Thus far, these different approaches to Lithium Valley workforce development have proceeded along parallel tracks. However, there is potential to coordinate these efforts more closely so that the training investments in the community colleges can be harnessed to support high-road workforce development. Government intervention thus far has been to fund workforce development, but without labor standards

High Road Training Partnerships (HRTPs)

A high-road approach addresses both sides of the labor market, simultaneously focusing on 1) equity for workers (labor supply) and 2) employers offering high-quality jobs (labor demand).

The High Road Training Partnership (HRTP) is a core element of the State of California's 2020 Jobs and Climate Action Plan (Zabin et al. 2020) which, in Chapter 3, describes in detail how workforce development can work with labor and employers to deliver on good jobs and pathways into those jobs for workers from low-income communities.

Forming the key bridge between labor supply and demand, High Road Training Partnerships (HRTPs) are collaborative, industry-led training initiatives that focus on equipping workers with the skills to be employable in good quality, in-demand jobs. As noted by the California Workforce Development Board (CWDB):

"Successful HRTPs start with the jobs. Their goal is the filling of actual jobs needed by actual high road employers with workers who are qualified for those specific jobs and career paths. They prioritize building particular skill sets needed for upskilling, promotion, re-training for new ways work may need to be performed, and problem solving for future demand (CWDB 2000, p.2)."

HRTPs offer a level of engagement between employers and workers that community colleges or training programs alone are not positioned to provide. Thanks to constant engagement with the industry, HRTPs design training to respond to industry's evolving needs, while also giving workers a voice in ensuring safety standards, worker rights, wages, and benefits.

HRTPs bring together employers, workers, and partners in the workforce development ecosystem (e.g., community colleges, or other training providers), to design and implement training programs that will serve as a pathway to good jobs for workers, and a pipeline of skilled workers for employers. Industry and labor partners determine skills-building needs and collaborate to work out solutions. By facilitating collaborative problem-solving, HRTPs are able to lift operational and cultural barriers to training, learning, and advancement, such as scheduling, safety, or supervisor support.

California launched the HRTP initiative designed by the CWDB to model partnership strategies for industries in the state. Ranging from transportation to healthcare to hospitality, the HRTP model embodies the high-road principles discussed in this report, with industry-based, worker-focused training to support California's high-road workforce goals. The state's certified apprenticeship system is the quintessential HRTP formalized into a state-wide infrastructure. The HRTP initiative aims to promote the essential elements of apprenticeship in order to develop HRTPs in other industries throughout the state.

attached to these jobs, they may not result in jobs offering family-sustaining wages, wage improvements linked to skill acquisition, and local hire. Once such agreements are in place, and workers have the ability to engage directly with employers, the community college investments in specific training modules and certifications can be incorporated into the Lithium Valley HRTP.

In sum, public support for training for a future critical minerals and battery manufacturing hub needs to proceed along three tracks. For the small portion of the workforce where a college degree is needed, continued investments in higher education will help build local capacity and recent state investments in the Brawley campus show significant progress in this area. The college and university programs should develop partnerships and articulation agreements with local high schools in order to provide an important pathway for local low-income young people into professional careers.

For the construction workforce, relying on and building up the state-certified apprenticeship program will ensure a skilled workforce while providing pathways to family-supporting careers for local residents, particularly when paired with pre-apprenticeship programs to help local residents successfully enter and stay in apprenticeship programs. The role of community colleges in this sector can be to provide pre-apprenticeship training and/or be the local educational affiliate for the classroom portion of the apprenticeship programs. Here, the key is to ensure that businesses tap into the apprenticeship system by agreeing to project labor agreements (PLAs) or similar commitments.

For the permanent operations jobs, building HRTPs will be critical and aligning existing efforts in the community colleges and the local labor organizations can accelerate this process enormously. As with apprenticeship, the success of this strategy hinges on the creation of quality jobs where workers can be rewarded for their training and skills. A community benefits agreement can provide the structure to ensure quality jobs and their accessibility to local residents, as well as employer commitment to investing in their workforce. Community benefits agreements can also provide an avenue of ongoing and engaged partnership between the community and employer so that the workforce grows as the company grows and the Lithium industry advances.

Calls for Community Benefits Agreements (CBAs)

In Imperial County, the Lithium Valley Community Coalition and others have called for firms involved in lithium extraction to agree to a **Community Benefits Agreement (CBA)** (see **Box**). Such an agreement can make sure that workers and Imperial County residents have a voice in shaping major developments, that wages and benefits are family-supporting, and that local workers are hired into these good jobs. The CBA is a mechanism of particular relevance in the Lithium Valley context, as an effective, enforceable structure for empowering communities in the face of new development, so that it may ensure broadly shared prosperity and advances on diversity and inclusion goals. A CBA can provide the upfront agreements needed to develop a full High Road Training Partnership (HRTP).

There is no guarantee at present that all the businesses engaged in lithium extraction in Imperial County will generate good jobs, defined by the U.S. Department of Energy as 1) a commitment to

ensuring workers have a free and fair chance to join a union, 2) above average wages and benefits for the industry and region, 3) investments in workforce education and training, and 4) engaging workers in the development and execution of workplace health and safety plans. It is promising, however, that some developers have already signed agreements for the construction phase of new projects, although to date there are no formal announcements regarding operation and maintenance jobs which constitute a larger number of on-going jobs. CBAs are a mechanism to systematically ensure quality jobs in both construction and on-going operations and maintenance. They generally include a project labor agreement for the construction phase of a development, and agreements about job quality, job access, union neutrality, and other community benefits for the operations phase of the business enterprise.

CBAs can also be a key component of efforts to streamline permitting. As stated by the U.S. Department of Energy:

> CBAs pivot around local and state government officials: since governments need support from their constituencies and developers need government support for items like zoning approvals, developers have clear incentives to accommodate community interests. When synergistic development models like CBAs are employed, developers experience reduced risk and communities profit from improved cost/benefit positions. Thus CBAs are mutually-reinforcing, since all three stakeholder groups gain, albeit uniquely.[62]

62 https://www.energy.gov/justice/community-benefit-agreement-cba-toolkit

Community Benefits Agreements (CBAs)

A CBA is a legally binding agreement signed by a developer or company and community groups, specifying measurable benefits that the parties will work towards in return for community support of the project. The community groups signing such an agreement may include a wide range of organizations, such as tribal governments, neighborhood associations, environmental organizations, unions, faith-based organizations, and others representing the interests of residents and workers who will be impacted by proposed developments. CBA provisions vary according to communities' needs and interests and are negotiated between parties during the elaboration of the agreement. Typical CBA provisions include commitments on targeted hire, local hire and sourcing, investment in training programs, and can define a process for shared decision making between community organizations and the company on other issues for affected frontline communities. CBAs may include a fund for unintended consequences[63] and provisions on open lines of communication, dispute resolution, and "regulating" any otherwise unregulated areas of local impact, such as traffic or other issues relating to the sharing of infrastructure by industry and community.[64] The aim is for the agreement to be tailored to the specific local context, so that it reflects the true issues at stake for the community.

CBAs are also used to clarify roles and identify resources that help companies identify trained workers, or develop training programs used to ensure a skilled workforce prior to learning on the job. By partnering with community organizations and committing to shared decision making, companies and developers are supported in delivering on employment and training commitments that residents seek from new development and are not solely responsible for areas of work outside of a company's area of expertise, like workforce development and training certification. Developers also benefit from CBAs by building and ensuring a community's support for a project, while reducing the risk of lengthy litigation that has previously derailed clean energy and infrastructure projects. Community buy-in can also be a precondition for expedited permitting, or a factor in securing local or state government approvals for large scale projects. Most of all, the trust and relationships built through the CBA process continue to contribute to companies' long-term success and stability in a community.

Local and state governments can be instrumental in bringing about effective CBAs by helping ensure that community coalitions play significant roles in negotiations for project approval, and by conditioning public subsidies and funding programs on the existence of CBAs. The state can facilitate collaboration between key stakeholders, including industry representatives, community leaders, environmental advocates, and local residents, and can mandate or provide incentives for developers to enter into and abide by CBAs. A CBA process can help promote transparency and clarity of outcomes, as well as centralize dispersed information, supporting collaboration and accord between communities and developers.

Recent CBAs have shown the potential of these agreements in establishing high-road partnerships balancing economic progress with community wellbeing and environmental stewardship. In 2017, a community-labor coalition in California signed a landmark CBA with electric bus manufacturer BYD. The CBA ensures deep investments in pre-apprenticeship and training programs, as well as commitments to hiring 40% of BYD workers from populations facing significant barriers to employment, including women, African Americans, justice-impacted individuals, and veterans. This agreement led to the creation of the country's first electric bus apprenticeship and pre-apprenticeship program.[65]

See the U.S. Department of Energy's CBA Toolkit for practical information on negotiating and implementing CBAs, as well as lessons learned from real-world examples.[66]

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63 See "Unintended Consequences Fund," **https://www.gordiehoweinternationalbridge.com/sites/default/files/documents/files/Meetings/Financial-Close/Community-Benefits-Report-2018-09-27-VP-App.pdf**

64 **https://reports.sibanyestillwater.com/2022/download/ssw-FS22-good-neighbor-agreement.pdf**

65 **https://en.byd.com/news/electric-bus-manufacturer-byd-motors-renews-landmark-community-benefits-agreement/**

66 **https://www.energy.gov/diversity/community-benefit-agreement-cba-toolkit**

2.3 BEYOND EXTRACTION: REALIZING A BATTERY SUPPLY HUB IN IMPERIAL VALLEY

Given the small job numbers and limited tax benefits of lithium extraction on its own, the real promise of "Lithium Valley" is the growth of employment in other steps along the lithium-ion battery and EV value chain (outlined in **Figure 2** below). Only an estimated 9% of total revenue potential along the battery value chain is expected to be captured at the extraction stage, with another 13% in refining. Most of the revenue opportunities in the value chain are in the production of battery components (27%), cell manufacturing (30%), and pack manufacturing (18%), as well as in EV manufacturing itself (Hanicke et al. 2023). Likewise, by our estimates, only 0.7% of the jobs related to processing lithium from Imperial County into electric vehicles are in extraction (see our calculations below). The remainder of the report addresses the following questions: is it feasible to develop more parts of the battery supply chain in Imperial County, and what would it take to do so in a way that meaningfully benefits the local community?

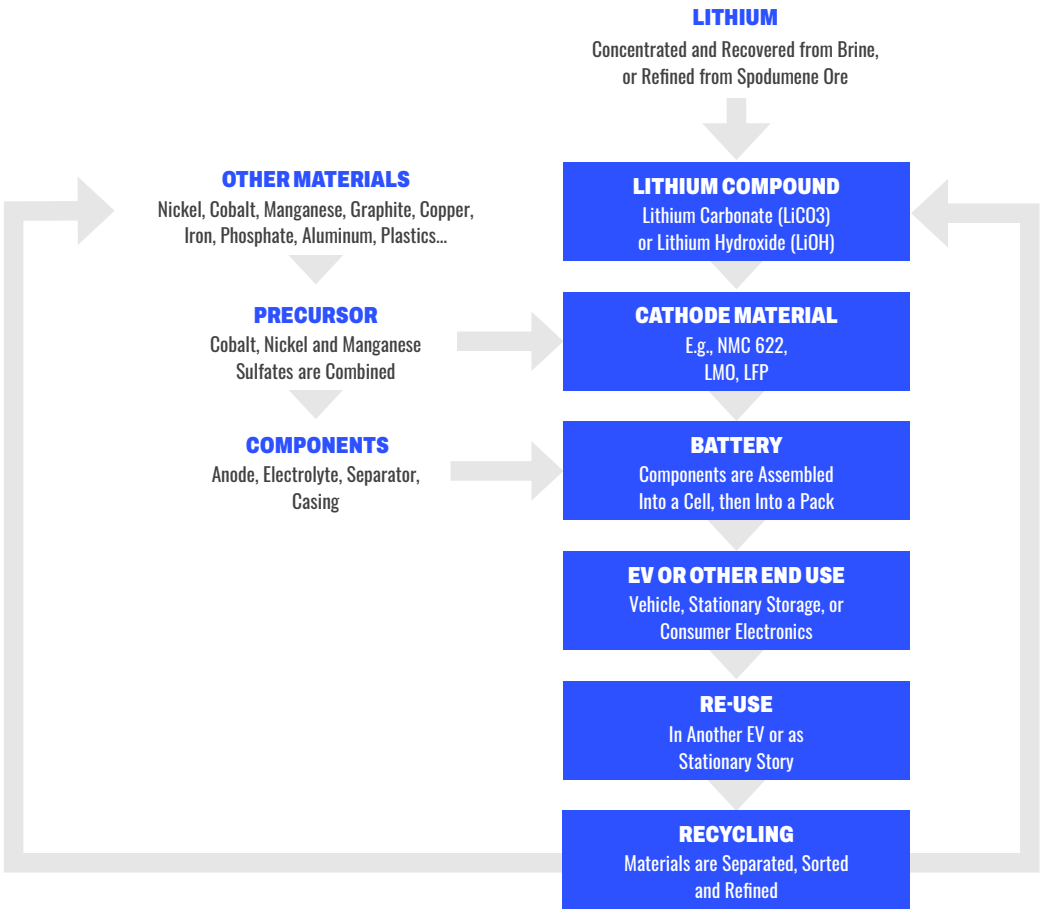

FIGURE 2.

Lithium-ion battery supply chain overview.

After lithium is extracted and refined, the next stage in the supply chain is the production of battery components in the form of precursor and cathode active material (CAM) manufacturing. Precursor cathode active material (pCAM) is a powder where the metal sulfates (e.g., nickel sulfate or cobalt sulfate) are combined and synthesized according to the desired ratio of metals (e.g., NMC 622 or NMC 811 refer to different ratios of nickel, manganese, and cobalt). Next, the pCAM is dried and blended with a lithium source to produce cathode active material. There is currently no pCAM manufacturing capacity in the United States, and very little CAM production; as such, the knowledge and intellectual property is highly concentrated in Asia, and future U.S. production would likely be developed in partnership with a Japanese or Korean company. This is the case, for example, in Ford's joint venture with SK Innovations, a Korean company that will supply batteries for F-150 Lightnings that will be built in Tennessee.

Further along the supply chain is battery cell and pack production. One concrete vision of what this might look like in Imperial Valley is that of battery startup Statevolt, which has announced plans to build a battery gigafactory near the Salton Sea lithium reserves. In January 2023, Statevolt announced the purchase of a 135-acre site in Imperial County, with plans to build a 54 GWh factory with capacity to produce batteries for 650,000 vehicles a year. It estimates this will provide employment for up to 2,500 people in the region.[67] Statevolt has also entered into a Letter of Intent agreement to source lithium from CTR's Hell's Kitchen Lithium and Power plant.[68] Another co-location vision comes from CTR itself, which, as part of its plans to expand geothermal production and lithium extraction, has created space for the co-location of battery production facilities. Similarly, Imperial County, as part of the Lithium Valley Specific Plan and Programmatic Environmental Impact Report (PEIR), is considering land use and infrastructure needs to support manufacturing and assembly of clean energy products, including EV batteries.[69] The presence of some private investments in other parts of the battery supply chain, beyond lithium extraction, are promising and suggest that an extraction-only scenario for Lithium Valley is not inevitable.

2.3.1 Jobs Associated with a Battery Supply Hub

As we have seen, the number of jobs associated with lithium grows dramatically when more steps in the value chain are included. **Table 1** provides examples of the types of facilities Imperial Valley is hoping to attract, including what they produce and how many people they employ (or expect to), and **Table 2** is a list of sample occupations in these facilities. While the specifics may vary, cathode, cell, pack,

67 **https://www.linkedin.com/posts/statevolt_new-us-battery-entrant-targets-fully-domestic-activity-7024036856619008000-jmN5/?utm_source=share&utm_medium=member_desktop**

68 While promising, the Statevolt opportunity must be treated with some caution, as the company is new and thus without an established track record. Statevolt was launched in 2022 by Lars Carlstrom, founder and CEO of two other major battery efforts: Italvolt, which is pursuing building a 45 GWh battery factory in Italy, but so far without substantial progress, and Britishvolt, which intended to build a 30 GWh factory in the UK. But a year after co-founding Britishvolt in 2019, Carlstrom stepped down when details of a minor tax fraud conviction several decades previously in Sweden were revealed. The company went on and began construction of a battery factory in Northeast England in 2021, but work was halted in August 2022 due to funding difficulties, the company went into insolvency in January 2023, and was bought out by an Australian startup company, Recharge Industries, which says it plans to resume construction in late 2023, but focusing initially on batteries for energy storage. Once valued at over $1 billion and celebrated as the first mostly domestically owned battery factory, Britishvolt sold for only 8.6 million GBP (Approximately $10.3 million) **(Jolly 2023; Whitfield 2023)**.

69 **https://lithiumvalley.imperialcounty.org/wp-content/uploads/2023/07/LV-Workshop2_Slides_7.19.23.pdf**

and recycling companies are generally trying to hire for similar positions. These range from operational jobs that do not require a four-year degree, to positions requiring advanced degrees in chemistry and engineering. As mentioned above, blue-collar manufacturing jobs are estimated to make up 70% of the jobs in the battery supply chain (Li-Bridge 2022), with the remaining 30% made up of engineers, scientists, technicians, and "other white-collar" jobs.

TABLE 1.

Example production hub facilities.

Product	Company	Location	Output	Employees	Source
Cathode Active Material	BASF	Japan	35,000 MT	130	BASF TODA Materials
Cathode Active Material	Umicore*	Ontario, Canada	"Enough for 1 million EVs", CAM and pCAM	300	Ontario Newsroom
Cell	Panasonic	Tahoe Reno Industrial Center	38 GWh, Cells	4000	Panasonic Energy of North America
Cell	Panasonic*	Kansas	30 GWh, Cells	4000	Panasonic Energy of North America
Pack	Tesla	Tahoe Reno Industrial Center	460,000 Packs	10521	Gigafactory Nevada
EV	Tesla	Fremont	444,600 EVs	22000	

** Indicates announced facilities that are not yet operating.*

TABLE 2.

Sample occupations in the battery value chain.[70]

Segment	Occ. Type	Occupation title	Annual mean wage in CA (Q1 2023)	Typical education needed for entry
Mineral extraction and refining	Blue-Collar	Chemical technician	$56,834	Associate's Degree
		Chemical plant and system operator	$93,562	High school diploma or equivalent
		Occupational health and safety technician	$99,991	High school diploma or equivalent
Battery manufacturing	Blue-Collar	Electrical, electronic, and electromechanical assemblers	$48,719	High school diploma or equivalent
		Maintenance workers, machinery	$63,425	High school diploma or equivalent
		Industrial machinery mechanic	$70,596	High school diploma or equivalent
	Professional	Software developers	$189,587	Bachelor's degree
		Electrical engineers	$156,741	Bachelor's degree
		Electronics engineers	$143,938	Bachelor's degree
		Chemical engineer	$122,432	Bachelor's degree
		Industrial engineer	$121,881	Bachelor's degree
Other jobs needed for Lithium Valley	Professional	Environmental scientists and specialists, including health	$105,079	Bachelor's degree

Estimating exactly how many jobs might be at stake involves multiple assumptions, and certainly not all of the jobs could be located in Imperial County, due to a range of factors. But it is still useful to assess the overall scale of jobs associated with lithium from the Salton Sea region, particularly since a large portion of them could be located in California, with sufficient investment, accountable incentives, and political leverage. To make our estimate, we gathered employment and production data from existing facilities

70 Sources: Occupational Wages from CA Employment Development Department Labor Market Information Division Occupational Employment and Wage Statistics July 2023 (**https://labormarketinfo.edd.ca.gov/data/oes-employment-and-wages.html#OES**). Training Requirements from U.S. Department of Labor Bureau of Labor Statistics, Occupational Employment and Wage Statistics, 2022 (**https://www.bls.gov/oes/additional.htm**)

that produce precursor and cathode active material, cells, packs, and EVs. We estimated the battery capacity in GWh that could be produced using the output of that factory using conversion factors from the BatPaC cell balance table and lithium to LCE conversion factors from (Warren 2021).

If 90% of the lithium flowing through power plants today in Imperial County were captured, we estimate that it would be enough lithium to produce 222 GWh of battery production a year, or enough to supply 2.9 million electric vehicles a year. The process of turning that amount of lithium into cathodes and cells could involve over 20,000 jobs. When those components are turned into battery packs and EVs, the number of jobs could be as high as 200,000, and up to 400,000 with the projected increase in lithium extraction in future years.[71]

TABLE 3.

Estimates of potential lithium recovery from current and future geothermal facilities

Scenario	Li (MT per year)	Process efficiency (%)	Recoverable Li (MT/year)	Battery Production (GWh/year)	Potential EV production
GT1	24000[72]	90%[73]	21600	222	2.9 million
GT2	48360[74]	90%	43524	447	5.1 million

71 How do we arrive at these estimates? First, we use information about the volume of brine that flows through the geothermal power plants today on an annual basis (Geothermal Estimate 1 or GT1 in the table), with an additional scenario modeling planned expansions of 407 MW based on company announcements and permit applications (GT2). Then, we used the BatPaC 5.0 model developed by Argonne National Laboratory to translate lithium quantities into potential battery production (**https://www.anl.gov/cse/batpac-model-software**). We used data from BatPaC's elemental analysis of the electrodes to estimate how many batteries could be produced provided a specified quantity of lithium. BatPaC 5.0 has default parameters that can be adjusted by the users. We used the default settings, which calculate outputs for a 100 kWh NMC 811 EV battery with pouch cell, with additional scenarios for an LFP battery of the same capacity.

$$\text{Li (MT)} \times \text{MWhMT Li} = \text{Capacity (MWh)}$$

We then divided by 1000 to calculate the potential battery capacity in GWh that could be produced using lithium from the Salton Sea geothermal brine, assuming half the batteries are LFP and half are NMC 811. We calculate how many EVs could be produced assuming a pack capacity of 75 kWh, which is representative of a mid-size electric vehicle.

72 CalGEM reported data.

73 Based on company reports.

74 Potential throughput considering the existing geothermal capacity plus planned expansion of 357 MW from BHER and 49.9 MW from CTR, assuming the same brine composition and flow rate.

TABLE 4.

Jobs estimates of 2 different lithium recovery scenarios

Product	Sample facilities	Jobs/GWh	Total GT1	Total GT2	Percentage of Total Jobs
LCE	ESM, BHER, CTR	4	931	1891	0.67%
CAM	BASF Japan, Umicore (Ontario), Redwood Materials (South Carolina)	8	1765	3583	1.26%
Cell + Pack	Panasonic (Nevada and Kansas), SK (Tennessee and Kentucky)	115	25294	51357	18.13%
EV	Tesla (Fremont), Ford (Blue Oval Tennessee), Rivian (California)	507	111514	226420	79.94%
Total		634	139503	283251	100%

It is clear that the majority of employment comes in battery pack and EV manufacturing. These later value-add manufacturing steps also generate more revenue compared to mineral extraction.

This analysis shows a breakdown of estimated jobs similar to what we see in the full domestic lithium battery supply chain—with the employment opportunities concentrated in battery and EV manufacturing, rather than in the raw materials, refining, and processing end of the industry (see **Figure 3**). At present, out of over 150,000 existing jobs in the industry in the U.S., 43% are in electric vehicle manufacturing. Another 26% are in the manufacturing of battery components, cells, and packs. Only 6% of jobs in the U.S. are estimated to be in the mining end of the industry, including mining of all materials, not just lithium.[75]

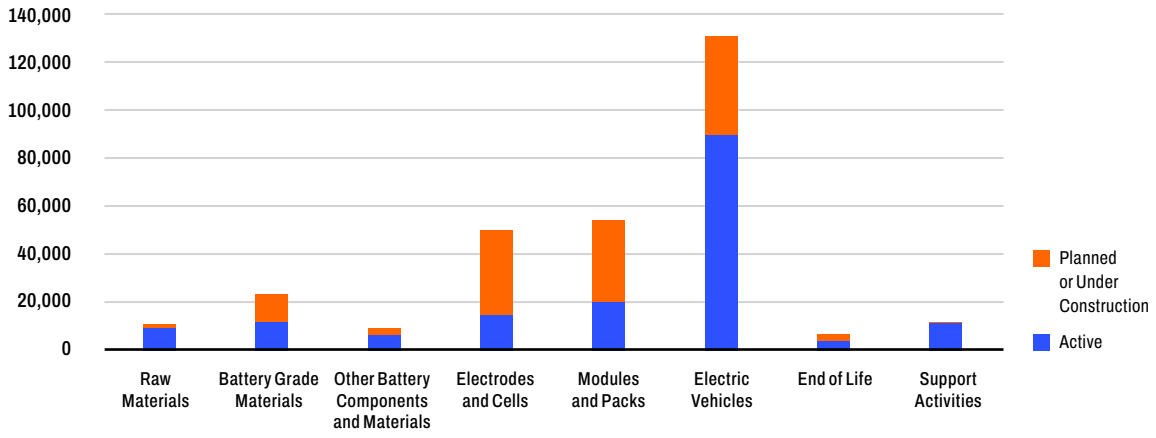

FIGURE 3.

Estimated employment in the lithium-ion battery and EV supply chain in the U.S., 2023.

75 Based on authors' analysis of the custom databased used in "**Lithium Battery Supply Chains of North America**".

2.3.2 Government Support for Battery Hub Development

In Imperial County and at the state level, concrete steps are already being taken to build support and lay the groundwork for a Lithium Valley value chain beyond lithium extraction. In 2022, the State of California allocated $5,000,000 to Imperial County in part to help develop a Lithium Valley Specific Plan and Programmatic Environmental Impact Report (PEIR). The goal of the Specific Plan is to "expedite the development and permitting of additional power plants, mineral recovery, lithium battery manufacturing, and other renewable industries" in the Specific Plan Area adjacent to the Salton Sea.[76] The initial study for the Lithium Valley Specific Plan was released in December 2023, and the PEIR is expected to be released in early 2024, with both slated to be finalized by Fall 2024.[77] Initial land use proposals for the large Specific Plan Area include substantial areas devoted to industrial and manufacturing uses with an explicit goal of promoting not just lithium extraction, but also the refining and processing of materials and the downstream assembly of clean energy products, such as EV batteries. This planning also includes significant logistics and transportation areas, to support the downstream supply chain of manufactured projects for distribution to the rest of the country.

The PEIR is designed to streamline the process for getting approvals to build out infrastructure and facilities for manufacturing in the region by aggregating the approval process for a series of related developments, rather than having to produce an Environmental Impact Report (EIR) for each individual project. Imperial County also requested an executive order or legislative action that would exempt current and future projects within the Specific Plan and PEIR from further environmental review, such as the California Environmental Quality Act (CEQA). It is unlikely that the PEIR will result in the same level of rapid approval for new projects as the **Tahoe Reno Industrial Center**, the site east of Reno where the Panasonic/Tesla Gigafactory is located, but it can hopefully speed approval for new manufacturing efforts. The State of California has also allocated $500,000 a year for 10 years to Imperial County to establish a Lithium Valley Development Office (IVDEC).[78]

Clearly, there is strong political desire to see Lithium Valley develop beyond lithium extraction into a broader battery value chain. The extent to which this is feasible is further explored in **Section 4**, which takes stock of trends in the domestic EV battery market and their implications for the Lithium Valley battery hub vision but we first examine what the high-road pathway looks like for a Lithium Valley battery hub.

76 **https://lithiumvalley.imperialcounty.org/planning/**

77 **https://lithiumvalley.imperialcounty.org/planning/** and **https://lithiumvalley.imperialcounty.org/wp-content/uploads/2023/12/Lithium-Valley-Specific-PEIR-Scoping-Mtg-12-14-23.pdf**. Full Initial Study for the Imperial County Lithium Valley Specific Plan is available here: **https://www.icpds.com/assets/Lithium-Valley-NOP-web-12-21.pdf**

78 **https://lithiumvalley.imperialcounty.org/**

3

LITHIUM VALLEY IN THE NATIONAL LANDSCAPE

Natural resource extraction can lead to perverse economic outcomes. Extraction industries are often capital intensive, providing few local job opportunities while multinational firms profit. Historically, the value-added refining and manufacturing rarely occur near the source of raw materials, limiting the host community's share in revenues generated from the resource. Infrastructure developed for extracting resources can distort government priorities, leading to the neglect of locally serving infrastructure that is important for economic diversification.

Creating the opposite outcome in Imperial County requires careful design and deliberate efforts, including: upholding strong environmental protection measures, investing in infrastructure that benefits both communities and industry, diversifying the economy so that it is not reliant on a single commodity

market, ensuring democratic and accountable decision-making processes, and sharing resource-driven prosperity equitably with communities through benefits and good, family-sustaining jobs. This requires attracting and supporting firms who compete on the basis of innovation, quality of product and service, and investment in a skilled and committed workforce in both professional and blue-collar occupations. This high-road model is the vision for Lithium Valley, and aligns with federal priorities for an equitable energy transition. Here we examine first the mechanics of this model and then the U.S. battery supply chain landscape, in order to gain insight into national market dynamics as they pertain to the high-road vision for Lithium Valley.

3.1 HOW HIGH-ROAD CO-LOCATION CAN MULTIPLY THE SOCIAL IMPACT OF LITHIUM VALLEY

Above we presented estimates of possible jobs stemming from lithium extraction, increasing substantially the broader the co-located value chain. We know that clean energy industries are subject to the same job quality dynamics as the broader economy: where jobs are union or public-sector, or where labor standards are required, jobs can offer the stability and economic security that allow families and communities to thrive. But where employers are not held to high-road practices, poor-job-quality issues can be found, i.e., low wages, harsh or unsafe conditions, lack of job security, and sometimes exploitative labor practices such as wage theft, etc., with a disproportionate concentration of workers from disadvantaged communities in these lower-quality jobs. In the wind and solar industries, for example, job quality varies widely nationwide, and poor job quality factors observed in the absence of high-road practices include boom-and-bust cycles, and subcontracting which tends to further drive down wages and worker protections.[79]

In Imperial Valley, efforts to promote both environmentally sustainable and socially beneficial development will need to be anchored in strong environmental and inclusive development practices. In terms of the social impact, as we have seen above, some local and state efforts are addressing the issues related to Lithium Valley job quality and workforce development, with a view to creating good local jobs. The positive outcomes that good jobs provide could multiply exponentially if value-added refining and manufacturing stages are also located there and if labor standards are high. Today, achieving this type of co-location is still an ambitious goal, and massive investments would be needed. However, there are also promising factors that make co-location a possibility, and strong community and political will to pursue this development on the high road in Imperial Valley.

A high-road strategy seeks to support firms that compete on quality, innovation, and investments in the workforce, so that providing good jobs makes business sense while also benefiting workers and the local economy. Policies to encourage the high road level the playing field for companies that provide good wages and benefits, foster career mobility, ensure worker voice, and prioritize workplace safety

79 https://www.vice.com/en/article/z34eyx/shifting-america-to-solar-power-is-a-grueling-low-paid-job

and worker protections. As shown in **Figure 4** below, a high-road approach addresses both sides of the labor market, using levers that support equity for workers (labor supply) and employers offering high-quality jobs (labor demand). These strategies look beyond simply creating jobs, and also focus on **job quality** and **job access**, advancing economic inclusion by creating good jobs and hiring local residents into them, including workers from communities historically excluded from prosperity.

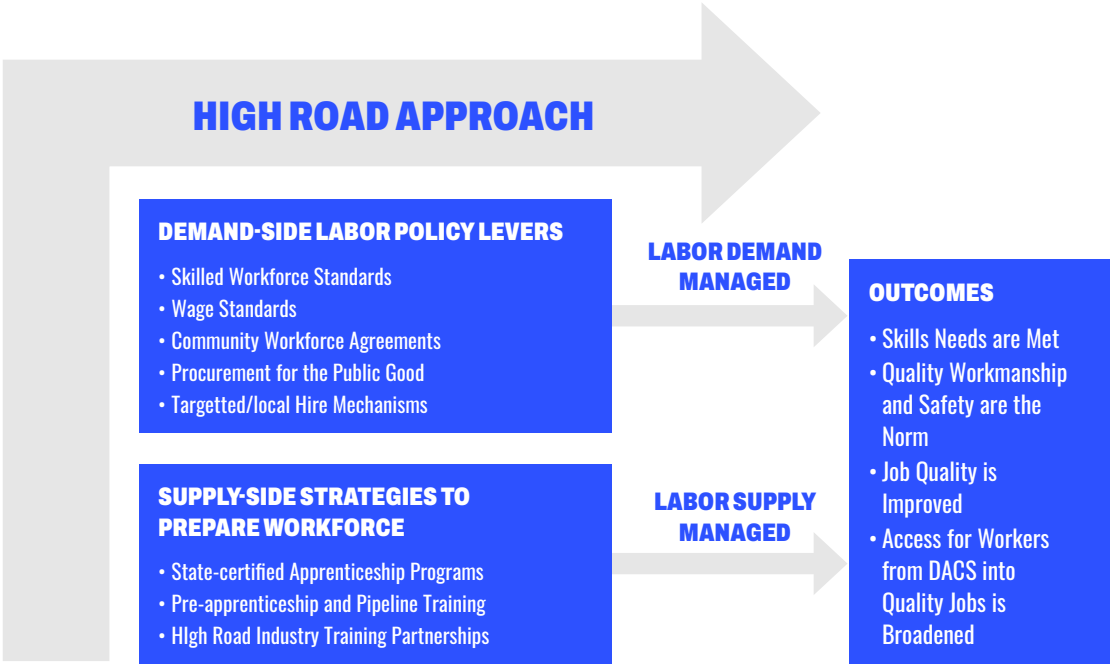

FIGURE 4.

Managed labor supply and labor demand in the high-road approach.

Source: Adapted from (Zabin et al. 2020).

Unions can play a key role in supporting high-road development. Union jobs are the benchmark for job quality, because good wages, worker advancement opportunities, benefits, and worker protections are built into them. In California, workers in unionized jobs earn higher wages and receive much more substantial health and retirement benefits, and the union premium is particularly large for black and Latino workers (Hunter et al. 2023; Thomason and Bernhardt 2018). President Biden has explicitly supported unionization as a way to maintain and grow the middle class while addressing our climate crisis. Unions are instrumental in the recruiting, training, and placement of workers, and in the effective transfer of knowledge and skills as new workers enter a trade. They also play an important role in environmental protections, as ensuring worker safety has often been the driving force in making industry cleaner. In the context of Lithium Valley, growing union support for the energy transition can help businesses attract and retain skilled and committed workers, reduce delays in permitting, and garner greater federal support for local projects.

High-road workforce strategies clearly benefit workers and communities, but there is growing evidence that they are also good for business, particularly in capital intensive industries. While better wages and benefits increase per-worker labor costs, labor accounts for only a small percentage of production costs in most parts of the battery supply chain. The cost of materials and machinery account for roughly 80% of total production costs, with labor accounting for an estimated 10% of total costs in a typical U.S. battery manufacturing facility (Orangi and Strømman 2022a). Changes in battery chemistry and efficiencies in material extraction, refining, and production processes can have a substantially greater impact on final battery price compared to labor, and skilled technical workers are needed to operate and monitor complex equipment, in highly precise production conditions. Higher productivity can thus more than compensate for higher wages in these circumstances.

Moreover, high-road labor practices can help firms sustain productivity gains over time. Research shows that paying higher wages reduces turnover, makes recruiting easier, and increases workers' productivity, translating into economic gains for the firm (Coviello, Deserranno, and Persico 2022; Dube, Lester, and Reich 2016).[80] More generous pay policies have been found to reduce separations in many industries, with these effects being especially pronounced in manufacturing and professional and business services (Bassier, Dube, and Naidu 2022; Levine 1992).[81] Lower turnover stabilizes a firms' talent pool, improves their staff's on-the-job experience, and reduces recruitment, hiring, and training costs.[82] Paid sick leave has been demonstrated to improve productivity by reducing both absenteeism and presenteeism, the term for an employee showing up to work despite being ill only to work ineffectively and potentially infect other employees (DeRigne, Stoddard-Dare, and Quinn 2016; Pichler and Ziebarth 2017; Stearns and White 2018). Participating in High Road Training Partnerships (HRTPs) is a strategic investment for companies. Built upon agreements between labor and management, HRTPs are an excellent way of ensuring a strong pipeline of skilled workers, trained in the skills employers need. Research also suggests that workers who have access to training opportunities are less likely to leave their jobs (Cockx, Linden, and Karaa 1998; Dearden, Reed, and Van Reenen 2006).

Good wages, benefits, and working conditions can also help address the labor shortages that many firms are experiencing since the pandemic. In a Fall 2023 survey by the National Association of Manufacturers, 72% of respondents identified the inability to attract and retain employees as their top primary challenge.[83] However, registered apprenticeship programs, with guarantees of job quality, good

80 **https://www.whitehouse.gov/cea/written-materials/2022/04/06/blocking-the-low-road-and-paving-the-high-road-management-practices-to-improve-productivity/**

81 Specific examples illustrating the impact of paying higher wages include the San Francisco International Airport's living wage ordinance (Jacobs, Reich, and Hall 2003), Ford Motor Company's "Five-Dollar Day" (Raff and Summers 1987), and data from the New Jersey Police Department (Mas 2006).

82 One review found that the cost of replacing an employee ranged from about 5% to 20% of annual salary for occupations with lower educational requirements (e.g., administrative assistants, home health workers, support staff, manual laborers), to between 34% and 97% for more specialized occupations (pilots, nurses, teachers, etc.) (Bahn and Cumming 2020).

83 **https://nam.org/wp-content/uploads/2023/09/Manufacturers_Outlook_Survey_Write_Up_Q3_Sept2023_Final.pdf**

pay, and pathways to the middle class, continue to receive a steady stream of applicants.[84] Meanwhile, employers who offer competitive wages and career stability face less recruitment woes than employers with lower labor standards (Banfi and Villena-Roldán 2019; Lollo and O'Rourke 2020). As a tested model for ensuring a quality workforce, a high-road approach in Lithium Valley can be an important lever in the hub's success.

Federal investment in the battery supply chain also seeks to promote high-road labor practices, and this offers a tremendous competitive advantage for firms in Imperial Valley willing to take the high road. The Biden administration has inserted high-road language into most of the Department of Energy's grant and loan opportunities, requiring firms to articulate Community Benefits Plans as part of their applications.[85] This gives a higher ranking to proposals by those firms who can demonstrate job quality, job access and partnerships with community and labor groups. As we will discuss below, there is a need for technical assistance to businesses applying for federal funding, notably in developing their Community Benefits Plans so that they can demonstrate concrete job quality, job access, and other community benefits.

To survive and prosper, firms in California have to compete with other regions. It is neither realistic nor desirable for California firms to compete on the low road, so they must be able to gain market edge through quality, innovation, highly skilled workers, and high environmental standards. State level policymakers need to focus on the race to the top as a market differentiator, i.e., a particular strength of California that positions employers favorably for high-road-oriented federal funding. Our assessment is that California labor standards are not, on their own, a strong enough factor to drive companies away from the state. If higher labor costs are a consideration, it is important to remember that labor costs make up only around 10% of operating expenses of battery manufacturing (Orangi and Strømman 2022a), and that the marginally higher cost of high-road labor comes with profit-enhancing advantages: a strong pipeline of skilled labor, less turnover, and greater eligibility for state and federal incentives in place for high-road employers.

3.2 TRENDS IN THE DOMESTIC BATTERY VALUE CHAIN AND IMPLICATIONS FOR IMPERIAL VALLEY

This section examines the ongoing development of the U.S. battery value chain in order to understand the competitive advantages and challenges involved in efforts to develop the Lithium Valley vision. We analyze the factors influencing private investment decisions in the EV supply chain across the country, to understand the potential of Imperial Valley to capture a greater portion of the supply chain, beyond lithium extraction. Our primary finding here is that trends in the domestic battery supply chain

84 The Department of Labor's latest "Registered Apprenticeship National Results," for fiscal year 2021, shows 64% growth in new apprentices from 2012 to 2021, with a strong rebound from the COVID-19-related dip (12%) seen in 2020. Meanwhile, the number of "total completers" has grown continuously: in 2021, almost 97,000 trained workers graduated from registered apprenticeships nationwide, up from 82,379 in 2020 and 81,552 in 2019. **https://www.dol.gov/agencies/eta/apprenticeship/about/statistics/2021**

85 **https://www.energy.gov/infrastructure/about-community-benefits-plans**

show some lowest-cost, low-road market forces in play, with clusters forming in states with lower labor standards and permitting requirements than in California. However, we believe that California still has a role to play in capturing a greater portion of the market. The state has strengths in its favor, and thanks to a combination of strategic infrastructure investments, federal incentives, and targeted assistance for companies, low-road dynamics can be offset. Before looking at the assets that support California's bid to host a high-road battery manufacturing hub, let us look at the backdrop in the domestic market.

At present, the U.S. relies heavily on imports to supply battery components and the critical minerals needed to make them.[86] Lithium extraction is concentrated in Chile and Australia (Jaskula 2023), and China plays a major role in graphite mining, cobalt and lithium refining, and battery manufacturing, producing 75% of all batteries worldwide (IEA 2022). Historically, domestic production in the U.S. has been limited to cell, pack, and vehicle manufacturing, with the majority of this dominated by Tesla. However, the U.S. battery landscape is rapidly developing, catalyzed by federal policy and investment (Climate Power 2024). Some $90 billion in new investments and 94,000 jobs in the domestic EV chain have been announced since the Bipartisan Infrastructure Law (BIL) was passed, and the Inflation Reduction Act (IRA) has spurred the announcement of at least 31 new battery and battery component manufacturing projects, 9 new EV plants, and 5 new battery recycling facilities nationwide (Deese 2023).

To identify the location of employment in the EV battery supply chain, we analyzed a custom supply database starting from the database developed by the National Renewable Energy Laboratory (NREL) and NAATBatt International (a trade association for the battery industry), adding data on EV manufacturing facilities from Automotive Manufacturing Solutions' EV database and various news reports and company announcements. We then overlaid this data with state level indicators of labor protection policies gathered in a report by Oxfam America (Henderson 2023) and census tract level indicators that are part of the Federal Government's Climate and Economic Justice Screening tool.[87] From these compiled datasets, we created an interactive online tool, "**Lithium Battery Supply Chains of North America**," that maps EV jobs with regard to labor standards and other economic justice indicators.[88]

The maps in **Figure 5** below show the operational and planned U.S. facilities either manufacturing EVs or in the lithium-ion battery and EV value chain, with the size of the bubble proportional to total employment at the facility (where data was available). Evident in these images is the geographical clustering of facilities within two main areas of the country: a western constellation linking California, Arizona, and Nevada; and the broad swath known as the "Battery Belt," from the upper Midwest (Michigan, Illinois) through the major battery and EV manufacturing hubs in Tennessee and Georgia.

86 For a detailed explanation of the battery value chain and major producers, see **Appendix**.

87 **https://screeningtool.geoplatform.gov/en/#3/33.47/-97.5**

88 **www.newenergynexus.com/lithium-map**

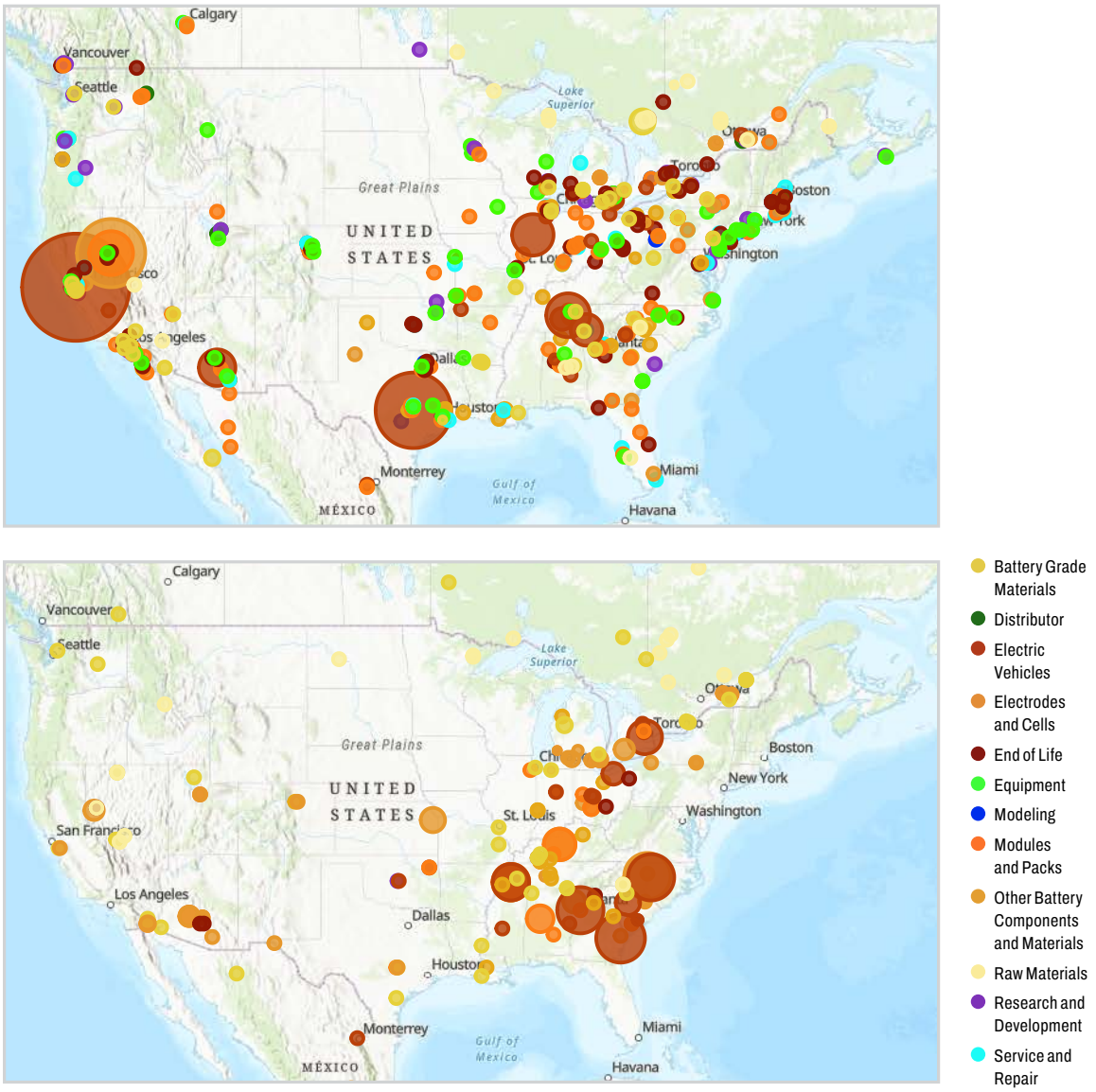

FIGURE 5.

Facilities in the EV and battery value chain: operational (above) and planned (below); bubble size represents estimated job numbers. Source: "**Lithium Battery Supply Chains of North America**."[89]

89 To access the complete interactive map—which allows users to see facility-level details, filter by supply chain step, and add labor policy and environmental justice indicators—please visit **https://lithium-map.netlify.app/**.

3.2.1 California, Nevada, and Arizona

The western cluster of EV and battery facilities includes several big-name manufacturing sites, along with a growing cohort of battery component, cell, and pack manufacturers and recycling companies. Thanks in large part to Tesla's auto factory in Fremont, California accounts for over 28,000 EV value chain jobs in total, roughly 19% of existing employment across the full domestic EV supply chain. Nevada accounts for approximately 12,000 existing EV value chain jobs, most tied to the combined Panasonic and Tesla Gigafactory outside Reno, while Arizona counts over 6,500 EV value chain jobs, or 4.4% of the national total, with the largest concentration in the Lucid EV plant outside of Phoenix. Together the three states now account for over 30% of total employment in the full domestic EV value chain, but this region is only seeing a 10% share of newly announced projects, which are disproportionately going to southeastern states.

While EV employment in southern states is heavily weighted toward automakers and their battery partners, the western employment is more comprehensive, with substantial employment opportunities across most of the supply chain, but heavily dominated by a single employer, Tesla.

California

California's automotive landscape has undergone a significant transformation since World War II, reflecting both historical shifts and the growth of EV development. California was once a thriving manufacturing hub for the auto industry, so that by the 1950s, Los Angeles was second only to Detroit as an automobile manufacturing center, and was producing even more makes of passenger cars than Detroit (Morales 1986). These plants began closing in the 1970s, as major automakers like Ford, GM, and later Toyota closed their California manufacturing operations, moving to the U.S. south and Mexico, in search of lower wages and production costs (Klier and Rubenstein 2010).

Nonetheless, California has continued to be a hub for clean tech and automotive innovation. Notable innovative start-up companies include Los Angeles-based Faraday Future, which has launched production at a Central Valley facility in Hanford;[90] Fisker Inc., an EV startup which has developed a full-length SolarSky roof to support the vehicle's battery-powered motor;[91] and Xos Inc., a new battery-electric truck and fleet services provider.[92] A number of innovative battery and battery materials companies—such as Sila Nanotechnologies developing new silicon based anodes,[93] and QuantumScape developing more efficient solid state lithium battery technologies[94]—are also headquartered in California. Using a broad industry definition, the Los Angeles Economic Development Corporation identified over 16,000 jobs in EV manufacturing in the Southern California region (LAEDC

90 https://www.ff.com/us/press-room/FF-reveals-new-manufacturing-updates-and-introduces-FF-ieFactory-California/
91 https://www.fiskerinc.com/ocean
92 https://www.xostrucks.com/
93 https://www.silanano.com/
94 https://www.quantumscape.com/

2020), noting that these jobs extend to production: Southern California hosts a significant cluster of EV companies working not only in software and design, but also full production and manufacturing sites for the electrical, motor, and transport equipment of various startup passenger, shared mobility, truck, drayage, and passenger bus vehicle models.

TABLE 5.

Selection of California EV companies

Company	Location	Facility type
Mazda USA	Irvine, CA	Headquarters
American Honda Company	Torrance, CA	Headquarters
Tesla	Fremont, CA	Headquarters and production
Fisker Inc.	Manhattan Beach, CA	Headquarters
Lucid Motors	Newark, CA	Headquarters
Rivian	Irvine, CA	Headquarters
Seres EV	Santa Clara, CA	Headquarters
Karma Automotive	Irvine, CA	Headquarters and production
Faraday Future	Los Angeles, CA	Headquarters
BYD	Lancaster, CA	Production
Gillig	Livermore, CA	Headquarters and production

The most visible player in California's EV industry is Tesla, the largest electric vehicle manufacturer in the U.S. Tesla employs more than 22,000 people at its Fremont automobile factory, making it the largest EV factory in the country. Over the years, Tesla has benefited from over $3.2 billion in direct and indirect California subsidies since 2009, particularly in the form of credits created by California's Zero Emission Vehicle (ZEV) program.[95] Tesla was also the primary beneficiary of federal incentives intended to support EV adoption; for example, 2010 federal legislation that created a $7,500 tax credit

Sundry Photography - stock.adobe.com

95 https://www.govtech.com/policy/gov-newsom-says-california-subsidies-powered-teslas-success

to the purchasers of the first 200,000 units of any company's zero-emission vehicles. In its early years of ramping up production, these credits helped both cash flow and the bottom line, e.g., "85 percent of Tesla's 2009 gross margin … came from ZEV credits" (Niedermeyer 2019:72). It is hard to find a more striking example of public policy helping create private value: Tesla's market capitalization peaked in late 2021 at over $1 trillion, but even dropping to $582 billion in January 2024, its market value was more than the next five most valuable automakers combined.[96]

Tesla has expanded rapidly and, despite the public dollars it has received in California, is now diversifying their operations away from the state, moving its headquarters to Austin, Texas, and launching manufacturing facilities in Austin, Texas and Buffalo, New York, as well as Berlin and Shanghai.[97] Other EV manufacturers in the state seem to be following this playbook. Proterra, an EV bus company that filed for bankruptcy in August 2023 in order to restructure and continue

96 **https://companiesmarketcap.com/automakers/largest-automakers-by-market-cap/** As of January 26, 2024, Tesla's market capitalization was $583 billion. The next five were: Toyota ($267 billion), Porsche ($76 billion), BYD ($73 billion), Mercedes-Benz ($71 billion), and BMW ($68 billion).

97 **https://www.theverge.com/2023/1/11/23549895/tesla-texas-factory-expansion-gigafactory** and **https://www.tesla.com/gigafactory2** and **https://www.tesla.com/manufacturing**

production, previously had shifted their operations from California to South Carolina.[98] Rivian, which is headquartered in California, conducts most of its manufacturing in Illinois with plans to expand in Georgia.[99]

Crucially, there are also several companies demonstrating that not only is it possible to manufacture in California, it is possible to do it with responsible labor practices. In 2013, the Chinese company BYD began manufacturing electric buses in Lancaster, outside of Los Angeles. BYD has since become one of the largest electric bus manufacturers in the country, claiming to account for 40% of U.S. electric bus manufacturing capacity, with a unionized workforce of 750 employees.[100] BYD was also notable for signing a legally enforceable Community Benefits Agreement (CBA) with Jobs to Move America in 2017, which committed BYD to a goal of hiring 40% of its workers from disadvantaged populations.[101] Another California-based bus manufacturer, Gillig, a family-owned company operating in Livermore, has a contract with Teamsters Local 853 that reportedly makes them some of the best paid vehicle manufacturing workers in the country.[102]

The state's ability to leverage its research and tech capabilities, coupled with the growth of EV startups, paints a promising picture for the future of the automotive sector in California. At the same time, as we will discuss further below, the trend of California-based firms locating the manufacturing of their innovations in other states is a challenge that will need to be addressed if the state is to succeed in building a robust battery manufacturing ecosystem that could utilize the resources from Lithium Valley.

Nevada

Nevada has the largest number of identified possible lithium sites of any state (Parker et al. 2022) and is home to Silver Peak, the only currently active lithium mine in the United States. Silver Peak has been producing lithium since the 1960s and is operated by Albemarle, a U.S. mining company headquartered in North Carolina who acquired the site in 2015. Production from the mine was 2200 metric tons of lithium in 2020, and there have been announcements of plans to double production capacity by 2025. Another lithium site at Rhyolite Ridge, close to the existing Silver Peak mine, is in the planning stage. Finally, **Thacker Pass** is a new lithium mining site that broke ground in February 2023, despite intense opposition from environment organizations and Indigenous communities (see **Box**). Silver Peak uses evaporation, while Thacker Pass and Rhyolite Ridge are both hard rock mining operations.

98 https://www.reuters.com/business/autos-transportation/ev-firm-proterra-files-chapter-11-bankruptcy-2023-08-07/ ; and https://www.reuters.com/business/autos-transportation/proterra-cut-jobs-merge-electric-bus-battery-production-south-carolina-2023-01-19/

99 https://rivian.com/our-company ; and https://electrek.co/2023/07/17/rivian-wins-georgia-ev-maker-green-light-5b-facility/

100 https://en.byd.com/news/byd-and-smart-union-applaud-biden-administration-plan-to-build-back-better-with-support-for-zero-emission-battery-electric-buses/

101 https://jobstomoveamerica.org/press-release/labor-and-community-groups-sign-landmark-agreement-with-electric-bus-manufacturer-byd-in-los-angeles/

102 https://www.independentnews.com/news/union-reps-confirm-new-gillig-layoffs/article_8c1a4de6-bc0e-11ea-9b9b-87873697749a.html

Thacker Pass

The Thacker Pass project area covers 17,933 acres of land, with a total disturbance footprint of approximately 5,695 acres, according to the Environmental Impact Report (EIR).[103] The estimated production capacity of this operation is 60,000 tons of lithium carbonate equivalent (LCE) per year, and the projected mine life is 46 years. The air, water, and mining permits required for the proposed mining operation were issued in February 2022.

There is strong opposition to the project, however, with groups like Protect Thacker Pass, People of Red Mountain, and Great Basin Resource Watch raising concerns about the environmental impact and the cultural significance of the area. They point to the fact that the area around the mine is considered sacred by Tribes in the area, used for gathering edible and medicinal plants, hunting and fishing, and conducting ceremonies. On these grounds, three Tribes, the Reno-Sparks Indian Colony, the Burns Paiute Tribe, and the Summit Lake Tribe, have brought a federal lawsuit against the Bureau of Land Management for not doing due diligence in permitting for the mine, and for lying about the extent of tribal consultation that was done in order to secure legally required concurrence about historic properties in Thacker Pass.[104] The lawsuit asserts that the Bureau of Land Management has violated the Federal Land Policy Management Act, the National Historic Preservation Act, and the National Environmental Policy Act, and is also guilty of Breach of Contract.[105]

Additionally, opponents criticize the excessive water consumption required for the mining operation, the expedited permitting process, and the greenwashing tactics of the mining company. On the other hand, supporters of the project believe that it has the potential to produce a significant amount of lithium, which is crucial for growing demand in the electric vehicle and renewable energy sectors.

Although located in neighboring states, the Thacker Pass and Lithium Valley lithium capture projects are striking in their differences. The Thacker Pass mine, run by Lithium Americas, aims to extract lithium from hard rock through a crushing and leaching process—a method with a considerably heavier carbon, land, and environmental impact than the direct lithium extraction (DLE) possible in Imperial Valley. The continuing local opposition and the lawsuit brought by local tribes with regard to their historic properties in Thacker Pass indicate serious failings in the stakeholder engagement process, with the developer having failed to work meaningfully towards securing community support. The outcome of the lawsuit remains to be seen, but these issues in Thacker Pass are reminders of the important work to be done to set a new precedent in Lithium Valley, modeling meaningful stakeholder engagement, transparency, and just, equitable, and environmentally sound practices that unambiguously break with exploitative extractive legacies.

103 https://eplanning.blm.gov/public_projects/1503166/200352542/20030633/250036832/Thacker%20Pass_FEIS_Chapters1-6_508.pdf
104 https://www.aljazeera.com/news/2023/3/15/nevada-lithium-mine-breaks-ground-despite-indigenous-opposition
105 https://www.protectthackerpass.org/breaking-this-fight-isnt-over-three-tribes-file-new-lawsuit-challenging-thacker-pass-lithium-mine/

Part of Nevada's competitive advantage is the presence of a growing industrial hub for manufacturing across the battery supply chain. Nevada has production capacity for battery cells and packs (Panasonic/Tesla Gigafactory and Lithion Battery Inc), cell containers (H&T Battery Components Nevada), recycling operations that produce battery-grade materials (Redwood Materials, Aqua Metals), and reuse and repair (Global Battery Solutions).

Tesla's Gigafactory in Nevada began operations in 2014. Located in the Tahoe Reno Industrial Center and spanning some 5.4 million square feet, the factory produces battery cells and packs, which are used at the Tesla factory in Fremont, California. The Gigafactory is bolstered by Tesla's partnerships with Panasonic Energy of North America, which produces the prismatic cells used in the pack,[106] as well as H&T Battery Components, which produces cylindrical cans used for cell casing.[107] Tesla says that between the two sites the facilities since 2014 have produced 7.3 billion battery cells (37+ GWh) and 1.5 million battery packs, as well as 3.6 million drive units and 1 million energy modules (14+ GWh total).[108] According to Tesla, the Gigafactory has directly hired 11,000 people in the region. In January 2023, Tesla announced plans to expand the Gigafactory even further, investing over $3.6 billion to add two new facilities: a 100-GWh, 4680-cell factory with the capacity to produce enough batteries annually for 1.5 million light-duty vehicles, and their first high-volume semi-truck manufacturing site.[109]

Nevada is also home to a hub of battery recycling companies that are either already in operation or developing new battery recycling technologies. The most prominent is Redwood Materials, headquartered in Carson City. They specialize in recycling end-of-life batteries and consumer electronics, as well as production scrap from the Panasonic/Tesla Gigafactory. Their products are sorted and recycled to recover and refine constituent materials, ultimately producing copper anode foil and cathode active material that can be reused as inputs for battery production. Redwood operates two facilities in Nevada with a combined processing capacity of 6 GWh/year, and employs more than 400 people. Panasonic recently announced plans to source cathode active material (CAM) from Redwood for its cell production facility under construction outside Kansas City, Kansas.[110]

Other players in the growing Nevadan recycling ecosystem include American Battery Technology Company and Aqua Metals.[111]

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106 **https://na.panasonic.com/us/panasonic-energy**

107 **https://ht-recharge.com/**

108 **https://www.tesla.com/blog/continuing-our-investment-nevada**

109 **https://www.tesla.com/blog/continuing-our-investment-nevada**

110 **https://www.redwoodmaterials.com/news/redwood-high-nickel-cathode-panasonic/**

111 American Battery Technology Company has a $2 million contract with the U.S. Advanced Battery Consortium and the Department of Energy to demonstrate commercial production of battery-grade recycled cathode products. They are currently building a recycling facility under construction in Fernley that will demonstrate an automated deconstruction and hydrometallurgical process and is expected to process 20,000 metric tons of end-of-life batteries annually.

Aqua Metals is developing battery recycling technology that does not use heat or chemicals. They operate a battery recycling facility called the Li AquaRefining Plant, which is designed to process over 20 million pounds of LIB material each year. The facility processes black mass and is expected to process 3,000 metric tons per year at full capacity in its initial phase. The Aqua Metals Innovation Center began conducting lab-scale testing of its lithium-ion recycling technology in September 2021.

Many of the production facilities, including Panasonic and the original Tesla Gigafactory, are located in or around the **Tahoe Reno Industrial Center (TRIC)**. TRIC is a privately owned industrial park where most industrial uses are pre-approved, and the permitting process is extremely rapid. It offers an interesting case study of an effort to create a development-friendly zone (see Box) albeit one that diverts local and state tax revenues while potentially undermining labor and environmental standards.

Tahoe Reno Industrial Center

The Tahoe Reno Industrial Center (TRIC) spans 107,000 acres in Storey County, Nevada, approximately nine miles east of Reno. It was formerly a ranch before developers purchased it from Gulf Oil in 1999. Through their initial agreement with the county, the development is designed to be essentially construction-ready for any company who wishes to build an industrial operation. The entire area is zoned as Heavy Industrial, meaning that most uses are pre-approved. The developers also paid to install industry-supporting infrastructure, including roads, grid interconnection, a telecommunications network, and power generation. In exchange, the Development Agreement restricts the county's ability to impose new fees or regulations. The quick timeline to construction is above all what attracted Tesla to build its Gigafactory at TRIC, and numerous companies have followed their lead.

The flip side is that most of the employees do not live in Storey County; TRIC is explicitly a nonresidential area, and the companies do not provide employee housing. Instead, employees are moving to nearby cities such as Reno and Sparks, which do not receive any direct tax revenue from the development and are struggling to accommodate the rapid population growth.[112] According to local elected officials, this has put a strain on their ability to provide public services like education, health services, housing, and infrastructure.[113] In 2017, a bill was proposed that would have forced Storey County to pay impact fees to Washoe County, but it fell flat, and in any case, the Development Agreement limits Storey County's ability to impose any new fees that would help offset these costs. Tesla's tax abatement agreement is scheduled to end in 2024, at which point Storey County will experience a significant windfall of new tax revenue. There is an ongoing debate over whether neighboring counties should receive some benefit, or if the economic benefit of new residents and payroll spending should be benefit enough.[114]

112 https://www.governing.com/archive/gov-industrial-parks-reno-tahoe.html
113 https://www.nnbw.com/news/2023/feb/10/sparks-mayor-reno-sparks-need-nevada-help-from-leg/
114 https://www.nevadaappeal.com/news/2023/feb/22/tric-exec-dont-force-storey-county-to-share-tax-windfall/

Arizona

Arizona is also quickly becoming a hub for battery technology and production, supported by state officials who have started calling the area surrounding Phoenix "Electric Valley." LG Energy Solutions plans to start production at its cylindrical cell manufacturing plant in the Greater Phoenix area in 2024, after announcing a $1.4 billion investment, and later announcing it would build another facility there specializing in LFP pouch-type batteries for energy storage systems, bringing its total investment to $5.5 billion.[115] EnPower,[116] Nikola,[117] Zero Electric Vehicles,[118] and KORE Power[119] are among other battery and EV manufacturers that are either headquartered or have invested in the region. There are also several companies focused on battery testing and innovation, such as Admiral Instruments,[120] Sion Power,[121] and Enovix.[122]

Finally, Arizona is becoming a hub for end-of-life (EOL) collection and recycling of spent batteries. This includes Cirba Solutions, which has an operational sorting and storage facility in Mesa and plans to open a recycling facility.[123] Li-Cycle is another prominent company that opened a "spoke" recycling facility in 2022, where they receive EOL batteries and production scrap which they shred to produce **black mass** that will be refined at their hub facility in Rochester. Li-Cycle's Arizona Spoke has a processing capacity of 10,000 tons/year, which is the equivalent of approximately 20,000 EVs a year.[124]

3.2.2 The "Battery Belt"

In the broad swath of operational and announced facilities stretching from Michigan down through Georgia, Tennessee and Kentucky particularly stand out as a hub for battery manufacturing. Firms setting up new ventures there include major automakers, like Ford and Volkswagen, as well as leading battery companies such as LG Chem and a host of new battery manufacturers. In Tennessee alone, companies have invested $12.7 billion in EV battery-related projects since 2017.[125] Examples of prominent investments and newly announced facilities in the region include the following:

- LG Chem is setting up the largest EV battery cathode manufacturing facility in the United States in Clarksville, Tennessee, with production slated to be roughly 120,000 tons of cathode material annually by 2027, enough for 1.2 million electric cars a year. In its announcement, LG

115 https://www.azcommerce.com/news-events/news/2023/3/lg-energy-solution-to-invest-55-billion-to-build-battery-manufacturing-complex-in-queen-creek/
116 https://www.enpowerinc.com/enpower-opens-new-headquarters-in-phoenix-arizona/
117 https://www.nikolamotor.com/
118 https://zevx.com/
119 https://korepower.com/
120 https://www.admiralinstruments.com/
121 https://sionpower.com/
122 https://www.enovix.com/about-us/
123 https://www.cirbasolutions.com/new-lithium-ion-battery-recycling-facility-in-eloy-az-announced/
124 https://li-cycle.com/technology/
125 https://www.usnews.com/news/best-states/tennessee/articles/2022-11-28/40m-tennessee-incentive-for-battery-cathode-plant-approved

Chem specifically referenced Tennessee as the best choice for the facility due to its proximity to key customers, ease of transporting raw materials, and active cooperation of the state and local governments.[126] The investment is expected to create 860 new jobs and is the largest announced foreign direct investment in Tennessee's history.[127]

- Ultium Cells, a joint venture between General Motors and LG, is building out a 2.8-million-square-foot, $2.6 billion plant in Spring Hill, Tennessee. Expected to employ 1,700 people, the Spring Hill plant will produce cells for the Cadillac Lyriq, which is produced at the adjacent GM assembly plant.[128] It is now scheduled to begin production in 2024, delayed from its original 2023 projected opening, and is the second of three planned plants.[129]
- BlueOval SK, a joint venture between Ford and Korean battery producer SK Innovation, announced plans for a $5.6 billion mega campus in Stanton, Tennessee, called BlueOval City, which will create approximately 6,000 new jobs. The 3,600-acre campus covering nearly six square miles will encompass vehicle assembly, battery production, and a supplier park in a vertically integrated system to supply Ford's electric vehicles. Construction on the plant began in 2022 and will include a $2.5 billion battery plant, as well as production facilities for electric trucks and SUVs.[130]
- Ford is also investing $5.8 billion to build a twin battery manufacturing plant estimated to create 5,000 full-time jobs in Glendale, Kentucky, in close proximity to the Tennessee plant, and is projected to open in 2025.[131]
- Toyo Ink SC Holdings Co., Ltd., a Japan-based specialty chemicals manufacturer, is investing more than $104 million to expand its battery material manufacturing operations to Simpson County, Kentucky.
- Envision AESC, an EV battery manufacturing company, plans to build a $2 billion plant in Bowling Green, Kentucky.[132] The 30 GWh facility will manufacture battery cells and modules for Envision's multiple car manufacturers and is expected to create over 2,000 jobs.
- Ascend Elements announced plans to invest $310 million in the first phase of construction for a new sustainable lithium-ion battery materials facility in Hopkinsville, Kentucky. This new facility will incorporate Ascend Elements' Hydro-to-Cathode direct precursor synthesis process technology, which uses black mass from spent electric vehicle batteries to produce lithium-ion battery precursor and cathode active material. The company estimates it will be able to produce materials to equip up to 250,000 EVs per year.

126 https://apnews.com/article/technology-united-states-business-tennessee-clarksville-dc8cb2d517e0b9a5e4dbb5564fad9005
127 https://tnecd.com/news/the-top-five-projects-of-2022
128 https://insideevs.com/news/626235/ultium-cells-factory-tennessee-additional-investment/
129 https://insideevs.com/news/693537/gm-ultium-cells-tennessee-plant-delayed-2024/
130 https://media.ford.com/content/fordmedia/fna/us/en/news/2021/09/27/ford-to-lead-americas-shift-to-electric-vehicles.html
131 https://www.courier-journal.com/story/news/politics/2021/09/27/gov-beshear-kentucky-incentivizes-ford-south-korea-battery-park/5851302001/
132 https://ced.ky.gov/Newsroom/NewsPage/20220413_EnvisionAESC

Georgia is also investing heavily in developing a battery industry, and showing some signs of success. The state reports that at least 45 EV-related projects have brought in $25 billion in investments since 2020.[133] The state is home to at least 23 e-mobility companies, including the Korean company SungEel, which plans to invest $37 million in a new battery recycling plant.[134] In addition, Ascend Elements is also launching an EV battery recycling plant and cathode materials facility near existing EV and vehicle battery manufacturers. The plant is projected to generate 104 jobs and is being fast-tracked for vetting and approval in order to ensure accelerated development. The operation's slated launch date is 2024. Electric vehicle manufacturer Rivian has also begun siting a plant outside of Atlanta, which reportedly will begin production in 2024 and have an annual capacity of 400,000 EVs,[135] although there is local opposition to the development from group's concerned about the plant's impact on the region's environment and rural economy and lifestyle.[136] Hyundai and Kia have also announced new EV manufacturing investments in Georgia.[137]

3.3 FACTORS SHAPING GEOGRAPHY OF NEW U.S. DEVELOPMENTS

What explains these patterns of employment and growth in the U.S. electric vehicle and battery supply chain? Answering this is important in assessing opportunities to grow the industry in California, and specifically for expanding opportunities beyond lithium recovery in Imperial County. In our interviews with companies and economic development officials, and our review of research on growth and development of the battery and EV value chain, a number of key considerations emerged as important:

3.3.1 Costs of Production

Costs of production are, of course, important considerations in siting a manufacturing facility, though the importance of differences in these costs between different locations can sometimes be exaggerated. Broadly, these costs can be categorized into materials, machinery, labor, land and buildings, energy (and other utilities), and company overhead. Most companies pointed to the cost of land and energy as influencing siting decisions.

However, research about the battery supply chain suggests that most of the costs of production are in the materials and the machinery (including purchase, installation, and maintenance), which do not vary substantially across U.S. regions. In the international landscape, one recent study developed a model for comparing production costs for NMC111 battery cell manufacturing in nine countries. It found that materials costs (including cost of scrap) ranged from 54% to 69% of total production costs, with

133 https://www.georgia.org/EV#/analyze?show_map=true&region=US-GA
134 https://www.globalatlanta.com/korean-battery-recycler-is-latest-in-parade-of-metals-firms-investing-in-georgia/#:~:text=SungEel%20HiTech%20will%20build%20a,nickel%2C%20lithium%20and%20other%20metals.
135 https://www.waste360.com/recycling/georgia-ramps-electrification-supply-chain
136 https://no2rivian.org/
137 https://www.georgia.org/EV#/analyze?show_map=true&region=US-GA

machinery and maintenance accounting for another 15–19% of costs. Combined, these costs ranged from a low of 70% of total costs in Norway and Germany, to a high of 87% in China. The U.S. was in the middle, with materials and machinery accounting for 79% of total estimated costs (Orangi and Strømman 2022b).

This implies that changes in battery chemistry, improved efficiencies in mining and refining, and basic commodity prices can have a substantially greater impact on final battery price than other factors of production that companies point to when comparing sites within the U.S. For example, the cost of producing an NMC811 battery in the U.S. is roughly a third less than an NMC111 battery because it has much lower levels of manganese and cobalt (Orangi and Strømman 2022b).

Beyond materials and machinery costs, labor costs are the most important factor. In the same study, labor accounted for an estimated low of 2% of total costs in China, to a high of 18% in Sweden, with the U.S. estimated at 10%. Since the manufacturing of lithium-ion batteries and their components requires extreme precision in assembly and a pristine manufacturing environment, manufacturing processes typically have high levels of automation, thus requiring substantial technical skills to operate the sophisticated production machinery (Brodd and Helou 2013). As a result, companies are typically looking for a balance between costs and skills in their workforce.

Other production costs—namely, land, buildings and energy—are significant but on the margin, each accounting for an estimated 3% to 5% of total production costs. The differences in total costs of production in different parts of the U.S. are marginal, although not completely insignificant.

Compared to other places in California, particularly urban areas, Imperial County is relatively inexpensive when it comes to land and energy. One interviewee estimated that prices for industrial land are between $10–15k per acre, compared to $100k per acre in Los Angeles. Electricity rates, at least for residential users, are estimated to be 50% lower in Imperial County than the statewide average, and 15% lower than the national average.[138]

3.3.2 Proximity to Suppliers and Customers

Some companies *must* locate close to a larger auto or battery manufacturer, which is referred to as "captive" site selection. However, more and more new battery pack manufacturers are voluntarily locating close to auto company partners for strategic reasons. Several recent developments, such as BlueOval and Ultium, are joint ventures between auto companies and battery manufacturers characterized by deep levels of integration between battery properties and the manufacturing processes. Auto manufacturers are also playing an increasingly important role in influencing the entire value chain, as they have been entering into supply agreements with lithium mining companies, along with partnering with battery manufacturers to ensure adequate supply for their projected demand (Bridge and Faigen 2022).

138 https://www.energysage.com/local-data/electricity-cost/ca/imperial-county/

Co-locating recycling and manufacturing can also create synergistic benefits; the recyclers process scrap from the manufacturing process, and the materials recovered from recycling old batteries can be used in new production. Some examples of this are Redwood Material's facility in Nevada, which processes production scrap from the Panasonic factory, or Ascend Elements' strategic partnership with SK Innovation in Georgia.[139] Co-location reduces the need for transportation, which makes the value chain more cost-efficient and reduces environmental impact. This seems to be important between recyclers and manufacturing, but we found little evidence of proximity to lithium extraction sites as being an important factor. Without precursor and CAM manufacturing capacity, there is no way to use locally sourced lithium as a production input.

This suggests that a lithium resource may not be a strong enough draw to attract battery manufacturing to Imperial County on its own, and points to the importance of developing precursor and CAM manufacturing. It also suggests that as a hub develops, it could create a center of gravity that would attract additional steps in the value chain. As it is, Imperial County is still in a strategic location under this criteria considering its proximity to the growing battery supply hub in Arizona, including recycling facilities that could supply additional sources of critical minerals such as nickel or cobalt, as well as to EV companies and markets in Southern California. It also provides close access to the substantial California EV market for potential EV manufacturing sites.

3.3.3 Permitting

Multiple interviewees talked about rapid permitting as one of the most important motivating factors in location decisions. One informant noted that the permitting process was faster in rural areas with a smaller government, as fewer people were involved and "everyone works in the same building." Lengthy permitting processes increase the uncertainty and complexity of production planning, making it more difficult for companies to attract upfront investment. Several people we spoke to pointed to this as the primary barrier to siting a manufacturing facility in California, even if their company was founded and headquartered there. As discussed in **Section 2**, Imperial County is no exception to California's long permitting processes, but there are steps being taken to ease this with the county's Programmatic Environmental Impact Report (PEIR).

3.3.4 Transportation Networks

Another factor shaping the location of EV manufacturing facilities is access to final markets via rail and interstate highways. Several of our interviewees described the importance of this when considering areas like Tennessee and Kentucky for locating EV manufacturing. These sites provide easy access to a large portion of the U.S. population—everything from East of the Rocky Mountains, to Chicago, to the Eastern Seaboard and the South. Transportation networks are also important for receiving basic materials and components that go into the production process. Imperial County is well-situated from this

139 https://ascendelements.com/sk-ecoplant/

perspective. The region has strong interstate connections with very little traffic, although local roads will need to be improved. It is also close to major ports, which we discuss in **Section 5**.

3.3.5 Clean Energy and Sustainability Credentials

Companies are facing increasing pressure to answer for the sustainability of their value chains on multiple fronts, from consumer preferences, to Securities and Exchange Commission (SEC) regulations requiring companies to disclose information about climate-related risks and impacts,[140] to investor and insurance broker demands for Environmental, Social, and Governance (ESG) and climate risk assessment. As definitions of "sustainability" start to encompass emissions within a company's supply chain (also known as Scope 3 emissions), locating in an area with a relatively clean grid is becoming an increasingly important competitive advantage.

This is perhaps where Imperial County presents the greatest competitive advantage. California has one of the least carbon intensive energy mixes in the United States at 219 kg CO2 per megawatt-hour (MWh) in 2022, compared to 390 for the U.S. as a whole, and 448 for the East South Central region,[141] so simply locating in California would reduce their Scope 3 emissions. Beyond that, the potential to co-locate near geothermal plants would take the carbon intensity even lower; geothermal power plants in California emit around 83 kg CO_2 per MWh.[142]

3.3.6 Workforce

The availability of an adequately skilled workforce was seen as an important factor in location decisions by many of our key informants, and companies look for places with strong local STEM and vocational programs.

As shown in the chart below (**Figure 6**), blue-collar manufacturing jobs are estimated to make up 70% of the jobs in the battery supply chain , with the remaining 30% made up of engineers, scientists, technicians, and "other white-collar" jobs (Li-Bridge 2022). Many positions will be based in chemistry and engineering; as a result, a common theme across industries was a need for more people who have a background in chemistry. According to interviewees, skilled trades positions are some of the most difficult to hire for; they require semi-advanced mechanical or electrical knowledge and hands-on work with equipment and end-processes.

140 **https://www.sec.gov/comments/s7-10-22/s71022-20158742-326653.pdf**

141 This includes Alabama, Kentucky, Mississippi, and Tennessee. Source: **https://www.eia.gov/electricity/data/emissions/**

142 **https://geothermal.org/sites/default/files/2021-02/Geothermal_Greenhouse_Emissions_2012_0.pdf**

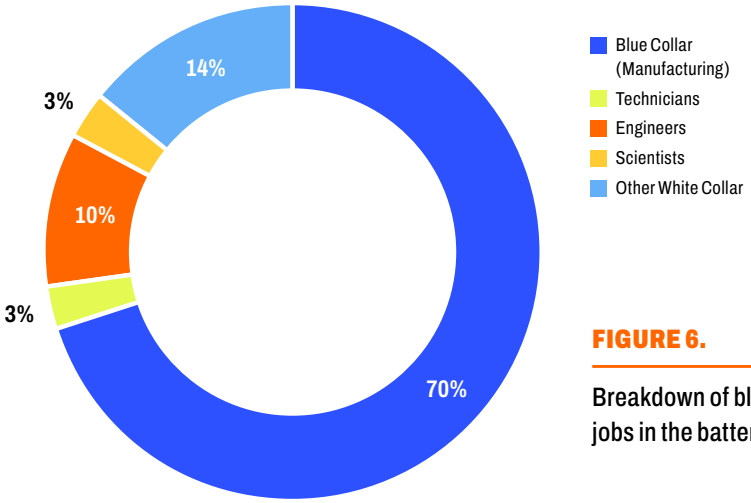
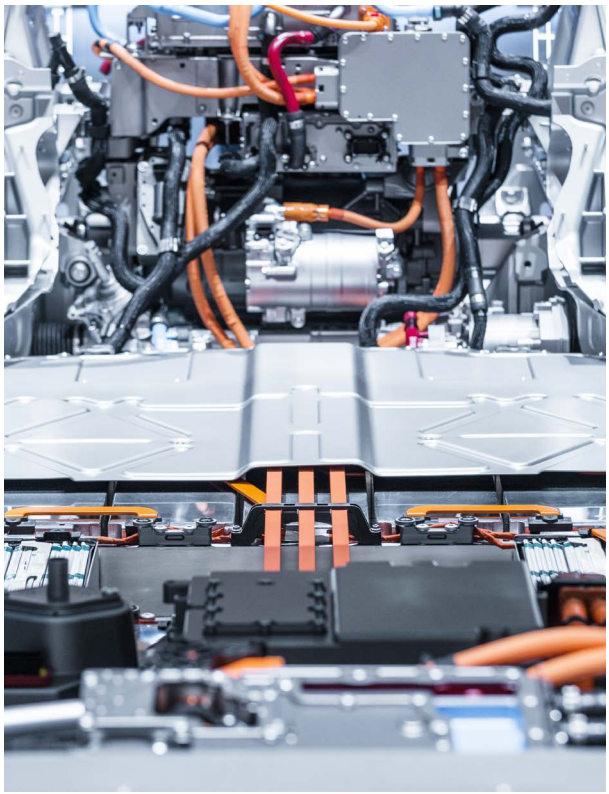


FIGURE 6.

Breakdown of blue-collar versus white-collar jobs in the battery supply chain

To develop local workforce capacity, economic and workforce development offices across the country have fostered partnerships with companies and local community colleges to build courses and training programs with appropriate skills, including basic chemistry, machine operators, and production skills (see **Table 4**). For example, part of Tennessee's draw is the Tennessee Promise program, which offers free community college to all high school graduates.[143] The state is now providing $40 million to open a qualifying technology institute on the Ford-SK campus in Stanton, which will train students to work at Blue Oval City but is open to anyone who wants to build a skillset in the battery industry.[144] Companies also often provide training internally so they can keep proprietary technologies in-house.



143 https://www.tbr.edu/initiatives/tn-promise; https://www.tennessean.com/story/news/2017/05/10/tuition-free-community-college-adults-tennessee/316011001/

144 https://www.tn.gov/governor/news/2021/9/28/gov--lee-announces-landmark-workforce-development-partnership-between-tennessee-college-of-applied-technology-and-ford-.html

TABLE 6.

Selection of relevant workforce development programs in the United States

Location	Program	Description
Tennessee	Tennessee Promise	• Last-dollar scholarship program making it free for high school graduates to attend one of 13 community colleges and Tennessee Colleges of Applied Technology (TCATs). • TCATs offer two-year and certificate-level credentials, geared towards mechatronics, robotics, advanced manufacturing.
	Governor's Investment in Vocational Education (GIVE) initiative	• $25 million grant program for regional partnerships between high schools, industry, and TCATs to build new work-based learning and apprenticeship programs.
Kentucky	Kentucky Work Ready Skills Initiative (WRSI)	• Partnership between the Kentucky Department of Education and the Kentucky Workforce Innovation Board. • Recently distributed $100 million dollars to 40 high schools to develop training programs in advanced manufacturing
Nevada	Nevada Robotics, Desert Research Institute	• Deliver robotics training to K-12 students across Nevada. • Started through Tesla's K-12 Education Investment Funding.
Alabama	AIDT	• State agency that offers no-cost technical training programs to attract and expand industries. • Companies are required to pay a living wage and offer full-time employment and healthcare benefits.
Arizona	Drive48[145]	• Training center developed by Lucid Motors in partnership with the City of Casa Grande and county leaders, Central Arizona College, and the Arizona Commerce Authority.
California	Imperial Valley College Lithium Industry Force Training (LIFT) Program[146]	• IVC developed custom certificate programs for key occupations in the developing lithium extraction operations, including plant operator, chemical technician and instrumentation technician which launched in fall 2023.
	San Diego State University Brawley Campus[147]	• SDSU received $80 million in the 2022-23 state budget to expand their STEM facility at the Brawley campus, with the goal of improving technical skills for a future lithium and battery industry.

145 https://www.azcommerce.com/programs/arizona-advanced-technology-network/drive48

146 https://www.thedesertreview.com/education/lithium-supporting-classes-coming-to-ivc-in-fall/article_a3221488-fb49-11ed-9e0e-c71d10707f0d.html

147 https://newscenter.sdsu.edu/sdsu_newscenter/news_story.aspx

The focus on local workforce development is promising, and these types of industry-driven training programs can address challenges that traditional workforce development and education systems may not reach. For example, they can be designed up front to factor in operational issues and worksite culture in addition to education and training courses. However, there is a tradeoff between attracting a skilled workforce and minimizing the costs of labor, and companies often take advantage of public investments in training without necessarily offering the wages and benefits to attract and retain a skilled workforce. **As in the Lithium Valley initiatives, a crucial aspect that is overlooked by many of these programs is the establishment of industry-worker training partnerships, also called High Road Training Partnerships (HRTPs), as well as assurances that jobs will be well paid and that workers will be engaged and committed to the success of the business.** Research shows that HRTPs have been invaluable in promoting competitive, equitable, and sustainable economic development **(González-Vásquez, López, and Garcia-Perez 2021; Osterman 2018)**.

3.3.7 Tax Breaks and Financial Incentives

States are offering a variety of incentives to attract battery and EV manufacturers. One of the most well-known examples is Tesla's agreement with the state of Nevada, which included Tesla's commitment to invest a minimum of $3.5 billion in the state with its first Gigafactory. Tesla is also required to provide documentation that at least 50% of employees are Nevada residents and that all employees have healthcare coverage and contribute to the local education system. In exchange, they were granted abatements for a variety of taxes, including all local sales and use tax, and received eligibility for subsidized power use and transferable tax credits of $12,500 per permanent full-time employee.[148]

In another example, Kansas recently implemented the "Attracting Powerful Economic Expansion (APEX)" Act, which establishes economic development incentives for firms in specific industries that agree to invest a minimum of $1 billion in the state within a five year period.[149] Some of the targeted industries include advanced manufacturing and distribution, logistics, and transportation, while several other industries, including mining and ranching, are excluded. The incentives include investment tax credits, reimbursement of a percentage of total payroll, and reimbursement of a percentage of eligible employee training and education.

Companies have come to expect such subsidies as part of their location decisions, but it is important to note that when strong labor standards are not attached to them, this can equate to low-road attraction, handing companies tax abatement and credits that pave the low road with taxpayer dollars **(Mattera 2009)**. The basic factors of production are more important than incentives in shaping location decisions, but as one of our interviewees put it, incentives are the "gravy."

148 **https://www.sec.gov/Archives/edgar/data/1318605/000156459015006666/tsla-ex101_265.htm**
149 **http://www.kslegislature.org/li_2022/b2021_22/measures/documents/summary_sb_347_2022**

Are tax breaks an effective economic development tool?

Tax incentives account for $47 billion out of $60 billion in local economic development spending across the country, and this amount has tripled since the 1990s **(Bartik 2020)**. However, research finds that tax incentives offer limited benefit as an economic development strategy. A recent review found that although firm-specific tax incentives can lead to direct employment gains, the study did not find evidence of this translating into broader economic growth, either at the state or local levels (Slattery and Zidar 2020). Tax incentives also transfer resources disproportionately to large and successful firms who are the least in need of assistance, and run the risk of creating race-to-the-bottom dynamics. Firms with over 100 employees get more than 90% of tax incentive resources, despite representing only 66% of private jobs (Bartik 2020; LeRoy et al. 2015). Over 30% of firms with over 1,000 employees receive discretionary subsidies, while less than 0.2% of establishments with under 250 employees receive subsidies (Slattery and Zidar 2020). Tax incentives can also be extremely expensive, especially when compared to the number of jobs created: the average across all deals in this study between 2001 and 2014 was $108,000 per job.

Meanwhile, tax incentives limit the revenue that is available to governments while also requiring additional expenditures to meet the increased demand for public services that comes with economic expansion (Buss 2001). The dynamics we discussed around the Tahoe Reno Industrial Cluster are a prime example of this, with the costs of new service provision being borne by counties outside of where the new economic enterprises are located.

Another recent study looked at 32 states from 1990 to 2015, estimating the effect of five types of financial incentives on the fiscal health of states across three models, controlling for economic, demographic, and political conditions. Their primary conclusion was that when a state uses financial incentives, the fiscal health of the state diminishes as a result of the resources pulled out of the budget, and incentive use is associated with increasing state debt and a greater reliance on federal intergovernmental revenues. The largest effect they found is from research and development tax credits, which are often seen as beneficial but in fact can be costly with no certainty of a payoff. According to the results, a 1% increase in research and development tax credits negatively affects the ratio of expenditures to revenue by approximately 11.7%, increases federal government dependency ratio by 53.9%, and increases the debt ratio by 29.4% (McDonald III, Decker, and Johnson 2021).

The race-to-the-bottom dynamics in localities offering increasingly large incentives to get big-name firms to locate in their jurisdictions reduces taxes for successful, mobile firms, but does nothing to increase the efficiency of business location (Mast 2020). Instead, research suggests that local and state governments would do better by using tax revenue on initiatives that foster a competitive environment for all businesses, paying particular attention to both new businesses and small and medium businesses (Chatterji 2018).

Federal incentives can also feed into this race-to-the-bottom dynamic if they don't include criteria to ensure good paying jobs or promote community benefits agreements. One of the most striking recent examples of this is the Advanced Manufacturing Production Credit, which was part of the Inflation Reduction Act, and provides a tax credit for component manufacturing in the U.S., related to renewable energy, battery and critical minerals production.[150] Since it is a tax credit, it does not show up as a budget outlay, but it could result in more than $200 billion in reduced tax payments for companies during the lifetime of the program (it phases out by 2032). An initial study looking at five newly announced battery plants estimated that the value of this tax credit would range from $6–13 billion per plant, the equivalent of $2–7 million per expected job in these plants, with a promised wage in these plants that is lower than the average wage in the automotive sector—a striking case of tax policy subsidizing substandard jobs (Whiton and LeRoy 2023)

150 https://www.whitehouse.gov/cleanenergy/clean-energy-tax-provisions/

3.4 PROSPECTS IN THE CIRCULAR ECONOMY FOR BATTERIES

Reuse, repurposing, and recycling are important parts of the lithium value chain. This is certainly true for environmental reasons, as improper handling of the large expansion in batteries could lead to significant waste issues. But there are also significant economic and employment opportunities associated with lithium-ion batteries even after they have reached the end of their expected life in an EV. Batteries can be reused in vehicles as affordable replacement packs, repurposed into stationary storage systems that help facilitate the integration of renewables, and eventually recycled to recover the constituent materials. Producing batteries with recycled material has a lower environmental impact compared to raw material (Ciez and Whitacre 2019), and will effectively create a domestic source of critical mineral supply as more batteries reach the end of their usable life.

The possibility of setting up recycling in Imperial Valley strikes us as worth further study, for the symbiotic advantages it could represent in the longer term. Since California is the largest market for EVs and stationary storage, it will also see the greatest volumes of retiring batteries in the coming decades. As larger volumes of EVs begin to reach end of life, more lithium-containing batteries will become available at the same time as the geothermal lithium resources are becoming diluted. What this means for Lithium Valley is that setting up recycling close to the lithium extraction sites at the Salton Sea would provide a complementary source of minerals for use in making new batteries. These batteries would also be sources of other minerals like nickel, cobalt, and manganese, that would otherwise need to be mined and imported.

At present, the reuse and recycling system is entirely market-driven. While it is illegal to dispose of lithium-ion batteries in a landfill, no party is obligated to make sure batteries are recycled at end of life. This does not mean reuse and recycling will not happen; indeed, the recycling industry is already growing rapidly in North America. However, it means the system relies on recycling being profitable; in other words, the value of recovered materials has to be higher than the cost of collecting and processing the battery pack. This could be a challenge as the market trends away from cobalt-based cathodes towards lower-cost chemistries like LFP, which will have a lower value from a recycler's perspective. The other issue is the cost of shipping batteries, which represents an estimated 40–60% of the cost of recycling (M. Slattery, Dunn, & Kendall, 2021). Shipping costs will be higher for batteries in remote locations or damaged batteries, making them less profitable to recycle. In the absence of policy, there is a risk that unprofitable batteries will be stranded or exported to countries that may not have the infrastructure to handle them safely.

A number of stakeholders are, or will be, part of the battery reuse and recycling ecosystem; from dealership technicians, to repurposing companies, to independent auto recyclers. They all require access to information about the contents, condition, and history of the battery they are handling in order for the system to function efficiently. For example, information about a battery's remaining capacity is necessary to determine whether it is suitable for reuse; information about the material composition is necessary to assess its value for recycling, and information about the vehicle's accident history would

help identify whether special safety precautions are necessary. To address this barrier, the California Air Resources Board established requirements around labeling and state-of-health reporting that manufacturers must meet for their EVs to qualify for zero-emission incentives under the Advanced Clean Cars II Act. The labels must include information about the battery (like the cathode chemistry and voltage), as well as a digital identifier (i.e., QR code) that will link to an online database. Meanwhile, standardized requirements about how state-of-health is measured and reported will support reuse by providing transparent data about the EV and battery's condition. However, as mentioned above, repurposing may require access to information about the battery's condition and history after it has been removed from the car, pointing to the importance of tracking and traceability platforms (Kendall, Slattery, and Dunn 2022).

California's Lithium-ion Car Battery Recycling Advisory Group proposed two models to manage battery recycling: a "producer backstop" model which identifies the responsible party under three possible scenarios depending on how the battery retires, and a producer take back model which makes the battery or EV manufacturer responsible in any scenario where the battery is no longer wanted by its owner.[151] Responsibility would include assuming the cost of transporting and processing batteries, arranging collection, and providing proper documentation. In either case, responsibility for recycling transfers to the repurposing company if batteries are repurposed, which implies the need for a traceability mechanism to identify who is responsible for the battery. Tracking and traceability are also important to verify that the battery was managed properly; was it recycled, and where? Building traceability into any lithium battery industry being designed today is a strategic priority, and one of our core recommendations for Lithium Valley, laid out in **Section 6**.

This is an area of ongoing progress. A producer responsibility bill for end-of-life (EOL) electric vehicle batteries (SB 615) was introduced to the California State Senate in February 2023, but later withdrawn for further discussion. While the California legislature considers how to institutionalize battery infrastructure, we believe the State should actively participate in the development of existing transparency initiatives, such as the Global Battery Passport,[152] and require company-reported data about emissions and labor practices during production. We see this as an important lever for the future of Lithium Valley, and include it in our recommendations laid out in **Section 6**.

3.5 OVERALL PROSPECTS

Our main finding in the domestic battery supply chain landscape is that market trends currently lean strongly towards lowest-cost, low-road models, in which it is neither feasible nor desirable for California

151 The Lithium-ion Car Battery Recycling Advisory Group ("Advisory Group") was convened in 2020 by AB 2832 and tasked with making policy recommendations to ensure that as close to 100% as possible of EV batteries in the state would be reused or recycled **(Kendall, Slattery, and Dunn 2022)**. For more background on the battery reuse and recycling landscape, see **Appendix Section A.4**.

152 **https://www.globalbattery.org/battery-passport/**

to compete. The lithium resource in Imperial Valley is a unique asset for the state, as a vast source of domestic lithium that—because it comes from geothermal brines already at the surface—is far more environmentally friendly than most other domestic lithium. However, in choosing not to compete in a lowest-cost playing field, California will have to continue to build out and remain fully committed to the high-road "brand." The state will also have to leverage the strengths in its favor, such as its prominence as an innovation hub, its proven strength in high-technology manufacturing, its EV-market-generating policies, its strong EV consumer base, and various locational benefits, as discussed in the following section.

4

ATTRACTING AND SUPPORTING HIGH-ROAD BATTERY MANUFACTURING IN IMPERIAL COUNTY AND CALIFORNIA

We have seen that building manufacturing in California can be a powerful driver of high-road jobs, and that there is an enormous job potential stemming from the unique lithium resource in Imperial Valley. Capturing added-value manufacturing steps in the EV battery supply chain, while also upholding inclusive economic development principles, is a feasible but ambitious goal and requires business friendly strategy. Here we examine the ways in which California and Imperial County can promote economic development on the high road, and the particular challenges they will face along the way.

4.1 ADDRESSING THE CHALLENGES

We have seen from the domestic trends in the battery supply chain that co-locating high-road battery manufacturing in Imperial Valley, and building out a broader battery supply chain in California, are ambitious goals, facing significant challenges at both the state and county levels.

4.1.1 Infrastructure and Water Availability

The lithium resource is a powerful asset, but proximity to raw material sources is not enough to guarantee the success of a broader manufacturing hub. While affordability[153] and a strategic location[154] work in the area's favor, informants pointed out a number of challenges the region will have to overcome to build a successful manufacturing hub in the region. First and foremost are major deficiencies in physical infrastructure, which is problematic for both communities and industry. Many roads and bridges are in poor condition, water and sewage services need upgrading, and rural areas in the county have limited internet access (Paz et al. 2022). Air quality and public health are urgent issues, and the region is also characterized by extreme heat, with average temperatures regularly exceeding 100 degrees Fahrenheit for four months per year.

Investments in infrastructure that will enable economic growth (e.g., improved roads and internet), support healthy communities (e.g., improved public health services and Salton Sea restoration), and build climate resilience (for example, climate-resilient housing, trees, and shading structures) are all foundational to building out a successful battery hub. The importance of these investments are expressed in many of the public comments submitted to the County.[155] It is also important to note that community-based organizations have been advocating for support to meet many of these needs since before the concept of "Lithium Valley" was introduced.

Finally, growth in the region is limited by water availability, which should be carefully considered when making planning decisions about how much infrastructure and population growth can realistically be supported in the region. Currently, geothermal and other industrial uses account for only a small fraction (around 1.5%) of Imperial Irrigation District's (IID) water use. However, the total water demand for an industrial hub has not been estimated. The companies operating today have secured water allocations, and IID has set aside water rights for additional renewable energy development. In the event that the

153 Compared to other places in California, Imperial County is relatively inexpensive, including its industrial land, especially compared to more urban areas of the state ($10–15k/acre in Imperial County versus $100k/acre in LA). Low housing prices in the area, with ample land for new housing (up to 12,000 acres of potential housing according to one interviewee), suggests the potential for growth and ability to attract new residents to the area. As of June 2023, Imperial had among the lowest costs of electricity in the state—with average residential rates of $16.54 per kWH, 5th lowest of any county in the state, although industrial rates were close to state averages. **https://findenergy.com/ca/imperial-county-electricity/** See also the U.S. Energy Information Administration Electricity Data Browser to compare state-level data: **https://www.eia.gov/electricity/data/browser/** .

154 As discussed in **Section 4**, the region has a strong interstate connection with very little traffic, although local roads will need to be improved. It has the potential and proximity to other states in the region along the battery supply chain including Arizona and Nevada, as well as to Mexico and the ports of Los Angeles and Long Beach.

155 **https://lithiumvalley.imperialcounty.org/wp-content/uploads/2023/05/Lithium-Tax-Public-Comment-Period-3-1-23-to-4-30-23-Comments-Log2.pdf**

industry grows beyond what they have planned for or, perhaps more importantly, California's Colorado River water allocation is reduced, water would likely need to be reallocated from agriculture, which currently consumes 97% of IID's water allocation (IID 2022:27).

4.1.2 Permitting

Stakeholders across the value chain cited the cumbersome permitting process as one of the largest deterrents to setting up new industries in California. The law critics point to most is the California Environmental Quality Act (CEQA), which was passed and signed into law by then Governor Ronald Reagan in 1970. CEQA is an important piece of legislation, and was originally implemented to protect the environment and improve public participation. However, in recent years, it has been criticized as becoming a litigious and even weaponized process that deters investment in clean energy and housing projects (Gray 2021).

The high cost of permitting in California is a particularly significant barrier to in-state recycling, according to AB 2832 Advisory Group members (Kendall et al. 2022). To build a new battery recycling facility, a company would need a hazardous waste treatment permit from the Department of Toxic Substance Control (DTSC) on top of fulfilling all CEQA requirements before they could start construction. This means that it would likely take five or six years before a facility could be operational, and it is difficult to secure investment under such circumstances. According to stakeholders in the recycling industry, that long and uncertain timeline is the main issue, not the stringent environmental performance standards.

It should be noted here that having a rigorous and effective permitting process in place is incredibly important, particularly for hazardous waste facilities. Our recommendation is not to eliminate permitting, but rather to use expedited processes that balance community and environmental protection with the need to build new green infrastructure rapidly.

Any discussion of how to streamline the permitting process must not lose sight of the crucial reasons permitting exists in the first place:

- The public is able to know what is going on in their community. In the case of potentially toxic sites, for example, anytime DTSC makes a decision, draft or final, they inform the public, hold public meetings, make information about the facility available to the public, and respond to comments.
- Permitting forces facilities to be more protective. Many hazardous waste treatment facilities, for example, are in neighborhoods, and often in communities of color and low-income communities who face barriers to participating in public decision-making processes. Measures to control emissions and prevent runoff likely would not be implemented if they were not required by a permit.
- Permits require facilities to set aside funds for closure and cleanup measures. This prevents situations of orphaned sites, where a company shuts down and the state would have to pay for it.

Nonetheless, the time-consuming nature of the process may make it difficult for California to compete with other states. The state has recognized permitting as a roadblock, with Governor Newsom recently announcing a legislative agenda to reform CEQA. To date, these efforts have been mostly focused on housing, but will need to be expanded to attract manufacturing while also ensuring safeguards for communities and the environment. Any effort at permitting reform should also recognize not just the need for streamlining, but the importance of increased capacity for coordination, planning, and community participation processes, which will be important for realizing the opportunities offered by new industries (Bozuwa and Mulvaney 2023). While CEQA reform is outside the scope of this report, addressing permittings barriers is a key component of our recommendations, laid out in **Section 6**.

One example of permitting reform particularly relevant to developing a high road battery supply chain in California is Assembly Bill 205, passed in 2022. This law created a new permitting certification program that can help streamline permits for certain clean energy projects when the project applicant meets specific labor standards and community benefits. Under this program, eligible clean energy power plants, energy storage, and manufacturing and assembly facilities can optionally seek certification through the CEC in lieu of any local permit or local law or ordinance. To approve an opt-in project, the CEC must find that the project will provide an overall net positive economic benefit to the local government, that the applicant has entered into a community benefits agreement, and that the applicant pays prevailing wages and agrees to the use of a skilled and trained workforce for all construction. The statute aims to significantly reduce permitting delays by mandating that the CEC conducts the environmental review process within 270 days after the complete application is submitted (with some exceptions).[156]

4.2 COMPETING ON THE HIGH ROAD

While challenging, the difficulties identified above are not insurmountable, but will require concerted effort and adequate investments. The high-road argument, and the environmental argument given the lower-impact lithium source available in Imperial Valley, can help secure the necessary support at every level—from local communities to the federal government. Moreover, California possesses a number of strengths that can be built on in order to break out of the low-road playing field.

Harnessing the State's Manufacturing Prowess

California has a long history as a manufacturing powerhouse. The state is home to more than 33,000 manufacturing firms employing over 1.1 million workers and enjoys locational advantages as an export hub for Mexico, Canada, and Asia.[157] California is the largest state contributor to national manufacturing GDP, representing 14.5%, followed by Texas at 10.9%.[158] The state has experienced remarkable growth

156 see **https://www.energy.ca.gov/programs-and-topics/topics/power-plants/power-plant-licensing**.

157 see Census Bureau Statistics of U.S. Businesses, 2021 (**https://www.census.gov/data/tables/2021/econ/susb/2021-susb-annual.html**) and **https://www.nam.org/state-manufacturing-data/2021-california-manufacturing-facts/**

158 **https://labusinessjournal.com/retail/california-is-king-of-manufacturing/**

in “value added” manufacturing, outpacing the national rate three-fold since 1997, driving innovation and becoming a world supplier of goods in industries such as aerospace, computers, electronics, and more recently, zero-emission vehicles.[159]

California’s largest manufacturing hubs include San Diego, San Jose, Contra Costa, Los Angeles, Irvine, and Santa Clara, all promising potential locations for parts of the EV battery supply chain. Areas in close proximity to the Salton Sea include Los Angeles County, the state’s top county in manufacturing jobs (321,800 in 2022), as well as Orange County (155,400) and San Diego County (117,400).[160]

Currently, California’s manufacturing industry focuses on high-technology industries, including semiconductors, computers, peripherals, electronic components, and communications equipment. Computer and electronic product manufacturing is the state’s top industry, accounting for 22% of total manufacturing employment in 2022, though much of this employment is in headquarters, research and development, and other product development activities in firms producing electronic products, with actual production taking place elsewhere. Transportation equipment manufacturing is another 11% of total manufacturing employment, mostly in aerospace products and parts, but 2% of total manufacturing is already in motor vehicle manufacturing in the state.[161]

California’s prowess in manufacturing—and particularly the nimbleness it shows in manufacturing on the cutting edge of technology—positions it well for success in battery manufacturing. Harnessing the state’s proven manufacturing strengths can be a major asset in building a robust California battery manufacturing industry, with Imperial County potentially a critical part of this ecosystem.

Leveraging Proximity to Ports

There is a direct link between the strength of California manufacturing hubs and their proximity to the ports. The state has 12 ports, through which large volumes of goods are both imported and exported internationally. These ports vary in size, operations, and revenue. The two largest ports in the nation are the Port of Los Angeles and the Port of Long Beach, together transporting over 130 million tons a year. Despite recent disruptions at both ports, they still remain the port of entry and exit to ship goods like electronics, equipment, and agricultural products to and from Asian markets.[162]

For battery manufacturing, the proximity of ports could reduce transportation costs for any materials imported from Asia, and offer an advantage if the U.S. plans to expand domestically made EVs to global markets.

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159 **https://www.cmtc.com/hubfs/California%E2%80%99s%20Manufacturing%20Industries%20-%20Employment%20&%20Competitiveness.pdf?hsCtaTracking=ca09eb55-3c50-406c-a9d0-cc1958b1de8b%7C79bd892e-2572-4bc7-8a2e-73c0361b2143**

160 Figures from CA EDD LMID Employment by Industry, **https://labormarketinfo.edd.ca.gov/data/employment-by-industry.html**

161 Authors’ calculations from EDD LMID Employment by Industry data. **https://labormarketinfo.edd.ca.gov/data/employment-by-industry.html**

162 **https://lao.ca.gov/Publications/Report/4618.**

Established Leadership in Policy

Alongside its powerful technology ecosystem, California's policy infrastructure continues to play a major role in shaping the EV industry. The state has led the country in regulating auto emissions since the 1960s, and passed the first zero-emission vehicle (ZEV) mandate in 1990, requiring 10% ZEV sales by 2003. This stimulated GM's launch of the EV1, the first modern EV (Situ 2009). Updates to California ZEV regulations include the 2012 Advanced Clean Cars Program, which raised criteria in limiting overall greenhouse gas emissions and set targets for 22% ZEV sales in 2025; and the 2022 Advanced Clean Cars II regulation, requiring all new cars in the state to be zero-emission by 2035 (McConnell and Leard 2021; Tal, Davis, and Garas 2022).

Another California agency helping drive transportation electrification is the California Alternative Energy and Advanced Transportation Financing Authority (CAEATFA), which provides financial incentives through sales and use tax exclusions, aimed at attracting cutting-edge manufacturers that promote alternative energy and advanced transportation.[163] Other legislation has been specifically focused on supporting the reuse and recycling of batteries. AB199, passed in 2015, provided a sales and use tax exclusion for projects utilizing "recycled feedstock."[164] The California Recycling Market Development Act, passed in 2019, extends the program's duration until January 1, 2026, to support recycling initiatives, including battery recycling. Lastly, AB 209, enacted in 2022, allowed additional sales and use tax exclusions specifically for projects involved in the manufacturing, refining, extraction, processing, or recovery of lithium, with an allocated budget of $15,000,000 per calendar year for 2022, 2023, and 2024.[165]

California has a long-standing reputation as a leader in environmental action, leading the nation in air and water quality standards, natural resource protections, and ambitious decarbonization goals. The state passed its landmark California Global Warming Solutions Act ten years before decarbonization entered national policy meaningfully. Since then the state has set further targets to achieve carbon neutrality by 2045.[166] The state has taken significant steps to transition to a low-carbon economy, growing its renewables industry, setting ambitious goals to achieve 100% zero-emission vehicle sales by 2035 with rebates, and building charging infrastructure.[167] Moreover, time and time again, California has shown its commitment to progressive social policy, ranking as one of the top three states for workers, consistently raising the state's minimum wage, supporting union growth, and implementing policies around consumer protection, healthcare, gun control, and immigrant rights (Henderson 2023; Pastor 2018).

163 https://www.treasurer.ca.gov/caeatfa/index.asp
164 https://legiscan.com/CA/text/AB199/id/1265462
165 https://legiscan.com/CA/text/AB209/id/2606026
166 https://www.gov.ca.gov/2022/11/16/california-releases-worlds-first-plan-to-achieve-net-zero-carbon-pollution/
167 https://ww2.arb.ca.gov/news/california-moves-accelerate-100-new-zero-emission-vehicle-sales-2035

California has outsized clout in the automotive world: as of 2023, seventeen other states follow California's tailpipe emission rules for smog-forming and climate-warming pollutants, accounting for over 40% of new light-duty vehicle sales in the U.S.[168]

Its role as a longstanding leader in policy gives California particular credibility in the EV industry, another asset that can work to its advantage in gaining support for its high-road battery manufacturing industry.

Wielding the State's Economic Power for Good

California is considered the fifth largest economy globally if it were a country,[169] and has a diverse set of industries that make it an economic power, both in the United States and globally. From technology and innovation, entertainment and media, to agriculture and tourism, as well as green manufacturing, California has economic power, and with that power comes the ability to shape the economic trajectory of new industries. The preferences and purchasing power of the state can influence businesses and sectors, including the battery industry, and this has historically been the case as companies often cater to California's regulations and demands, adapting their products to meet the market. California has flexed this muscle before—being the first state to adopt a Buy Clean program to reduce the embedded emissions of construction materials purchased by public entities.

California is the largest consumer of electric vehicles in the country. The state represented 19% of all new car sales nationally in 2022, and this trend is only expected to grow as the state crossed 1.5 million cumulative EV sales, two years ahead of the state target.[170] Beyond the consumer market share, the State has also set public procurement targets (e.g., AB 739 and SB 498) that will continue to make it a major buyer of electric transportation as it greens the state fleets.[171]

Leading as an EV Innovation Incubator

The remarkable growth of the EV industry in California owes much to the broader ecosystem of technology innovation and growth in Silicon Valley. Tesla, for instance, has benefited from the region's skilled labor force and innovative ecosystem to maintain its technological leadership. The company was founded in Palo Alto in 2003, and for most of its history has competed on technology and design, only turning to a mass market model in the mid-2010s with the Model 3 (Turner et al. 2020).

The benefits of this ecosystem have not been not lost on other automakers, many of whom operate their own research offices and technology incubators in California, leveraging the state's network of technology companies, intellectual expertise, and research. The companies with design and technology

168 https://ww2.arb.ca.gov/our-work/programs/advanced-clean-cars-program/states-have-adopted-californias-vehicle-regulations
169 https://www.gov.ca.gov/2022/10/24/icymi-california-poised-to-become-worlds-4th-biggest-economy/
170 https://www.gov.ca.gov/2023/04/21/california-surpasses-1-5-million-zevs-goal-two-years-ahead-of-schedule/
171 https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180AB739 & https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201720180SB498

studios throughout the state range from EV startups to incumbent automakers, including Volvo, Aria Group, Five Axis, Ford, Hyundai, Tesla, Kia, General Motors, Honda/Acura, Toyota, Honda, BMW, Designworks, Volkswagen Group, Audi, Icona Design, Geely, Toyota, Mercedes-Benz, and Nissan. And as discussed in **Section 4**, while a significant cohort of companies that start in California go on to manufacture elsewhere, others like BYD have demonstrated that high-road manufacturing is viable in the state.

California's position as a hotbed for EV innovation supports its bid to host a major hub for battery manufacturing, but on its own is not likely to sway manufacturers committed to lowest-cost, low-road economic models. However, compiling these strengths can help gain additional support, particularly federal resources, and attract forward-thinking companies and investors to the area. Coupled with California's strong labor standards, these assets give California a head start and a strong competitive edge in an area that may prove "make or break" for manufacturers in coming years, i.e., the ability to attract and retain skilled workers. California has paved the way before, implementing clean energy and high-road policies well ahead of the curve. To claim its place in the U.S. battery manufacturing industry, to show by example that the high-road is possible and sets up a better future, it will once again have to be out in front.

A Promising Initiative

The Torres Martinez Desert Cahuilla Indians (TM) have the highest poverty and asthma levels in the state, even amongst other tribes. By contrast, their land base spans Imperial and Riverside counties and sits closest to the greenest lithium resource in the world. Faced with these stark contrasts and as stewards of the Salton Sea region, the tribe is leading on the vision for developing lithium in a way that maximizes sustainable and inclusive economic development for the state and the nation. They are currently engaged in the preplanning and development of a tribally led and owned green industrial campus–a turnkey ready offering for high-road employers in the advanced battery manufacturing supply chain.

Having taken stock of the potential of Lithium Valley, the ambitious high-road vision for its development and the benefits it can bring to Imperial County and beyond, the domestic market trends, and the particular challenges and competitive levers that must inform strategy around this project going forward, we now turn to our recommendations.

RECOMMENDATIONS

Based on our analysis, we propose the following recommendations to support high-road training and labor practices, to ensure that communities in Imperial County benefit from lithium extraction and battery manufacturing, to attract and keep innovative companies in California, and to create a more circular and transparent battery supply chain.

For in-depth guides on the tested high-road strategies we have drawn on here, we point stakeholders to the State of California's 2020 Jobs and Climate Action Plan (Zabin et al. 2020);[172] and to the high-road climate workforce report prepared as part of the San Diego Regional Decarbonization Framework (Zabin, Jones, and Jones 2022).[173]

The first two areas set out below—**supporting high-road workforce development** and **investing in locally serving infrastructure**—are immediate priorities to secure high-road labor outcomes and concrete community benefits in the already emerging lithium extraction phase. However, these levers must be implemented in tandem with medium and long-term policy planning around the buildout of a high-road battery manufacturing ecosystem in Imperial County and in the state. This entails building on the state's historic incubation of the EV and battery industry, but with a focus on ensuring that there is **an innovation to implementation pipeline,** providing the business benefits and public support for high-

172 **Putting California on the High Road: A Jobs and Climate Action Plan for 2030** , prepared at the behest of the California Workforce Development Board (CWDB) pursuant to California's AB 398.

173 **Putting San Diego County on the High-Road: Climate Workforce Recommendations for 2030 and 2050**.

road companies who stay and manufacture their technologies in the state. It also means **addressing permitting barriers** to ensure that companies can compete in California while also providing good jobs and career pathways for local workers. Finally, it means ensuring that there are mechanisms in place for **battery supply chain transparency** from extraction to recycling that can monitor, measure, and uphold environmental, labor and air quality standards. These recommendations are the critical steps in ensuring that California can create the high-road ecosystem of businesses innovating and manufacturing in the state, while simultaneously creating economic benefits for the workers who power those industries and the communities that host them.

R.1 Support high-road workforce development

State and local governments are providing significant resources to support lithium extraction in the region, including direct grants and subsidies. The state is also investing in the infrastructure needed to make lithium extraction possible, including in workforce development programs to help ensure a skilled local workforce. Community and public leaders should also help ensure that the jobs that emerge, both in the construction phase of the project and the ongoing operations, are high-quality jobs and that there are enforceable agreements to ensure job access for local residents.

RECOMMENDED ACTIONS

- **Condition public funding for private businesses on the negotiation of Community Benefits Agreements (CBAs) with labor and community groups.** Existing formalized agreements, or commitments to negotiate them, between industry, labor and community organizations, can be used as criteria to evaluate eligibility for, or maximize, funding available for a project. CBAs are formalized agreements between companies, workers and community groups. They elevate worker and community voices in project development and create avenues of ongoing partnership with the company to ensure a project's success. CBAs are tools proven to show that by elevating worker and community voices in project development residents and workers can ensure lasting avenues of ongoing partnership with the company to ensure a project's success. Typical CBAs contain commitments to local hiring, living wages, environmental protections, and shared decision making on a range of other issues relevant to the project and of concern to local communities. The U.S. Department of Energy (DOE) continues developing resources to support the use of CBAs in energy-related industries, including its **CBA Toolkit**,[174] and guidance on the use of proposal-stage **community benefits planning** during funding application processes, as a precursor to a subsequent CBA.[175]

174 https://www.energy.gov/justice/community-benefit-agreement-cba-toolkit
175 https://www.energy.gov/infrastructure/about-community-benefits-plans

- **To ensure a robust skilled workforce, deploy the following strategies to address skills and job quality in the following key sets of occupations**:
  - + For the **construction trades workers**, including those involved in maintaining equipment once facilities are operational, utilize the state-certified apprenticeship system.
  - + For the **blue-collar operations workers**, develop labor management High Road Training Partnerships (HRTPs) that include the key elements found in apprenticeship programs, including agreements on joint labor- and- employer input into training curricula and skill certification, shared funding, wage improvements as skills are acquired, and partnerships with training organizations such as community colleges. These high-road principles should be incorporated into existing workforce development programs in Imperial County, aligning the nascent HRTPs with ongoing investments in workforce training by Imperial Valley College for the blue-collar workforce in both extraction and future operations work.
- For the professional and technical workers who need higher-education degrees at the two-year, four-year, or graduate level, utilize the community colleges and state university for training, articulating degree pathways in consultation and collaboration with industry.

R.2 Invest in locally serving infrastructure

Developing new industries requires reliable transportation networks, modern utilities, and access to education and healthcare facilities. Both community and industry need upgrades to the electric grid, roads, and broadband/internet. But there is a danger that infrastructure development will be focused narrowly on what is required to extract lithium and ship it to external markets. Instead, infrastructure investments should be designed to support lithium extraction as well as foster the co-location of a broader supply chain and economic diversification throughout the county.

This includes investments in physical and social infrastructure to improve quality of life for those living and working in the area, such as public health services, public transportation (both within Imperial County and connecting it to other population centers), climate resilient housing, and environmental restoration related to Salton Sea management and air quality. This not only benefits the companies located in Lithium Valley, who will be able to recruit and retain workers, but is also an important step towards inclusive economic development for the communities in Imperial Valley who are hosting and supporting this new industry.

RECOMMENDED ACTIONS

- **Use county revenue from the lithium extraction excise tax to fund not just infrastructure supporting lithium companies and their extraction and transportation needs, but also infrastructure that will benefit the local community and support diversified economic**

development (e.g., roads, public transportation, updating electric grid, improving broadband access). The County is already investigating infrastructure needs as part of the Programmatic Environmental Impact Review (PEIR) process. We are recommending that revenues from the lithium extraction excise tax be used to also support infrastructure development that can support broader economic diversification and quality of life initiatives in the area.

- **Incentivize companies to support investment in local infrastructure through suggested CBA provisions informed by the needs of Imperial County residents.** This would allow for alignment with community needs while ultimately helping lithium companies to recruit and retain the workers they need, as well as helping build out opportunities for high-road manufacturing in the region. The State could also incentivize companies to invest in community-supporting infrastructure by requiring companies to submit community benefits plans as part of funding applications, as the Department of Energy has done for companies applying for funding under the Bipartisan Infrastructure Law and Inflation Reduction Act.[176]
- **Secure more state and federal funding for critical infrastructure to support a high-road advanced battery supply chain.**

R.3 Keep manufacturing in California by supporting an "Innovation to Implementation" pipeline

Building a green manufacturing industry in Imperial County will require significant collaboration across multiple sectors, between federal, state, and local actors, to support high-road companies leading the race to the top. Coordinating multiple policies to support economic development along the full lithium supply chain is critical to create the conditions for high-road development in regions like the Imperial Valley.

This report highlights a trend of innovations developed in California being taken out of state for manufacturing. An important part of building high-road manufacturing is ensuring that employers who start in California stay in California, all while incentivizing the high road. While standards (the "sticks" in a policy context) play a part, there must also be incentives ("carrots") to reward companies that adopt high-road labor practices like CBAs, labor peace agreements, and HRTPs.

RECOMMENDED ACTIONS

- Increase funding to California clean energy entrepreneur support organizations and accelerator programs that support high-road pathways for startup commercialization in lithium supply chain related enterprises.

176 https://www.energy.gov/infrastructure/about-community-benefits-plans

To build on these incentives and support California's homegrown innovation hubs, California should support the in-region commercialization of rich innovation originating in California in collaboration between state and federal agencies. Incentives can be provided to California companies and startups who are receiving California incubator program money and who commit to keeping their prospective advanced manufacturing operations in the state. These can look similar to or build on existing programs including the CEC advanced technology grants, CalSEED, and CalTestBed. Part of this funding would support pathways to commercialization for startups that receive seed grants, particularly for those involved or pursuing ideas in battery / clean manufacturing. This support would also include assistance in applying federal grants, and providing further funding if they stay in California. To ensure these partnerships were high-road, this funding and support would include connection with HRTPs to proactively build a manufacturing workforce.

- **Provide public resources and match federal dollars for companies with high-road labor standards that commit to keep lithium supply chain manufacturing in California.**

To incentivize companies to set up manufacturing operations in California, the state can build on the federal green labor standards: either by setting incentives of their own for projects, or by supporting companies in applying for federal funding, ensuring that funding is matched or that California provides an extra portion for companies meeting these requirements. Partnering with the federal government for targeted high-road investment into lithium valley can be extremely impactful during this time, and utilizing that partnership to further build out labor incentive standards would ensure a two-fold objective of bringing companies to California while also ensuring that they adhere to high-road labor practices.

The state has the ability to provide seed dollars that can unlock federal dollars specifically earmarked for high-road green development. The federal dollars are meant to advance workforce standards; California investments can be used to leverage this federal funding for high-road outcomes, by incentivizing companies that take the high road to stay in California.

California also has the ability to support companies in applying for federal funding, making their application stronger. The example of the battery startup SPARKZ is a compelling one: the company set up in California and partnered with the United Auto Workers (UAW), including agreeing to be neutral on unionization. SPARKZ is explicitly basing its strategy on showing that the high road is the best business case, particularly for manufacturing.[177] For Imperial County, collaborating with companies on securing federal funding is also a means of building trust with companies looking to set up in the area.

- Create statewide workforce standards and condition funding for battery manufacturing companies that receive state dollars on the development of community benefits agreements (CBAs).

177 https://www.reuters.com/business/autos-transportation/battery-startup-sparkz-strikes-partnership-with-auto-workers-union-2023-04-25/

At the same time, the state must ensure workforce standards that support the race to the top. A direct way to do this is by setting up workforce standards for battery manufacturing (or green manufacturing in general), and conditioning funding for companies on their development of CBAs.

- **Create a "high-road employer accelerator program" to provide technical assistance for companies who are committed to shared prosperity and partnerships with labor and community.**

R.4 Address permitting barriers for high-road employers

Making the permitting process more efficient will be necessary if Imperial County and California are to attract investment in green industries. Expedited permitting, for example, can be made available for projects that have formalized agreements and support from community members and local organizations. Through a CBA, where companies have committed to shared decision making and regular convenings with community stakeholders regarding specific issues of community concern, public agencies can allow for expediting permitting without sacrificing environmental protections, local community concerns, and transparency.

RECOMMENDED ACTIONS

- Support the creation of a Regulatory Roadmap for companies interested in setting up a manufacturing facility in Imperial County.

One of the more immediate ways to mitigate permitting barriers is to encourage the use of regulatory checklists that clearly spell out permitting requirements and what a company should expect. California currently encourages this for EV charging infrastructure throughout the Permitting Olympics program. This idea can be taken a step further through the development of an industry- and city-specific Regulatory Roadmap program, inspired by the State of Washington. The Roadmaps are essentially a website where companies input information about their prospective facility and receive information such as zoning districts that are feasible for their facility, likely requirements, the sequence of regulatory approvals needed along with the estimated time and cost. With support from the State, Imperial County could develop a similar program.

A novel addition to this tool would be to gather input from community and labor organizations and include information about the surrounding communities, suggested CBA and labor provisions, and advice about effective community engagement, so that these expectations are clearly communicated upfront.

- **Create a regulatory streamlining district for desired project types, building on the outcomes of the Programmatic Environmental Impact Report (PEIR) process and conditional on commitment to high-road standards.**

The California Governor's Office of Business and Economic Development (GO-Biz) highlights several "place-based" economic development strategies for local agencies, one of which is Regulatory Streamlining:

> Regulatory streamlining districts enable local agencies to establish an area-wide regulatory evaluation system that covers qualifying individual projects within the defined boundary. These districts enable local agencies to incentivize desired project types (e.g., affordable housing) by removing project-based environmental reviews for developments that meet established criteria.[178]

Two examples of this are Housing Sustainability Districts and Workforce Housing Opportunity Zones, which come from state-level policies that allow local agencies to create regulatory streamlining districts to encourage housing development.

Beyond regulatory streamlining, states and counties can take stronger measures to incentivize development by providing industry-supporting infrastructure or tax incentives, such as in the **Tahoe Reno Industrial Center**, a privately owned development outside Reno where most industrial uses are pre-approved. However, this must be carefully implemented to avoid undercutting environmental and community protections. To stimulate a race to the top rather than enabling a race to the bottom, expedited permitting should be conditional on adherence to the high-road practices described in this report.

- **Identify suggested CBA provisions as part of the PEIR process, including proactive permitting discussions, and drawing on some of the recommendations made in reports led by Imperial Valley community organizations (Naimark 2023).**
- **Utilize long-range land use planning, and work with Tribal Nations, to identify areas that are desirable for manufacturing, including areas where communities are supportive and do not conflict with tribal cultural resources.**

To accelerate the clean energy transition, a recent report from the Roosevelt Institute called on land managers and planners to employ comprehensive land-use planning identifying lands and corridors where renewable and transmission infrastructure projects can be built rapidly, equitably, and without controversy (Bozuwa and Mulvaney 2023). Similarly, state and county governments could proactively identify areas that are desirable for manufacturing, including areas where communities are supportive.

178 https://economicdevelopment.business.ca.gov/place-based-strategies/

- **Work with Tribal Nations in the region to explore interest and suitability for tribally led and owned turnkey ready manufacturing sites on tribal lands, similar to the Tahoe Reno Industrial Center but designed to attract and support high-road employers.**

Developments on Native American reservations must comply with the National Environmental Policy Act (NEPA) and other applicable Federal laws, but as sovereign nations, they are not always required to complete CEQA analyses for projects within their reservations, though depending on the type of project, funding source or location, they may be subject to CEQA requirements, especially related to more limited analyses of off-reservation impacts. There may be a number of sites in the broader Salton Sea region that would be appropriate for battery component, cell, and pack manufacturing.

R.5 Support battery supply chain transparency initiatives

Local communities and environmental justice organizations have raised the importance of transparent monitoring and accountability for environmental and public health impacts, particularly related to waste management and water use (Naimark 2023).

Supply chain transparency is a necessary mechanism to reward companies for implementing high-road practices and investing in sustainable manufacturing (WEF 2021). Traceability is a key lever because it facilitates carbon accounting in value chains, which enables California's low-carbon grid to be a competitive advantage. This advantage would be significant for lithium or batteries produced in Imperial County using geothermal energy. Traceability mechanisms could also be used to verify domestic and recycled content. If suppliers were also required to report labor metrics, it would be possible to verify and reward high-road employment practices along the value chain. The ability to trace the source of minerals and component production along the entire supply chain could also give EV manufacturers a clear marketing advantage with environmentally and socially conscious consumers. People purchasing electric vehicles are typically motivated at least in part by environmental concerns. Knowing that the lithium in their vehicle came from relatively environmentally friendly processes in the Salton Sea Geothermal Area, rather than hard rock mining or large-scale evaporation ponds, would be a benefit.

Traceability is also critical to sustainable, safe, and efficient end-of-life (EOL) management. Better access to information supports stakeholders in the reuse and recycling industries who need to know the battery's chemistry and remaining capacity to handle it properly. Batteries can be reused in vehicles as affordable replacement packs, repurposed into stationary storage systems that help facilitate the integration of renewables, or recycled to recover the constituent materials, effectively creating a domestic source for critical mineral supply as more vehicles reach the end of their service lives.

Eventually, California could create standards for EV battery sustainability, for example, by requiring that EVs have below a specified level of carbon emissions during production in order to be eligible for tax incentives, similar to the low-carbon fuel standard. However, this would require additional research to determine an appropriate threshold, calculation protocol, and reporting mechanisms.

There have been proposed efforts by the Global Battery Alliance, as well as the European Union[179] and China, to establish battery passport programs that can be used to manage the industry's environmental, social and governance impacts. This type of program establishes a digital twin for every individual physical battery that conveys information about all the environmental and social dimensions of the production cycle (including recycling). California should support and actively participate in the development of existing transparency initiatives, such as the Global Battery Passport, advocating that they require company-reported data about emissions and labor practices during production.

RECOMMENDED ACTION

- **As the California legislature considers how to institutionalize battery infrastructure, they should actively participate in the development of existing transparency initiatives, such as the Global Battery Passport, and require company-reported data about emissions and labor practices during production.**

179 The European Commission's 2023 Green Deal policy would require a digital product passport (DPP) for all batteries sold in Europe. The key provisions were reached in a preliminary agreement in December 2022 and are expected to be adopted in 2024, for entry into force in 2027. When implemented, the Green Deal will establish a digital twin for every individual physical battery that conveys information about all the environmental and social dimensions of the production cycle (including recycling).

CONCLUSION

With lithium being a critical element in the green transition, the unique lithium resource in Imperial County presents a tremendous opportunity for a region of our state that has long been left behind and kept behind. Through investments in the companies actively pursuing lithium extraction in Imperial County, major automakers such as Ford, General Motors, and Stellantis have shown their interest and confidence in the Lithium Valley region as an emerging source of lithium. However, without intentional action now, there are no guarantees that residents of Imperial County will benefit meaningfully from the recovery of this lithium.

Around the world, examples abound of resource-rich communities that have seen few if any economic benefits from extraction; that have been left out of the planning and shaping of industries that affect them, only to be left legacies of environmental destruction and toxic dumping, while corporations profit. With sufficient community mobilization and government intervention, a better way is possible. In Imperial County, it is possible for lithium to be recovered with minimal environmental impact, and for Community Benefits Agreements (CBAs) and High Road Training Partnerships (HRTPs) to lead to a just and sustainable manufacturing hub in the region, delivering good jobs for local residents and supporting a broader high-road battery industry in California.

The state can use its tested high-road tools to ensure that the already planned lithium extraction—with first production expected in late 2025 or 2026—benefits the local community. Labor and community organizations have already secured a lithium extraction excise tax, passed by the State of California, which will provide a revenue source and a process that gives local residents a voice in its use. The State has also allocated funding to Imperial County to help prepare a Programmatic Environmental

Impact Report and establish a Lithium Valley Development Office, and to community organizations to help ensure broad community input into the process. Important state and local workforce development initiatives include work by Imperial Valley College to develop a Lithium Industry Force Training program and California state funding to expand San Diego State Universities Brawley campus to focus on STEM. The State has also funded a High Road Training Partnership planning grant led by the San Diego & Imperial Counties Labor Council to help promote high-road jobs in lithium recovery and related production.

These encouraging initiatives need further support to ensure that the jobs created by lithium extraction will be good jobs for local residents. Local coalitions are seeking CBAs with private lithium developers to ensure that workers have a voice, that wages and benefits are family-supporting, and that local workers are hired into these good jobs. Only with such agreements, or related policies with the same goals, can the training infrastructure that is currently being built best support high-road outcomes for workers.

For the more ambitious vision of Lithium Valley, where the jobs multiply due to landing more of the battery supply chain in the region, much more significant government support is needed. There are reasons why companies operating according to a lowest-cost logic would choose not to locate in Imperial Valley, but with strategic investments and incentives, and the right support, these reasons can be offset for companies amenable to high-road operations. California offers geographic and other advantages, and in the face of post-pandemic workforce challenges, companies may increasingly view the strong skilled workforce supported by the high road as a sound strategic investment. Moreover, there is political will to develop green industries in a way that benefits communities that have been left out from economic opportunity. Imperial County is a good place to try to do this, and its rare lithium resource—recoverable with a lower carbon and land footprint than most—provides a strong motivation.

The high-road co-location of further advanced battery chain jobs alongside Imperial Valley lithium extraction is ambitious but possible, and can multiply the benefits for the communities in Imperial County. We have discussed the most accessible prospects for co-location, notably CAM, as well as further possibilities, from component production to EV manufacturing. Looking beyond these horizons, battery recycling and reuse could also offer synergistic benefits in Lithium Valley, as the materials recovered from recycling old batteries can be used in new production. As EV retirement ramps up over time, spurring the recycling and reuse market, this represents a promising longer-term prospect for Lithium Valley, consistent with its brand as a specialized high-road advanced battery ecosystem, and a pioneering example of sustainable, just, and inclusive new green industry.

LIST OF INTERVIEWEES

Charita Allen
Tennessee Economic Development Council

Angelo Braun
Redwood Materials

Veronica Chavez
Economic Development Authority of Western Nevada

Tim Kelley
Imperial County Economic Development Corporation

Bernie Kotlier
IBEW-NECA Labor Management Cooperation Committee

Priscilla Lopez
Imperial County Workforce Development Board

Cristina Marquez
IBEW Local 569

Nancy McCormick
Economic Development Authority of Western Nevada

John McMillan
San Diego State University

Antara Murshed
Jobs to Move America

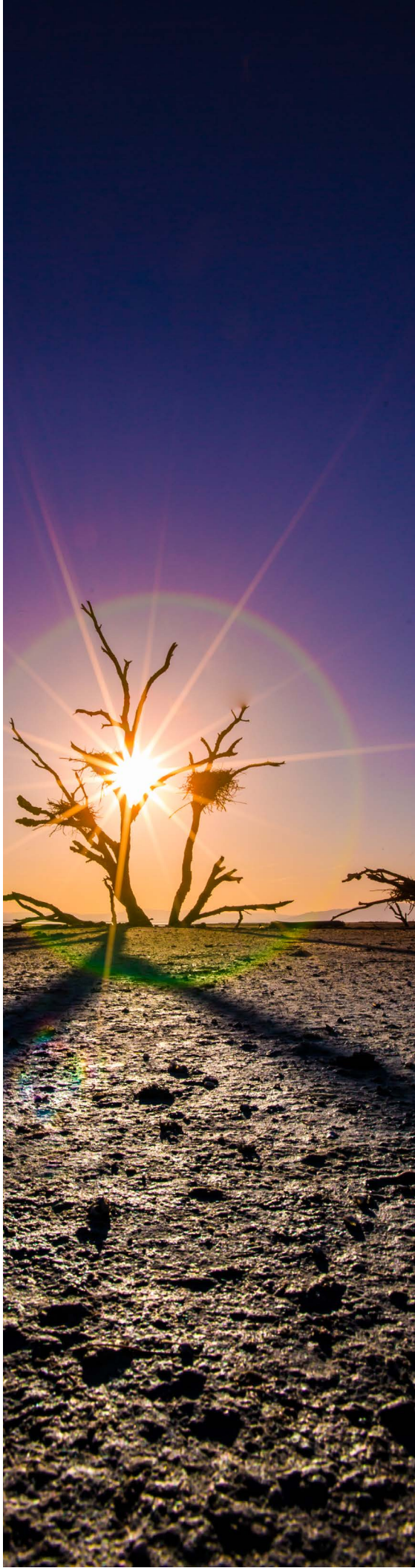
Jared Naimark
Earthworks

Vince Signorotti
Energy Source Minerals

Efrain Silva
Imperial Valley College

Chris Self
Clarksville Industrial Development Board

Will Tucker
Jobs to Move America

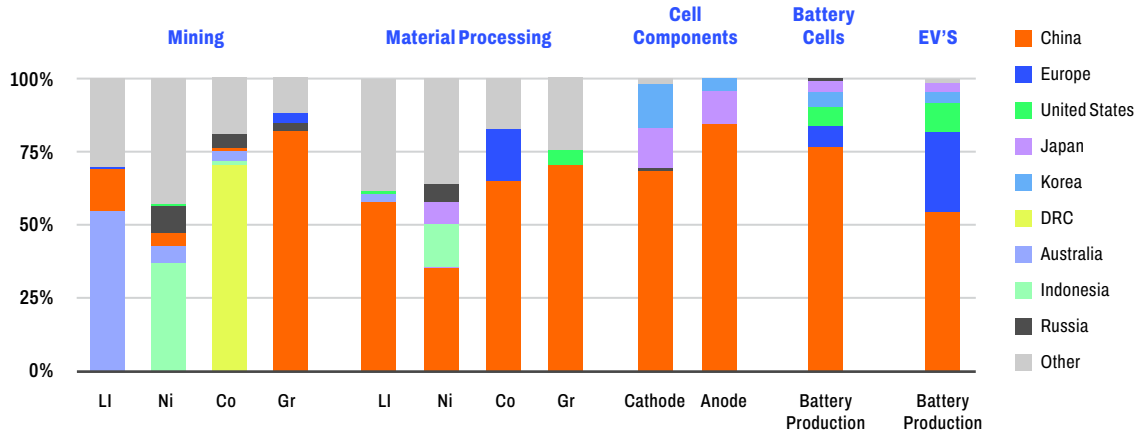


APPENDIX

GLOBAL CONTEXT OF THE LITHIUM SUPPLY CHAIN

In pursuing economic opportunities related to lithium mining in Imperial County, it is important to understand the full global value chain: the different components of the value chain, which countries currently lead in those components and why, and which steps in the value chain show the greatest potential for growth in the United States. From the technical detail provided below, we draw two major conclusions. First, most of the battery industry currently exists outside the U.S. China is not the largest site of lithium mining operations, but is the largest downstream producer, providing over 50% of world production in materials processing, battery component and cell manufacturing, and electric vehicle production. In 2021, China produced 75% of all lithium-ion batteries, while the U.S. made only 7%. China also plays a major role in other basic materials, extracting the majority of the world's graphite, and refining the majority of raw cobalt and lithium. They are also the global center for producing battery cell components, battery cells, and electric vehicles. Current trends suggest that the U.S. will expand

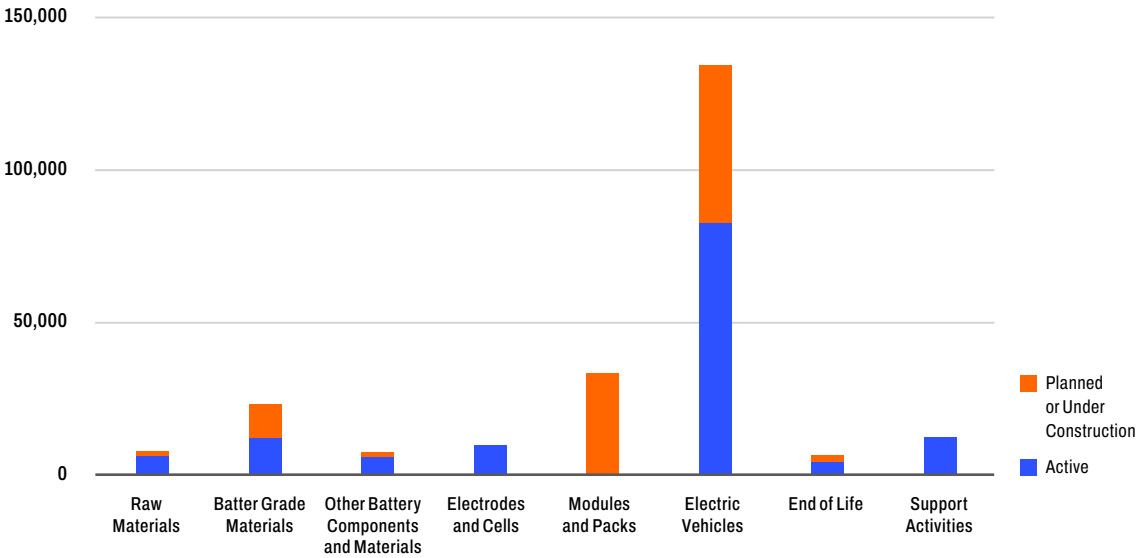
capacity in the overall value chain, eventually reducing China's dominance in the industry, but this will take time and require sustained investment and policy support.



NOTES: Li=Lithium, Ni= Nickel, CO=Cobalt, DRC=Democratic Republic of Congo. Geographical breakdown refers to the country where the production occurs. Mining is based on production data. Material processing is based on refining production capacity data. Cell component production is based on cathode and anode material production capacity data. Battery cell production is based on battery cell production capacity data. Ev production is based on ev production data. Although Indonesia produces around 40% of total nickel, little of this is currently used in the EV battery supply chain. The largest class 1 battery grade Nickel producers are Russia, Canada and Australia.

SOURCE: IEA analysis based on: EV Volumes; US Geological Survey (2022); Benchmark Mineral Intelligence; Bloomberg NEF.

Second, as discussed in **Section 2**, for the U.S., the largest employment opportunities are in battery manufacturing, rather than in the raw materials, refining, and processing end of the industry. With the growth of the EV industry and the incentives in the federal Inflation Reduction Act to support domestic production, we are seeing projected rapid job growth in electrode, cell, module, and pack manufacturing, based on facilities that have been announced or are under construction (see **Figure 3**).



There are five major steps in the full value chain linked to the build out of a lithium-ion battery production system: 1) mineral extraction and refining, not only of lithium but also other critical minerals; 2) manufacturing the critical components of a lithium-ion battery; 3) manufacturing the battery cell and battery pack; 4) assembly in the final product, most substantially electric vehicles; and 5) reusing and recycling lithium-ion batteries when their life in a vehicle is over. We will review each of these in turn.

A.1 MINERAL EXTRACTION AND REFINING

Minerals are a critical component of electric vehicles, far more so than in internal combustion engine vehicles. Not including steel and aluminum, a typical electric vehicle contains over 207 kilograms (kg) of minerals, compared to less than 40 kg in a conventional car.[180] Here, we focus on lithium, given its central importance in the production of lithium-ion batteries, but other critical minerals are also needed for battery production, including nickel, cobalt, manganese, and graphite. Two additional minerals—copper and rare earths—are critical for the EV motor. We have therefore looked at global production and reserves, and U.S. production, in each of these critical minerals as well.

180 https://www.iea.org/data-and-statistics/charts/minerals-used-in-electric-cars-compared-to-conventional-cars

Mineral	Production 2022	Total Production 2022 (tons)	Reserves	Resources	Total Estimated World Resources
Lithium	Australia (47%), Chile (30%), China (15%), Argentina (5%), U.S. (4%)	130,000	Chile (36%), Australia (24%), Argentina (10%), China (8%). Total: 26,000,000 tons	Bolivia (21%), Argentina (20%), U.S. (12%), Chile (11%), Australia (8%), China (7%)	98,000,000
Nickel	Indonesia (48%), Philippines (10%), Russia (7%), New Caledonia (6%), Australia (5%)	3,300,000	Indonesia (21%), Australia (21%), Brazil (16%), Total: more than 100,000,000 tons	widespread	at least 300,000,000
Cobalt	Democratic Republic of Congo (68%), Indonesia (5%), Russia (5%)	190,000	Democratic Republic of Congo (48%), Australia (18%), Indonesia (7%), Cuba (6%). Total 8,300,000 tons	Vast majority are in Congo, Zambia, Australia. About 1,000,000 tons in the U.S.	25,000,000, plus more than 120,000,000 in polymetallic nodules and crusts on ocean floors
Manganese	South Africa (36%), Gabon (23%), Australia (17%), China (5%), Ghana (5%)	20,000	South Africa (38%), Australia (16%), China (16%), Brazil (16%). Total: 1,700,000 tons	South Africa accounts for an estimated 70% of world's resources. U.S. sources are of low concentration, and expensive to recover	
Graphite	China (65%), Mozambique (13%), Madagascar (8%), Brazil (7%)	1,300,000	Turkey (27%), Brazil (22%), China (16%), Mozambique (8%), Madagascar (8%). Total: 330,000,000 tons	Domestic U.S. sources are small	more than 800,000,000
Rare Earths	China (70%), U.S. (14%), Australia (6%)	300,000	China (34%), Vietnam (17%), Brazil (16%), Russia (16%). Total: 130,000,000 tons	Rare earths are abundant in the Earth's crust, but minable concentrations are less common. North American resources include 3.6 million tons in the U.S. and more than 14 million in Canada	
Copper	Chile (24%), Democratic Republic of Congo (10%), Peru (10%), China (9%), U.S. 6%)	22,000	Chile (21%), Australia (11%), Peru (9%), Russia (7%), U.S. (5%). Total: 890,000 tons	About 38% of known resources in South America, 23% in North America, 9% in Central and Eastern Asia	at least 2.1 billion tons

Source: U.S. Geological Survey (2023), Mineral Commodity Summaries 2023: U.S. GS, 210p. https://doi.org/10.3133/mcs2023.

Lithium

Total world production of lithium in 2022 was estimated at 130,000 tons,[181] with four countries (Australia, Chile, China, and Argentina) accounting for 93% of total world production. Australia alone produced 45% (61,000 tons) of the world total. An estimated 26 million tons of available **reserves**[182] have been identified in major producing countries, with Chile having the largest estimated total (9,300,000 tons). However, with continued exploration, the volume of identified potentially economically viable lithium **resources** has grown substantially in recent years, to a global total of nearly 100 million tons. The U.S. is an important source of these potential lithium resources, with 12 million tons estimated to exist in the U.S. Outside the U.S., the other major site of new potential resources is in the "lithium triangle" in South America, with Bolivia at 21 million tons, Argentina 20 million tons, and Chile 11 million tons of identified lithium resources (USGS 2023).

There are currently two main natural sources of commercial lithium: lithium-rich brine and lithium-bearing rock. Brine is the primary source of lithium in Chile and Argentina and accounts for the majority of lithium in China. To access this lithium, mineral-rich brine is pumped to the surface, where it is passed through a series of large evaporation ponds. As the brine sits in the sun, some of the water evaporates and other materials (e.g., sodium, potassium, boron, magnesium) are precipitated out, leaving behind a concentrated lithium chloride solution that can be processed into lithium carbonate. Though estimates vary, roughly only 50% of the lithium in the brine is recovered, with the rest being lost in precipitated by-products (Khalil et al. 2022; Lewkowicz 2022). This production method has a relatively low carbon footprint because it relies primarily on energy from the sun. The estimated direct freshwater consumption is also relatively small: 9–23 cubic meters per ton of lithium carbonate, compared to 62 cubic meters for lithium produced from rock (Kelly et al. 2021). However, the process requires a substantial amount of land, and large volumes of brine are pumped from below the surface and evaporated into the atmosphere. This has significant impacts on the local environment and hydrology in these arid regions, with evidence of significant disruptions in local fresh water aquifers and groundwater levels (Blair et al. 2023; Garcés and Alvarez 2020).

181 Unless otherwise noted, all lithium quantities are reported as core lithium. Lithium is a highly reactive metal and, when used for different applicants, typically occurs in various compounds, including lithium carbonate, lithium hydroxide, and lithium chloride. Many sources will use Lithium Carbonate Equivalent or LCE as a standardized measure across these different compounds. As a general guideline, the conversion used in the industry between lithium and LCE is approximately 5.3, so that 130,000 tons of lithium translates into 689,000 tons of LCE.

182 The USGS defines "reserves" as "working inventory of mining companies' supplies of an economically extractable mineral commodity." The broader category of "resources" includes other identified and inferred amounts of material which could potentially be economically feasible to extract.

The other major production pathway is to extract and refine lithium from lithium-bearing rock, primarily spodumene, a lithium-containing mineral found in some pegmatite rocks. Australia is the major source of lithium mined from spodumene, with some hard rock mining also occurring in China. The spodumene is mined from underground, then crushed and leached with sulfuric acid (Tadesse et al. 2019). The process requires heat and chemical inputs, leading to a higher carbon footprint compared to evaporation (Kelly et al. 2021).

Globally, there are only a handful of corporations that extract the vast majority of the world's lithium, with China and Australia dominating as the headquarters sites of most companies (see below). The one exception is Albemarle Corporation, which is headquartered in North Carolina. Albemarle is the largest global producer of lithium, though it competes for this title with the Chinese company Ganfeng Lithium. It should be noted that there is a substantial level of cross investment in the lithium industry, and many mining operations involve more than one major corporation. For example, China-based Tianqi Lithium has a 51% ownership stake in the Greenbushes mine in southwestern Australia, which is jointly owned with Albemarle.

Major lithium companies worldwide

Company Name	Headquarters	Total Sales	Global Employees	Lithium Production	Major Lithium Locations
Albemarle Corporation	U.S. (North Carolina)	$7.3 billion (2022, roughly 80% from lithium)	7,400	200,000 tons LCE (2022)	Silver Peak, NV Kings Mountain, NC Salar de Atacama, Chile Antofalla, Argentina
Ganfeng Lithium	China	$6 billion (2022)	10,000+	120,000 tons LCE (2021)	China Argentina Australia
Tianqi Lithium	China	$1.07 billion (2021)	2,000		Australia Chile China
SQM	Chile	$8.15 billion	6,081 (as of 12/31/2021)	157,000 tons LCE (2022)	Atacama Desert, Chile Australia
Pilbara Minerals	Australia	$1.16 billion (2022)		377,902 tons Spodumene concentrate	Australia
Mineral Resources	Australia	$3.4 billion (2022)			Australia
Allkem	Australia	$1.1 billion			Australia

Lithium extraction taking place in the U.S. is currently very limited, with only one active mine producing commercial lithium (Silver Peak, Nevada). A number of additional resources are being explored or are under development in the U.S.

Like all minerals, getting lithium out of the ground is only the first step: it must go through further refining and then be incorporated into materials ready for components of a lithium-ion battery or other EV components. For evaporation ponds, as described above, lithium is usually recovered as lithium chloride. It has to be refined to battery-grade lithium carbonate (LiCO3) or lithium hydroxide (LiOH) before it can be used as an input in battery production. In the other method, producing lithium carbonate from spodumene typically requires grinding the ore, and then roasting the powder at high temperatures to convert the lithium-containing minerals into water-soluble compounds. The compounds are leached with sulfuric acid to produce a lithium rich liquid, which is then purified (e.g., through selective precipitation, ion exchange, and/or crystallization) to eventually produce lithium carbonate. The details of the extraction process vary depending on the specific characteristics of the spodumene ore, the desired product, and the available technology at the processing facility.

Lithium is then combined with a variety of other critical minerals to form the active materials in the cathode, the most complicated part of the battery (more on cathodes below). The composition of the cathode active material (CAM) is a key determinant of battery performance and cost, and lithium-ion batteries are typically identified by their cathode chemistry; for example, a lithium-ion battery with a cathode containing nickel, manganese, and cobalt is referred to as an “NMC battery.”

Nickel

The largest nickel producers in the world are Indonesia, the Philippines and Russia, with Indonesia alone providing nearly 50% of total production in 2022. Total global production in 2022 was 3.3 million tons, with identified global reserves of over 100 million tons, much of it in Indonesia, Australia, and Brazil. Leading global nickel suppliers include the Brazilian mining firm Vale,[183] Norilsk Nickel (Russian),[184] Jinchuan Group Ltd (Chinese),[185] Glencore (Swiss),[186] and BHP Billiton Ltd (Australian)[187] (Harrison and Ludwig 2022). On a global scale, the U.S. is a relatively small producer, producing only 1% of total global nickel, much of it from the Eagle Mine in Michigan.[188] Talon Metals Corporation received $115 million from the U.S. Department of Energy in 2022, through the Bipartisan Infrastructure Law, to construct a Battery Mineral Processing Facility in North Dakota, focused on nickel processing that will in part supply Tesla with battery-grade nickel; the company is also associated with a high-trace nickel sulfide deposit discovered in central Minnesota (USGS 2023).[189]

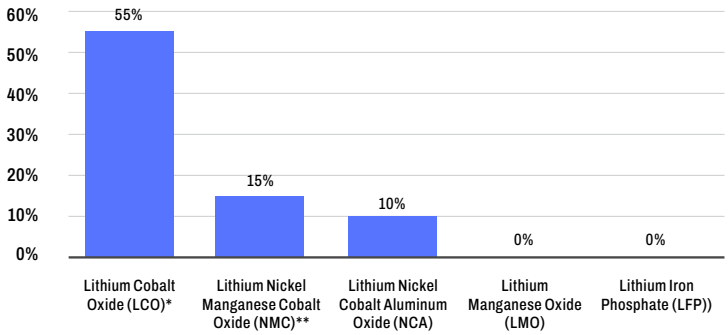
183 https://www.vale.com/nickel-and-cobalt-products
184 https://www.nornickel.com/
185 https://www.jinchuan-intl.com/en/index.aspx
186 https://www.glencore.com/what-we-do/metals-and-minerals/nickel#:
187 https://www.bhp.com/what-we-do/products/nickel
188 https://www.eaglemine.com/
189 https://talonmetals.com/talon-metals-battery-minerals-processing-facility-selected-by-us-department-of-energy-for-114-million-in-bipartisan-infrastructure-law-funding/

Cobalt

The Democratic Republic of the Congo (DRC) is by far the world's largest cobalt producer, providing 130,000 tons in 2022, or 70% of total commercial production. There are serious concerns about environmental and labor conditions in Congolese mines. An estimated 15–30% of Congolese cobalt comes from so-called artisanal miners—independent workers doing extremely dangerous labor for low wages, with a substantial proportion of child labor. The mining industry overall has been criticized for cutting down millions of trees, contaminating water supplies, and contributing to poor air quality with large amounts of dust and grit ending in the air (Kara 2023). This, combined with the political volatility and conflicts in the DRC, has led many battery and EV manufacturers to try to contract directly with cobalt suppliers, and to increasingly develop battery technologies that can limit the use of cobalt altogether (see graph below) (Harrison and Ludwig 2021).

The U.S. is currently a negligible producer of cobalt on a global scale, with some operations at the nickel-copper Eagle Mine in Michigan, a nickel-copper-cobalt operation in Missouri, and a new cobalt-copper-gold mine in Idaho. The U.S. does have an estimated 1 million tons of cobalt resources, mostly in Minnesota, but in most cases, any future cobalt production from these deposits would be a byproduct of mining for another metal, mostly copper. The vast majority of global cobalt resources are in large copper deposits in DRC and Zambia, or nickel-bearing deposits in Australia (USGS 2023).

Refined cobalt composition share in selected lithium-ion batteries, by volume, 2017



*NOTES: *LCO batteries have the highest concentration of Cobalt; however, they are not commonly used in EV's. **NMC batteries are commonly used in EV's and electric motorbikes.*

SOURCE: (Matthews 2020)

The Swiss multinational company Glencore is the world's largest cobalt-producing mining company, with an output of nearly 44,000 tons of cobalt in 2022, up 40% from 2021.[190] Other major global producers include Eurasian Resources Group, a privately held company with headquarters in Luxembourg; China Molybdenum, which is partially owned by the Chinese government; and a Congolese state-controlled cobalt mining company called Gécamines.[191] Chinese companies have significant investments in most of the large cobalt mines in the Democratic Republic of Congo as well.

190 https://www.glencore.com/media-and-insights/news/full-year-2022-production-report

191 https://investingnews.com/daily/resource-investing/battery-metals-investing/cobalt-investing/top-cobalt-producing-companies/

Manganese

Manganese ore has not been produced in the United States since 1970. Most manganese ore consumption is related to steel production, and some manganese is recovered in recycling operations along with iron, from steel slag. However, the critical role of manganese in batteries has led to its inclusion on the list of critical minerals in the U.S. Globally, South Africa, Gabon, and Australia are the largest producers, together accounting for 75% of global production. Total annual production of manganese in 2022 was 20,000 tons, and total identified reserves are nearly 2 million tons globally, so it is not a rare mineral, but an estimated 70% of the world's manganese resources are in South Africa, with U.S. resources being of very low grade and thus potentially costly to extract (USGS 2023). The world's leading manganese companies include Australian firms BHP and South32 (which was spun-out from BHP in 2015), the South African founded but now UK-based firm Anglo-American plc, and French multinational Eramet (Harrison and Ludwig 2022).

Graphite

Graphite is another critical battery-related mineral not currently produced in the U.S. China accounted for 65% of total global graphite production in 2022, with a total output of 850,000 tons. Mozambique, Madagascar, and Brazil together make up another 28% of total global production. In addition to China, there are large known reserves of graphite in Brazil, Turkey, and southeast Africa (Tanzania, along with Mozambique and Madagascar). U.S. domestic graphite resources are relatively small and not seen as a significant source for future graphite production (USGS 2023).

Graphite is used primarily as the active anode material, preferred for being a good electrical and thermal conductor, and for being chemically unreactive, corrosion resistant, and highly stable, even at high temperatures (Tsuji 2022). Natural graphite has higher charge-storage capacity and lower costs, but loses capacity more quickly and has lower cycle life than artificial graphite, which is produced from calcined petroleum coke or coal tar pitch. Artificial or synthetic graphite has higher purity and consistency, greater stability, and better operating consistency, but is more expensive. Blends of natural and artificial graphite are frequently used (Tsuji 2022).

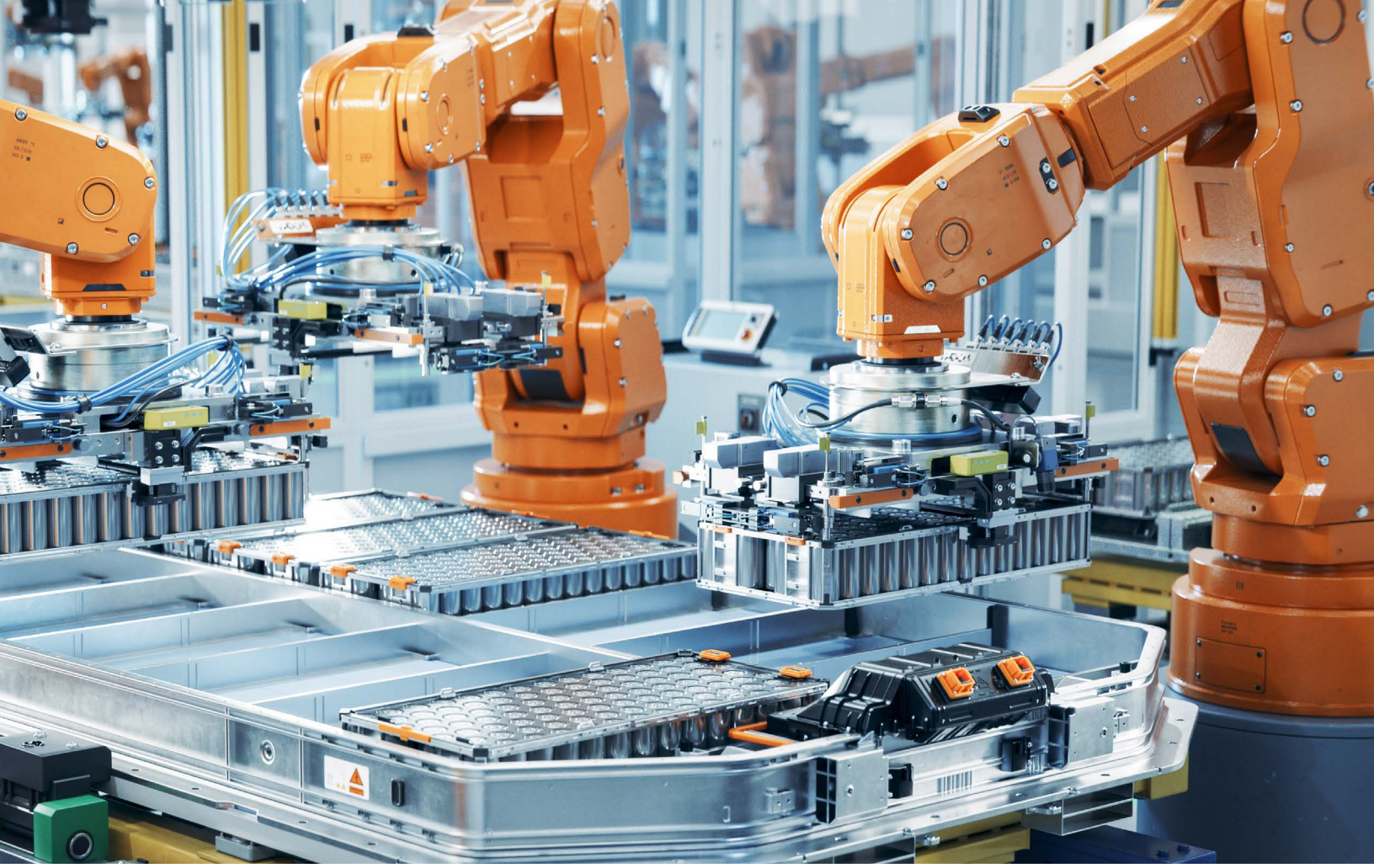
Copper

A typical electric vehicle contains more than 50 kg of copper—some have well over 80 kg. This is 3-4 times as much copper as used in a typical internal combustion engine vehicle. Copper is used in batteries, windings, and copper rotors used in electric motors, as well as in wiring and charging infrastructure. Chile remains the world's leading producer of copper, providing nearly a quarter of total global production, but the U.S. produces a substantial amount of copper as well, with Arizona accounting for 70% of domestic copper output (USGS 2023). U.S.-based Freeport-McMoRan is the world's largest copper producer, followed closely by the Chilean state-owned company Codelco and the Australian based BHP.[192]

Rare Earth Elements

Rare earth elements are a set of seventeen metallic elements that are critical to many products, ranging from the screens of smartphones, to motors of computer drives, to the Nickel Metal Hydride (NiMH) batteries that powered the first generation of hybrid vehicles, which used the rare earth element lanthanum as part of the anode.[193] Today their primary use in EVs is in the magnets that are critical to electric drive motors, although, given value-chain challenges, some companies, including Tesla, are developing EV motors with no rare earth elements.[194] Despite their name, which stems from their discovery in the 18th and 19th centuries when they were thought to be relatively rare, most rare earths are in fact not that rare. Cerium, the most abundant rare earth element, is more common in the Earth's crust than copper or lead, and nearly all are more abundant on average than silver, gold, or platinum, though mineable concentrations are less common (USGS 2023).[195] Nonetheless, global production at present remains dominated by China, which produces 70% of the total rare earth supply. The primary source of domestic U.S. production at the moment is in Mountain Pass, California, near the Nevada border.

192 https://investingnews.com/daily/resource-investing/base-metals-investing/copper-investing/top-copper-producing-companies/
193 https://www.sneci.com/blog/are-rare-earths-an-issue-in-the-production-of-ev-batteries/
194 https://electrek.co/2023/03/01/tesla-is-going-back-to-ev-motors-with-no-rare-earth-elements/#
195 https://pubs.usgs.gov/fs/2014/3078/pdf/fs2014-3078.pdf



A.2 BATTERY MANUFACTURING

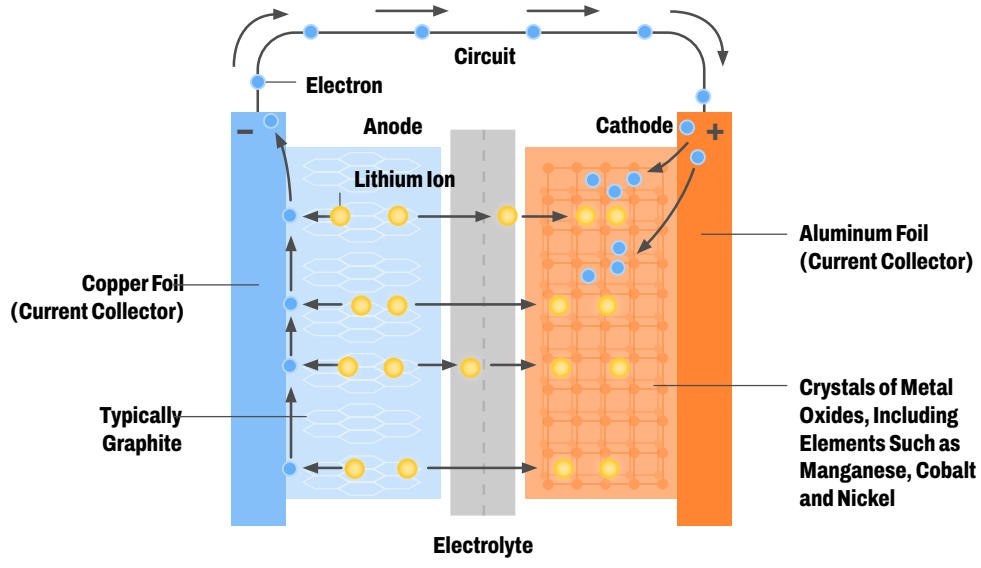
There are two main steps in the process of moving from refined basic materials to assembling a final electric vehicle: creating the basic components of the lithium-ion batteries, and assembling these components into battery cells and packs.

Lithium-ion batteries are highly complex. Batteries in EVs are in fact battery packs built of thousands of individual battery cells, each of which consists of an anode, cathode, electrolyte, separator, and outer casing. In an EV battery, the cells are arranged in a module, and multiple modules are then arranged and equipped with a battery management system (BMS) and a thermal management system (TMS) to form a pack. The BMS and TMS are essential for ensuring safe charging, monitoring of individual cell performance, and regulating temperature and electric discharge under a wide range of driving and weather conditions.

The anode and cathode are both electrodes, meaning they are electrical conductors that carry energy. When the battery is charging, an external source of electricity forces electrons to move from the cathode to the anode. When the battery is discharging (i.e., when you are driving an EV), the electrons flow back through the circuit to the cathode.

A typical lithium-ion battery cell is made of the following components

- **Anode**
  Aluminum foil coated with graphite, with recent advances in using silicon to improve energy density.
- **Cathode**
  Copper foil coated with cathode active material (CAM). The cathode active material is a lithium metal oxide, with the exact chemistry varying depending on the application and manufacturer. In addition to lithium, the most common metals used for cathodes today are nickel, cobalt, manganese, aluminum, iron, and phosphate.
- **Electrolyte**
  Lithium salt dissolved in an organic solvent.
- **Separator**
  Polyethylene or polypropylene, which are types of plastics.
- **Casing**
  Steel or aluminum.



SOURCE: (Castelvecchi 2021)

Cathode Chemistries

The term lithium-ion battery actually refers to a range of batteries that include lithium, but have varying chemical composition and properties that shape energy density, performance, and pricing (Harrison and Ludwig 2021). The chemistry of battery cathodes is a defining feature of EV batteries, and the technology is continually evolving as auto and battery manufacturers seek to lower cost and improve performance. Early electric vehicles like the Nissan Leaf used lithium manganese oxide (LMO) batteries, which had a relatively low material cost but insufficient energy density, or nickel-manganese cobalt (NMC 111) (i.e., Tesla Model S), which is costly due to the high amount of cobalt. Over the past decade, the market in the U.S. and Europe has gravitated toward cathodes with a higher ratio of nickel, such as NMC 622, NMC 811, or NCA. These batteries have higher energy density than previous generations, which improves the range and performance of the vehicle, but they also require more complex production processes (Li, Erickson, and Manthiram 2020).

The other major chemistry today is LFP, which avoids nickel and cobalt, instead relying on cheaper and more abundant materials (iron and phosphate). LFP is a more stable chemistry with a lower risk of catching fire, but typically has only 65–75% the energy density of high-nickel batteries (IEA 2022). LFP's market share has expanded in recent years, from 10% of the global EV market in 2018 to about 40% in 2022 (Crownhart 2023). Most of that deployment is in China, both in electric buses and passenger cars. Just a few years ago, analysts anticipated that LFP's market share would decline or be limited to China due to its lower energy density; however, growing awareness of supply chain issues has changed this outlook, and experts now expect LFP to maintain or increase its market share, even in the U.S. Tesla, reportedly, is using LFP batteries in half of all its new vehicles,[196] and LFP batteries are likely to become the standard in stationary battery energy storage systems, where the weight advantage of higher energy density is less important.

Lithium-ion battery component manufacturing: leading firms and percent total manufacturing

	Cathodes	Anodes	Electrolyte Solution	Separators
Leading Firms	CNGR, BASF, JM, Umicore, Sumitomo, Nichia, Toda Kogyo, Beijing Easpring, Ningbo Jinhe	Hitachi Chemical, BTR, Nippon Carbon, Ningbo Shanshan, Human Shinzoom Technology, Jiangxi Zeto New Energy Tech	BASF, CapChem, GTHR, Tinci Materials Tech, Panax-Etec, Ningbo Shanshan	Furukawa Electric, UACJ, Nippon Denkai, Doosan, Asahi Kasei, Toray Tonen, SKI, Celgard, Senior Technology Material
Country				
China	42%	65%	65%	43%
Japan	33%	19%	12%	21%
South Korea	15%	6%	4%	28%
U.S.	-	10%	2%	6%
Rest of World	10%	-	17%	2%

Source: FCAB 2021, Bridge 2022, Harrison and Ludwig 2022

196 https://electrek.co/2022/04/22/tesla-using-cobalt-free-lfp-batteries-in-half-new-cars-produced/

A.2.1 Cathodes

While materials are the most expensive component of batteries, the manufacturing of electrodes is the second most expensive, accounting for 20% to 40% of total battery pack costs (Hawley and Li 2019). Cathode chemistry and manufacturing is particularly complex. Once the raw materials have been refined into battery grade materials, the next step in the value chain is cathode precursor production. Precursor cathode active material (pCAM) is a powder where the metal sulfates are combined and synthesized according to the desired ratio of metals (e.g., NMC 622 or NMC 811). Next, the pCAM is dried and blended with a lithium source to produce cathode active material (CAM). During cell assembly, CAM is mixed with solvent, conductive additives, and binder to form a slurry, which is coated on a copper electrode to form the battery cathode.

BASF, headquartered in Germany, is one of the largest global cathode producers. BASF has a global footprint spanning China, Finland, Germany, the United States, and Canada. They have announced plans to build a CAM production facility in Quebec.[197] Sumitomo Metal is a Japanese company that provides the NCA material for the Panasonic batteries used in some Tesla EVs.[198] Major Chinese firms include CNGR (which also has operations in Indonesia, with other industrial facilities under development in South Korea and Finland), Beijing Easpring, and Ningbo Jinhe.

Umicore is a Belgium based multinational with colonial origins in mining in the Congo, that produces cathode materials for European clients from plants in Finland and Poland, and Asian clients from plants in China and Korea. In 2022 Umicore announced plans to develop a cathode active material plan in Canada, to serve a North American market.[199] Meanwhile, LG Chem, Eco Pro BM, Posco, and L&F Materials are all major cathode developers in South Korea (Herh 2023).

There is currently no pCAM manufacturing capacity in the United States, and very little CAM production. However, Redwood Materials was recently awarded $2 billion from the U.S. Department of Energy to build a facility in South Carolina that will produce CAM and copper foil using recycled and raw materials (for more on **Redwood Materials**, see below).[200] The facility is planned to have enough capacity to supply 100 GWh of battery production.[201] BASF also signed an agreement to build a 100kt CAM facility in Quebec, with the potential for integrated pCAM supply. The target commission date is 2025.[202]

197 https://www.basf.com/global/en/media/news-releases/2022/03/p-22-133.html

198 https://www.reuters.com/article/japan-sumitomo-mtl-min/sumitomo-metal-aims-to-boost-battery-materials-output-idUKL4N32D1PT

199 https://www.greencarcongress.com/2022/07/20220724-umicore.html

200 https://www.redwoodmaterials.com/news/announcing-redwood-south-carolina/

201 https://www.redwoodmaterials.com/news/announcing-redwood-south-carolina/

202 https://catalysts.basf.com/industries/automotive-transportation/battery-materials/global-footprint/americas-battery-materials-investment

A.2.2 Anodes

The process for manufacturing anodes is similar to cathodes, but with different materials. The basic materials—typically graphite, binders, and conductive additives—are mixed together in a uniform slurry which is coated onto a copper foil substrate and then dried to form a consolidated electrode film (Belharouak et al. 2020). China and Japan dominate the global production of anodes for lithium-ion batteries. Prominent companies involved in anode production include Hitachi Chemical, BTR, Nippon Carbon, Ningbo Shanshan, Hunan Shinzoom Technology, and Jiangxi Zeto New Energy Tech.

While cathodes tend to be the focus, industry leaders and researchers are starting to pay attention to potential improvements that can be realized by modifying the anode. Several companies are developing anodes that replace some or all of the graphite with silicon. For example, Sila Nanotechnologies, a startup based in Alameda, CA, claims their silicon-based anode can increase overall energy density by 40%.[203]

A.2.3 Other Components

Battery separators provide a barrier between the anode (negative) and the cathode (positive) to enable the charging and discharge process, while enabling the exchange of lithium ions from one side to the other. Separators are typically made from a thin, porous polymer film, often a combination of polyethylene and polypropylene, created through a process called extrusion or stretching. The film is coated with a ceramic layer to enhance its thermal and mechanical stability. Manufacturers are trying to make separators as thin as possible—some are now as small as 20 micrometers or less—so as not to add dead volume. However this is a highly complex process, and they still need to provide sufficient tensile strength to prevent stretching during the process of winding them into cells, and to offer good stability throughout their life. China remains the largest producer of separator material, although Japan and South Korea are also important producers in the market.

The **electrolyte solution** sits within the cells of the separator and plays a crucial role in facilitating the movement of lithium ions between the battery's electrodes. The most common electrolyte type is a liquid solution composed of lithium salts, such as lithium hexafluorophosphate, dissolved in an organic solvent like ethylene carbonate. The manufacturing process involves precise mixing of the electrolyte components, followed by purification to remove impurities and ensure high-quality performance. China remains the largest producer of electrolyte material, accounting for 65% of total global production.

The **casing material** provides structural integrity and protects the battery from external damage. Casing materials typically include metal or polymer-based compounds, depending on the application. For instance, cylindrical batteries often use steel casings, while flexible polymer films are employed in thin and flexible batteries. The casing is formed through processes like extrusion or injection molding, where

203 https://www.silanano.com/our-solutions/titan-silicon-anode

the material is shaped into the desired form. To ensure safety, the casing is designed to be durable, non-reactive with the battery components, and resistant to temperature variations.

Overall, the manufacturing process of separators, electrolytes, and casing materials for lithium-ion batteries involves a combination of material preparation, precise fabrication techniques, and stringent quality control measures to ensure the production of efficient, reliable, and safe energy storage devices.

A.2.4 Cell Assembly

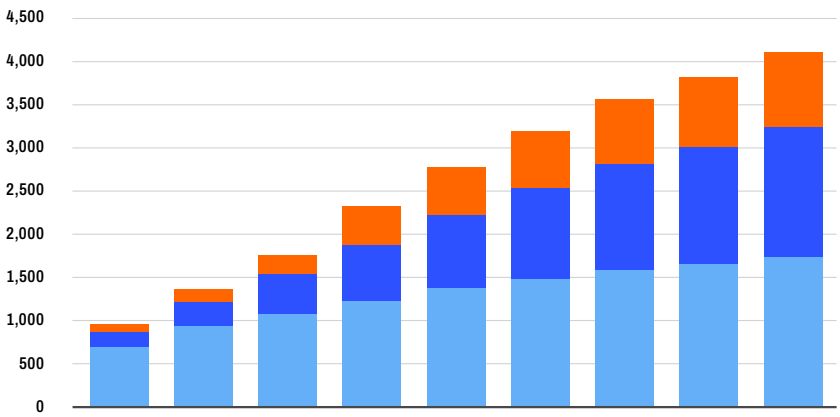
Assembly of the lithium-ion battery involves combining these various components into a functional energy storage unit. To assemble the cell, the separator is placed between the cathode and anode, with all three then either tightly rolled or stacked together, creating a compact, efficient design. This jellyroll-like or stacked structure is then inserted into a cylindrical or prismatic cell casing made of metal or a polymer, which acts as a protective shell and provides structural support to the cell. Then the liquid electrolyte is added to the cell before it is sealed.

A.2.5 Battery Pack

Battery pack manufacturers can be divided into two broad groups. The first are large and established battery producers, who often serve as Tier 1 suppliers to automobile manufacturers. This includes well-known firms like Panasonic, LG, and Samsung, but also somewhat lesser-known firms like SKI, CATL, and the Chinese firm BYD, an integrated battery and EV producer who recently surpassed Tesla as the largest annual global producer of EVs. The second group of emerging battery producers is more diverse, and includes a startup group of project developers such as Statevolt, Northvolt, and Freyr, current Tier 2 battery suppliers that are expanding into more supply agreements with automakers and Tier 1 suppliers (examples include CALB and SVOLT), and new joint enterprises being established by automakers and Battery companies, such as BlueOvalSK (Ford and SKI), Ultium (GM and LG), and Prime Planet Energy (Toyota with Panasonic) (Bridge and Faigen 2022)

In 2022, North America had a total estimated battery production capacity of 95 Gwh, representing 10% of total global capacity, compared to China's 73%. However, capacity in North America is expected to multiply in coming years, to nearly nine times its current size, reaching an estimated 859 Gwh in 2030. Alongside expanded capacity also in Europe and China, this means the U.S. share is expected to rise to 21% of global production by the end of the decade.

Global & Regional Gigafactory Capacity Forecast 2022-2030 (GWh)



North America Total	95	156	221	428	553	666	731	794	859
Europe Total	160	261	458	665	849	1041	1220	1350	1494
Asia Pacific Total	703	939	1082	1224	1368	1484	1592	1656	1738

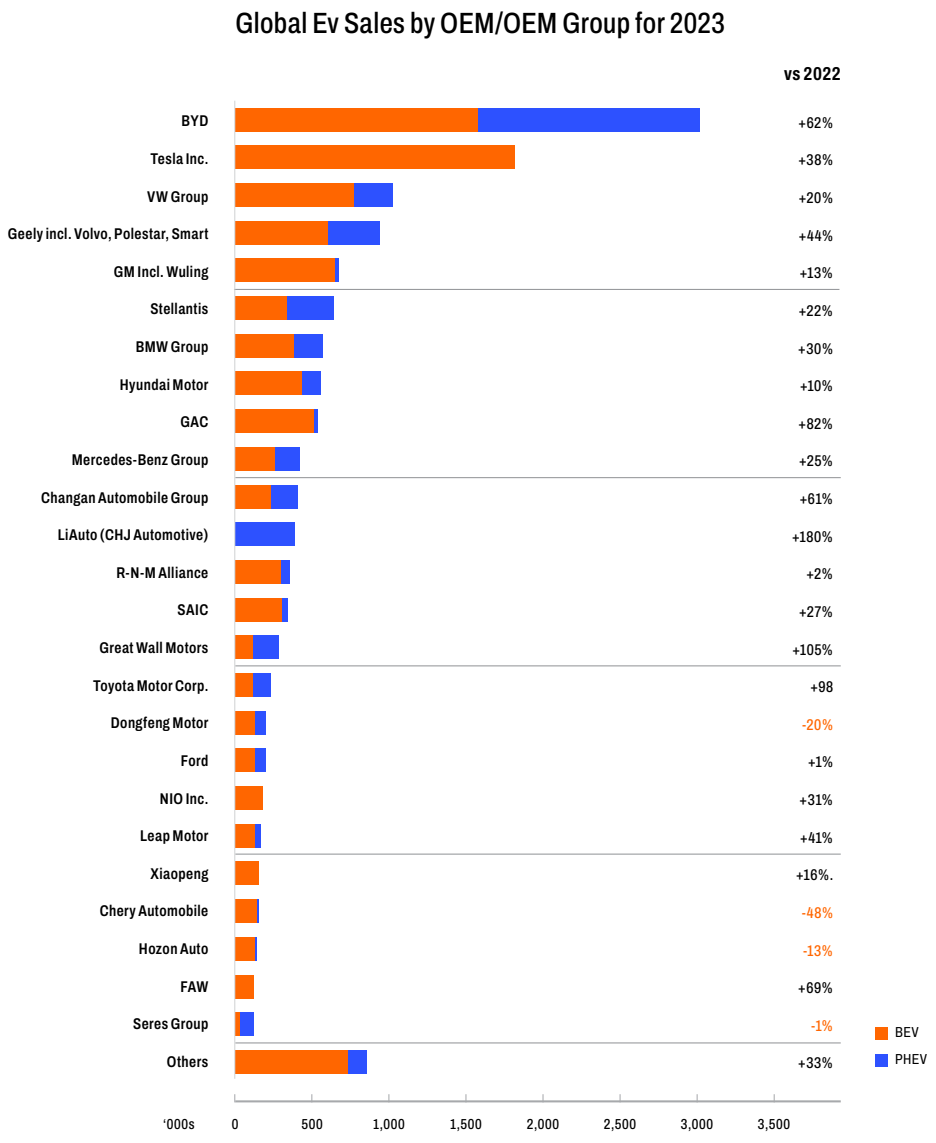
Source: AMS 2022 Lithium Ion Battery Gigafactory Database[204]

A.3 ELECTRIC VEHICLE MANUFACTURING

Globally, the total sale of electric vehicles and plug-in hybrids rose to 10.5 million in 2022, up 55% from the previous year. China remains the largest EV market, with 59% of global EV sales in 2022, and they produce 64% of total global EV volume. Europe represents 25% of total sales, with North America representing 11%.

204 https://www.automotivemanufacturingsolutions.com/ev-battery-production/lithium-ion-battery-gigafactory-database-2022/41937.article

Tesla remains the largest global producer of battery electric vehicles, with a total of 1.3 million units sold in 2022, roughly 18% of the total global volume.[205] But when plug-in hybrid vehicles are also included, BYD has now surpassed Tesla as the largest global producer of electric vehicles.



Source: EV Volumes — Aggregated BEV & PHEV Sales by Model nd Country[206]

205 https://insideevs.com/news/651978/world-top-ev-oem-sales-2022q4/
206 https://www.ev-volumes.com/

EV companies are playing an increasingly important role in shaping production relations along the value chain by entering into long term agreements or joint partnerships with major battery manufacturers. Tesla, for example, sources batteries for some of its models from LG, CATL, and BYD, and entered into a multi-billion-dollar joint venture with Panasonic in 2014 to produce batteries together at the Gigafactory Nevada, for both their Model 3 and Model Y cars. They also work closely together on Panasonic's battery production facility in Wakayama, Japan, producing batteries for both their Model S and Model X. Tesla is also developing their own in-house cell production capacity. Similarly, GM sources batteries from LG but has now also created a joint venture with LG called Ultium Cells LLC, to produce batteries for multiple GM models. Ford sources some batteries from Samsung and BYD but has now also created a joint venture with SKOn called BlueOvalSK, producing batteries for several Ford and Lincoln vehicles.

Automakers are also increasingly entering into offtake agreements with battery materials producers, rather than relying on battery manufacturers to source materials. Tesla has agreements, for example, with Piedmont Lithium for lithium, with BHP for nickel sulfate, and with Glencore for cobalt. BMW has agreements with Glencore and Managem for cobalt (Bridge and Faigen 2022). Mercedes-Benz has opened up a raw materials office in Canada in an effort to improve their sourcing of raw materials, after signing a battery material cooperation agreement with the Canadian government, and is willing to allocate capital to support or ramp up mining businesses (Reuters 2023).

The increasing integration of automakers in lithium mining and battery manufacturing is important since it means that the investment strategies of automakers are playing an increasingly important role in production location and network organization. These are increasingly approximating vertically integrated production systems, with automakers exercising significant influence on production processes at multiple points along the entire value chain (Bridge and Faigen 2022). Vertical integration is attractive to these firms since it allows them to manage supply risks and commodity price volatility, while also reducing costs and optimizing their gigafactory production facilities.

A.4 END-OF-LIFE AND NEW BEGINNINGS

A.4.1 Reuse and Repurposing

The suitability of a battery for reuse or repurposing depends on its state-of-health (SOH), which refers to the battery's ability to hold a charge compared to when it was first manufactured. If the overall SOH is high enough, the battery pack can be reused in an EV. This could happen when a relatively new battery has a few faulty cells but is overall in good condition, or when the vehicle itself is damaged in a collision that does not affect the battery. In the first case, the battery would likely be under warranty and managed within the automakers and dealership network. The driver would return it to the dealership, who would send it to a refurbisher. Refurbishers diagnose and replace faulty cells to restore the pack to appropriate specifications. Two major companies operating in this space are Spiers New Technologies in Oklahoma and ATC-Drivetrain in Michigan.

If an EV were totaled in a collision that did not damage the battery, the battery could be resold as-is and used as a replacement pack in another vehicle. These batteries would likely flow through the afterlife vehicle market, a sector comprising independent repair shops, auto dismantlers, and scrap metal recyclers. The network for reusing parts and recycling old vehicles is well-developed in California and across the U.S.; in fact, end-of-life vehicles have some of the highest recycling rates of any product (Saidani et al. 2019).

Repurposing can happen once the EV battery packs have degraded to the point that they no longer provide sufficient capacity for vehicles. In this case, many still have enough capacity to provide energy storage in other applications. For example, the modules can be put into a stationary system that charges from a solar panel and discharges energy during peak hours, reducing strain on the electric grid. California has a high demand for stationary storage to support the use of increased solar and wind energy production, which combined with the high EV adoption rates makes the state well-positioned to be a leader in the repurposing space.

Repurposers face a number of barriers to entry that make it difficult to compete with new battery systems and larger Original Equipment Manufacturers (OEMs) (Kendall et al. 2022). At present, repurposing is constrained by the low volume of retired batteries, simply because EVs have not been on the road for very long and are not retiring at large scale yet. Furthermore, car companies are still evaluating their own stances on repurposing. EV manufacturers do not necessarily want their batteries being repurposed by third parties, both for liability reasons (they worry it will come back to them if there is an accident involving a repurposed pack), and because they want to recover materials and use them in new battery packs—particularly for batteries containing nickel and cobalt. Without a partnership with an OEM, repurposers must acquire batteries from the independent afterlife market. Those connections are developing, but again, the scale will be limited until more EV batteries start retiring out of warranty.

Another challenge is the cost of the repurposing process, which involves diagnosing the state-of-health of the battery, then disassembling and rearranging modules to create a balanced system. Once the modules are rearranged, they have to be equipped with a new BMS and TMS for their stationary storage application. If more testing is required, the cost of the process increases, making it difficult to compete with new batteries (Neubauer et al. 2015). One way to reduce the cost of testing (and repurposing overall) is by making more information about batteries available upfront, so repurposers can make informed purchasing decisions and avoid needlessly shipping and testing batteries that have degraded beyond the point of usefulness (Slattery et al. 2021). Ideally, estimates of state-of-health would be readily available; however, even basic information about mileage and the climate the car was driven in can give repurposers a sense of the level of degradation they should expect. This information is generally easy to obtain when the battery is still in the vehicle, where information is readable on the dashboard if the car can still turn on, or information may be accessible through the vehicle identification number (VIN). However, it is difficult to get information once the pack has been removed from the car.

A.4.2 Recycling

Eventually, all batteries reach the end of their usable life. At this point, they must be recycled to recover materials that can be used to make new batteries or other products. At present, an estimated 9.2% (by mass) of used batteries due to go out of service in 2019 were recycled domestically, with an additional 44.5% sent to China for processing (Gaines et al. 2023:5). It is important to acknowledge, however, that specific material recovery rates vary widely depending on the material and recycling process—ranging from as high as near 100% for some elements, to 0% for others. Europe generally has been slightly ahead of the U.S. in promoting lithium battery recycling. The EU Battery Directive has a 2025 target of 65% total recycling rate by battery weight, with a target recovery rate of 90% for cobalt, nickel and copper, and 35% for lithium. By 2030, these targets rise to 95% and 70% respectively.[207]

Most battery recycling companies in the U.S. plan to use some type of mechanical pretreatment followed by hydrometallurgical processing. This is a generalized description; in reality, each company has a unique recycling process, and technology is likely to change as recyclers adapt to trends in battery chemistry and design. During pretreatment, the batteries are sorted and disassembled to the module level to remove the outer casing and separate out software and electronic components. The modules are then shredded, and the shredded materials are sorted to separate different metals for further processing. Copper, steel, and aluminum can all be sent to other established metal recyclers. Meanwhile, the lithium, cobalt, nickel, manganese, and graphite are contained in a black powder that is commonly referred to as black mass.

Black mass can be thought of as a raw material, requiring additional treatment to recover and refine the constituent metals. This is where hydrometallurgy comes in. Hydrometallurgy involves leaching the powder, or in other words, putting it in a solution that dissolves the metals. The next step is impurity removal to get rid of unwanted ions, like iron or aluminum, before extracting the manganese, nickel, cobalt, and finally, lithium. The metals recovered by these recycling processes can be purified into battery-grade metal sulfates and used to manufacture new cathodes.

In the United States, the pre-treatment (i.e., battery to black mass) infrastructure is more developed than that for metal recovery, at least for the time being. Two major companies in this area are Li-Cycle and Cirba Solutions. Li-Cycle operates with a “spoke and hub” model, where the spokes are smaller distributed facilities that shred packs to produce black mass, which is shipped to their “hub” facility in Rochester, NY. Cirba Solutions (formerly Retriev Technologies, Battery Solutions, and Heritage Recycling) operates lithium-ion battery recycling facilities in Ohio and British Columbia, and has announced plans to open a new facility in Arizona. The products from these facilities can be refined into battery-grade materials. Cirba also operates battery sorting and storage facilities in Michigan and Arizona.

207 https://www.eba250.com/the-sustainable-future-of-batteries-in-europe-rests-on-a-developed-recycling-industry

Meanwhile, Redwood Materials is the company most advanced in making products from recycled materials that can be used as inputs in battery manufacturing. Redwood is headquartered in Carson City, Nevada, where they operate a recycling facility that receives and sorts end-of-life (EOL) batteries from consumer electronics and EVs, and then processes them into materials used in anode products (copper foil) or cathode products (CAM, pCAM) at a facility outside Reno. Redwood also processes production scrap from the Panasonic factory in Reno, which is currently a greater source of feedstock than EOL batteries.

There are a number of other companies focusing on processing black mass to metal sulfate, or the cathode material step, such as Ascend Elements, AquaTech, Blue Whale materials, and American Battery Technology. These are mainly in a development phase, operating smaller pilot facilities with plans to build out full-scale commercial plants within the next five years. Notably, none of these planned recycling facilities are located in California, despite it being the largest EV market. Instead, companies are locating in neighboring states such as Nevada and Arizona, where they can still access the supply of EOL batteries from California.

Internationally, the most significant markets for recycling are China and Korea (Baum et al. 2022). Battery recycling in China is often part of a larger operation combined with production or recycling other products. For example, Taisen and Quzhou Huayou Cobalt New Material Co. both recycle batteries and refine battery-grade cobalt. Brunp Recycling, a subsidiary of CATL, also operates a vehicle dismantling and recycling facility that processes 20,000 scrapped automobiles per year. Planned expansions are massive; there are two companies, GEM and Burnp, that are scaling up to a capacity of 300,000 tons per year by 2026. In South Korea, two of the largest companies are SungEel Hi Tech and Posco Hy Clean Metal. SungEel has operated a pretreatment facility since 2008, and a hydrometallurgical facility since 2011 that recovers lithium, nickel, manganese, cobalt, copper, and aluminum. They also operate recycling parks in Poland, Hungary, India, Malaysia, and China, and export the shredded material to their hydrometallurgical facility in South Korea to be refined and used in Korean battery production. Posco Hy's facility in South Korea is a joint venture with Huayou Cobalt that treats 12,000 tons a year of black mass, some of which is sourced from a pretreatment facility in Poland.[208] Posco also announced plans to build a new cathode materials plant in South Korea with an annual capacity of 60,000 tons.

208 **https://news.metal.com/newscontent/101613007/huayou-cobalt-korea-joint-venture-posco-hy-clean-metal-posco-huayou-recycling-korea-co-ltd-start-construction**

REFERENCES

National Renewable Energy Laboratory. 2023. "NAATBatt Lithium-Ion Battery Supply Chain Database." **https://www.nrel.gov/transportation/li-ion-battery-supply-chain-database.html**.

Alston, Ken, Mikela Waldman, Julie Blunden, Rebecca Lee, and Alina Epriman. 2020. *Building Lithium Valley: Opportunities and Challenges Ahead for Developing California's Battery Manufacturing Ecosystem*. New Energy Nexus.

Appel, Sam, and Jessie HF Hammerling. 2023. *California's Climate Investments and High Road Workforce Standards: Gaps and Opportunities for Advancing Workforce Equity*. Berkeley, CA: UC Berkeley Labor Center.

Argyres, Anneta, and Susan Moir. 2008. *Building Trades Apprentice Training in Massachusetts: An Analysis of Union and Non-Union Programs, 1997-2007*. *Labor Resource Center Publications*. 2. University of Massachusetts, Boston, Labor Resource Center.

Arora, Aakash, William Acker, Brian Collie, Danny Kennedy, David Roberts, Ian Roddy, James Greenberger, John Cerveny, Nathan Niese, Venkat SArinivasan, and Vijay Dhar. 2023. *Building a Robust and Resilient U.S. Lithium Battery Supply Chain*. Lemont, IL: Argonne National Laboratory, Li-Bridge.

Bahn, Kate, and Carmen Sanchez Cumming. 2020. *Improving U.S. Labor Standards and the Quality of Jobs to Reduce the Costs of Employee Turnover to U.S. Companies*. *Issue Brief: Labor*. Washington, D.C.: Washington Center for Equitable Growth.

Banfi, Stefano, and Benjamín Villena-Roldán. 2019. "Do High-Wage Jobs Attract More Applicants? Directed Search Evidence from the Online Labor Market." *Journal of Labor Economics* 37(3):715–46. doi: 10.1086/702627.

Bartik, Timothy J. 2020. "Using Place-Based Jobs Policies to Help Distressed Communities." *Journal of Economic Perspectives* 34(3):99–127. doi: 10.1257/jep.34.3.99.

Bassier, Ihsaan, Arindrajit Dube, and Suresh Naidu. 2022. "Monopsony in Movers: The Elasticity of Labor Supply to Firm Wage Policies." *Journal of Human Resources* 57(S):S50-s86. doi: 10.3368/jhr.monopsony.0319-10111R1.

Baum, Zachary J., Robert E. Bird, Xiang Yu, and Jia Ma. 2022. "Lithium-Ion Battery Recycling-Overview of Techniques and Trends." *ACS Energy Letters* 7(2):712–19. doi: 10.1021/acsenergylett.1c02602.

Belharouak, Ilias, Jagjit Nanda, Ethan C. Self, William B. Hawley, David D. Wood III, Zhijia Du, Jianlin Li, and Ronald L. Graves. 2020. *Operation, Manufacturing, and Supply Chain of Lithium-Ion Batteries for Electric Vehicles*. ORNL/TM-2020/1729. Oak Ridge National Lab. (ORNL), Oak Ridge, TN (United States). doi: 10.2172/1737479.

Benson, Derek. 2023."Sustainable Lithium. Delivered." Presented at the Critical Minerals in California: Building the Supply Chain for Tomorrow, January 18, UC Riverside Palm Desert Campus.

Bilginsoy, Cihan. 2003. "The Hazards of Training: Attrition and Retention in Construction Industry Apprenticeship Programs." *ILR Review* 57(1):54–67. doi: 10.2307/3590981.

Blair, James J. A., Ramón M. Balcázar, Javiera Barandiarán, and Amanda Maxwell. 2023. "The 'Alterlives' of Green Extractivism: Lithium Mining and Exhausted Ecologies in the Atacama Desert." *International Development Policy | Revue Internationale de Politique de Développement* (16). doi: 10.4000/poldev.5284.

Bozuwa, Johanna, and Dustin Mulvaney. 2023. *A Progressive Take on Permitting Reform: Principles and Policies to Unleash a Faster, More Equitable Green Transition*. Roosevelt Institute and Climate + Community Project.

Bridge, Gavin, and Erika Faigen. 2022. "Towards the Lithium-Ion Battery Production Network: Thinking beyond Mineral Supply Chains." *Energy Research & Social Science* 89:102659. doi: 10.1016/j.erss.2022.102659.

Brodd, Ralph J., and Carlos Helou. 2013. "Cost Comparison of Producing High-Performance Li-Ion Batteries in the U.S. and in China." *Journal of Power Sources* 231:293–300. doi: 10.1016/j.jpowsour.2012.12.048.

Buss, Terry F. 2001. "The Effect of State Tax Incentives on Economic Growth and Firm Location Decisions: An Overview of the Literature." *Economic Development Quarterly* 15(1):90–105. doi: 10.1177/089124240101500108.

California Workforce Development Board. 2020. *Essential Elements of High Road Training Partnerships*. Sacramento, CA: CWDB. **https://cwdb.ca.gov/wp-content/uploads/sites/43/2020/01/HRTP-Essential-Elements_ACCESSIBLE.pdf**

Carnevale, Anthony P., Tamara Jayasundera, and Andrew R. Hanson. 2012. *Career and Technical Education: Five Ways That Pay along the Way to the BA*. Georgetown University Center on Education and the Workforce.

Castelvecchi, Davide. 2021. "Electric Cars and Batteries: How Will the World Produce Enough?" *Nature* 596(7872):336–39. doi: 10.1038/d41586-021-02222-1.

Chao, Julie. 2020. "Lawrence Berkeley National Laboratory: Geothermal Brines Could Propel California's Green Economy." *Targeted News Service (USA)*, August 6.

Chatterji, Aaron K. 2018. *The Main Street Fund: Investing in an Entrepreneurial Economy*. Washington, D.C.: The Hamilton Project, Brookings Institution.

Ciez, Rebecca E., and J. F. Whitacre. 2019. "Examining Different Recycling Processes for Lithium-Ion Batteries." *Nature Sustainability* 2(2):148–56. doi: https://doi.org/10.1038/s41893-019-0222-5.

Climate Power. 2024. *The State of the Clean Energy Boom*. Washington, D.C.: Climate Power.

Cockx, Bart, Bruno Van der Linden, and Adel Karaa. 1998. "Active Labour Market Policies and Job Tenure." *Oxford Economic Papers* 50(4):685–708. doi: 10.1093/oep/50.4.685.

Coviello, Decio, Erika Deserranno, and Nicola Persico. 2022. "Minimum Wage and Individual Worker Productivity: Evidence from a Large US Retailer." *Journal of Political Economy* 130(9):2315–60. doi: 10.1086/720397.

Crownhart, Casey. 2023. "What's next for Batteries." *MIT Technology Review*, January 4.

Dearden, Lorraine, Howard Reed, and John Van Reenen. 2006. "The Impact of Training on Productivity and Wages: Evidence from British Panel Data*." *Oxford Bulletin of Economics and Statistics* 68(4):397–421. doi: 10.1111/j.1468-0084.2006.00170.x.

Deese, Brian. 2023. "Opinion | The New Climate Law Is Working. Clean Energy Investments Are Soaring." *The New York Times*, May 30.

DeRigne, LeaAnne, Patricia Stoddard-Dare, and Linda Quinn. 2016. "Workers Without Paid Sick Leave Less Likely To Take Time Off For Illness Or Injury Compared To Those With Paid Sick Leave." *Health Affairs* 35(3):520–27. doi: 10.1377/hlthaff.2015.0965.

Dobson, Patrick, Naod Araya, Maryjo Brounce, Margaret Busse, Mary Kay Camarillo, Lauren English, Jennifer Humphreys, Boriana Kalderon-Asael, Michael McKibben, Dev Millstein, Nori Nakata, John O'Sullivan, Noah Planavsky, Joris Popineau, Theo Renaud, Jeremy Riffault, Margaret Slattery, Eric Sonnenthal, Nicolas Spycher, Jennifer Stokes-Draut, William Stringfellow, and Malcolm White. 2023. *Characterizing the Geothermal Lithium Resource at the Salton Sea*. LBNL-2001557. Berkeley: Lawrence Berkeley National Laboratory.

Dube, Arindrajit, T. William Lester, and Michael Reich. 2016. "Minimum Wage Shocks, Employment Flows, and Labor Market Frictions." *Journal of Labor Economics* 34(3):663–704. doi: 10.1086/685449.

FCAB. 2021. *National Blueprint for Lithium Batteries 2021-2030*. Washington, D.C.: Federal Consortium for Advanced Batteries.

Fudge, Thomas, dir. 2022. "The Promise of Lithium Sparks a Gold Rush in Imperial Valley." *KPBS Public Media*.

Gaines, Linda, Jingyi Zhang, Xin He, Jessey Bouchard, and Hans Eric Melin. 2023. "Tracking Flows of End-of-Life Battery Materials and Manufacturing Scrap." *Batteries* 9(7):360. doi: 10.3390/batteries9070360.

Garcés, Ingrid, and Gabriel Alvarez. 2020. "Water Mining and Extractivism of the Salar de Atacama, Chile." Pp. 189–200 in *Environmental Impact V*, edited by J. Casares. Southampton, UK: WIT Press.

González-Vásquez, Ana Luz, Magaly N. López, and Javier Garcia-Perez. 2021. *The High Road to Economic Prosperity: An Assessment of the California Workforce Development Board's High Road Training Partnership Initiative*. Los Angeles, CA: UCLA Labor Center.

Goodman, Dave, Patrick Mirick, and Kyle Wilson. 2022. *Salton Sea Geothermal Development: Nontechnical Barriers to Entry – Analysis and Perspectives*. *Prepared for the U.S. Department of Energy*. Pacific Northwest National Laboratory.

Grant, Alex. 2020. "From Catamarca to Qinghai: The Commercial Scale Direct Lithium Extraction Operations." Retrieved (https://www.jadecove.com/research/fromcatamarcatoqinghai).

Grant, Alex, David Deak, and Robert Pell. 2020. *Geothermal Lithium: The Final Frontier of Decarbonization*. Jade Cove Partners.

Gray, M. Nolan. 2021. "How Californians Are Weaponizing Environmental Law." *The Atlantic*, March 12.

Hanicke, Mikael, Dina Ibrahim, Sören Jautelat, Lukas Torscht, Alexandre van de Rijt, Martin Linder, and Patrick Schaufuss. 2023. *Battery 2030: Resilient, Sustainable, and Circular*. McKinsey & Company.

Harrison, Daniel, and Christopher Ludwig. 2021. *Electric Vehicle Battery Supply Chain Analysis 2021: How Lithium-Ion Battery Demand and Production Are Reshaping the Automotive Industry*. London: Automotive, from UltimaMedia.

Harrison, Daniel, and Christopher Ludwig. 2022. *Automotive Battery Supply Chain 2022: Risks, Regulation & Resiliency Rise Up The Agenda*. *Battery Supply Chain Report*. London, UK: AMS, Automotive, Ultima Media,.

Hawley, W. Blake, and Jianlin Li. 2019. "Electrode Manufacturing for Lithium-Ion Batteries—Analysis of Current and Next Generation Processing." *Journal of Energy Storage* 25:100862. doi: 10.1016/j.est.2019.100862.

Henderson, Kaitlyn. 2023. *Best and Worst States to Work in America 2023*. Washington, D. C.: Oxfam America.

Herh, Michael. 2023. "Korean Cathode Material Companies Growing Fast." *BusinessKorea*, February 3.

Hunter, Savannah, Annette Gailliot, Enrique Lopezlira, and Ken Jacoba. 2023. *California Union Membership and Coverage: 2023 Chartbook*. UC Berkeley Labor Center.

IEA. 2022. *Global Supply Chains of EV Batteries*. *Technology Report*. Paris, France: International Energy Agency.

IID. 2022. *2022 Water & QSA Implementation Report*. Imperial County: Imperial Irrigation District.

Imperial County Agricultural Commissioner. 2022. *2021 Imperial County Agricultural Crop & Livestock Report*. Imperial County: Agricultural Commissioner.

Jacobs, Ken, Michael Reich, and Peter Hall. 2003. *Living Wage Policies at San Francisco Airport*. Berkeley, CA: UC Berkeley Institute for Research on Labor and Employment.

Jaskula, Brian. 2023. *Lithium Data Sheet Mineral Commodity Summaries 2023*. USGS.

Jolly, Jasper. 2023. "Britishvolt: How Britain's Bright Battery Future Fell Flat." *The Guardian*, January 20.

Kara, Siddharth. 2023. *Cobalt Red: How the Blood of the Congo Powers Our Lives*. St. Martin's Press.

Kaspereit, Denis, Mary Mann, Sanyal Subir, Bill Rickard, William Osborn, and Jeff Hulen. 2016. "Updated Conceptual Model and Reserve Estimate for the Salton Sea Geothermal Field, Imperial Valley, California." *GRC Transactions* 40.

Kelly, Jarod C., Michael Wang, Qiang Dai, and Olumide Winjobi. 2021. "Energy, Greenhouse Gas, and Water Life Cycle Analysis of Lithium Carbonate and Lithium Hydroxide Monohydrate from Brine and Ore Resources and Their Use in Lithium Ion Battery Cathodes and Lithium Ion Batteries." *Resources, Conservation and Recycling* 174:105762. doi: 10.1016/j.resconrec.2021.105762.

Kendall, Alissa, Margaret Slattery, and Jessica Dunn. 2022. *AB 2832 Lithium-Ion Car Battery Recycling Advisory Group Final Report*. California Environmental Protection Agency.

Khalil, Abdullah, Shabin Mohammed, Raed Hashaikeh, and Nidal Hilal. 2022. "Lithium Recovery from Brine: Recent Developments and Challenges." *Desalination* 528:115611. doi: 10.1016/j.desal.2022.115611.

Klier, Thomas H., and James M. Rubenstein. 2010. "The Changing Geography of North American Motor Vehicle Production." *Cambridge Journal of Regions, Economy and Society* 3(3):335–47. doi: 10.1093/cjres/rsq024.

LAEDC. 2020. *The Electric Mobility Revolution in Southern California: Energizing an Ecosystem*. Los Angeles: Los Angeles Economic Development Corporation.

LeRoy, Greg, Carolyn Fryberger, Kasia Tarczynska, Thomas Cafcas, Elizabeth Bird, and Philip Mattera. 2015. *Shortchanging Small Business: How Big Businesses Dominate State Economic Development Incentives*. Washington, D.C.: Good Jobs First.

Levine, David I. 1992. "Can Wage Increases Pay For Themselves? Tests with a Productive Function." *The Economic Journal* 102(414):1102–15. doi: 10.2307/2234379.

Lewkowicz, Javier. 2022. "Can Lithium Be Produced with a Lower Environmental Impact?" *Dialogo Chino*. Retrieved May 28, 2023 (**https://dialogochino.net/en/extractive-industries/58865-can-lithium-be-produced-with-lower-environmental-impact-latin-america/**).

Li, Wangda, Evan M. Erickson, and Arumugam Manthiram. 2020. "High-Nickel Layered Oxide Cathodes for Lithium-Based Automotive Batteries." *Nature Energy* 5(1):26–34. doi: 10.1038/s41560-019-0513-0.

Li-Bridge. 2022. *Li-Bridge: Bridging the Lithium Battery Supply Chain Gap. Forum #3-How to Win, Prepared by Boston Consulting Group*. Argonne National Laboratory.

Lollo, Niklas, and Dara O'Rourke. 2020. "Factory Benefits to Paying Workers More: The Critical Role of Compensation Systems in Apparel Manufacturing." *PLOS ONE* 15(2):e0227510. doi: 10.1371/journal.pone.0227510.

Luke, Nikki, Carol Zabin, Dalia Velasco, and Robert Collier. 2017. *Diversity in California's Clean Energy Workforce: Access to Jobs for Disadvantaged Workers in Renewable Energy Construction*. UC Berkeley Center for Labor Research and Education.

Mas, Alexandre. 2006. *Pay, Reference Points, and Police Performance*. w12202. Cambridge, MA: National Bureau of Economic Research. doi: 10.3386/w12202.

Mast, Evan. 2020. "Race to the Bottom? Local Tax Break Competition and Business Location." *American Economic Journal: Applied Economics* 12(1):288–317. doi: 10.1257/app.20170511.

Mattera, Philip. 2009. *High Road or Low Road? Job Quality in the New Green Economy*. Washington, D.C.: Good Jobs First.

Matthews, Daniel. 2020. *Global Value Chains: Cobalt in Lithium-Ion Batteries for Electric Vehicles*. *Office of Industries Working Paper ID-067*. US International Trade Commission.

McConnell, Virginia, and Benjamin Leard. 2021. "Pushing New Technology into the Market: California's Zero Emissions Vehicle Mandate." *Review of Environmental Economics and Policy* 15(1):169–79. doi: 10.1086/713055.

McDonald III, Bruce D., J. W. Decker, and Brad A. M. Johnson. 2021. "You Don't Always Get What You Want: The Effect of Financial Incentives on State Fiscal Health." *Public Administration Review* 81(3):365–74. doi: 10.1111/puar.13163.

McKibben, Michael A., Wilfred A. Elders, and Arun S. K. Raju. 2021. "Lithium and Other Geothermal Mineral and Energy Resources Beneath the Salton Sea." in *Crisis at the Salton Sea: Research Gaps and Opportunities*. Atmospheric Sciences.

Morales, R. 1986. "The Los Angeles Automobile Industry in Historical Perspective." *Environment and Planning D: Society and Space* 4(3):289–303. doi: 10.1068/d040289.

Murphy, Olivia, and Maha N. Haji. 2022. "A Review of Technologies for Direct Lithium Extraction from Low Li+ Concentration Aqueous Solutions." *Frontiers in Chemical Engineering* 4.

Naimark, Jared. 2023. *Environmental Justice in California's Lithium Valley: Understanding the Potential Impacts of Direct Lithium Extraction from Geothermal Brine*. Washington, D.C.: Earthworks.

Neubauer, J., K. Smith, E. Wood, and A. Pesaran. 2015. *Identifying and Overcoming Critical Barriers to Widespread Second Use of PEV Batteries*. NREL/TP-5400-63332. National Renewable Energy Lab. (NREL), Golden, CO (United States). doi: 10.2172/1171780.

Niedermeyer, Edward. 2019. *Ludicrous: The Unvarnished Story of Tesla Motors*. Dallas, TX: BenBella Books, Inc.

Ohnsman, Alan. 2022. "California's Lithium Rush For EV Batteries Hinges On Taming Toxic, Volcanic Brine." *Forbes*, August 31.

Orangi, Sina, and Anders Hammer Strømman. 2022a. "A Techno-Economic Model for Benchmarking the Production Cost of Lithium-Ion Battery Cells." *Batteries* 8(8):83. doi: 10.3390/batteries8080083.

Orangi, Sina, and Anders Hammer Strømman. 2022b. "A Techno-Economic Model for Benchmarking the Production Cost of Lithium-Ion Battery Cells." *Batteries* 8(8):83. doi: 10.3390/batteries8080083.

Osterman, Paul. 2018. "In Search of the High Road: Meaning and Evidence." *ILR Review* 71(1):3–34. doi:

10.1177/0019793917738757.

Parker, Sophie S., Bradley Franklin, Andrew Williams, Brian Cohen, Michael Clifford, and Melissa Rohde. 2022. *Potential Lithium Extraction in the United States: Environmental, Economic, and Policy Implications*. The Nature Conservancy.

Pastor, Manuel. 2018. *State of Resistance: What California's Dizzying Descent and Remarkable Resurgence Mean for America's Future*. New York, NY: New Press.

Paz, Silvia (Chair), Ryan E. (Vice Chair) Kelley, Steve Castaneda, Rod Colwell, Roderic Dolega, Miranda Flores, James C. Hanks, Arthur Lopez, Luis Olmedo, Alice Reynolds, Frank Ruiz, Manfred Scott, Tom Soto, and Jonathan Weisgall. 2022. *Report of the Blue Ribbon Commission on Lithium Extraction in California*. CEC-300-2022-009-F. Sacramento, CA: California Energy Commission.

Philips, Peter. 2014. *Environmental and Economic Benefits of Building Solar in California: Quality Careers—Cleaner Lives*. UC Berkeley Donald Vial Center on Employment in the Green Economy.

Pichler, Stefan, and Nicolas R. Ziebarth. 2017. "The Pros and Cons of Sick Pay Schemes: Testing for Contagious Presenteeism and Noncontagious Absenteeism Behavior." *Journal of Public Economics* 156:14–33. doi: 10.1016/j.jpubeco.2017.07.003.

Raff, Daniel M. G., and Lawrence H. Summers. 1987. "Did Henry Ford Pay Efficiency Wages?" *Journal of Labor Economics* 5(4):57–86.

Reuters. 2023. "Mercedes-Benz Is 'Able and Willing' to Invest Capital in Mining CEO." *Reuters*, March 30.

Richter, Alexander. 2020. "CTR and Lilac Solutions to Unlock Massive Sustainable Lithium Resource in the U.S. | ThinkGeoEnergy Geothermal Energy News." *Think GeoEnergy*, March 16.

Ross, Michael L. 1999. "The Political Economy of the Resource Curse." *World Politics* 51(2):297–322. doi: 10.1017/S0043887100008200.

Saidani, Michael, Alissa Kendall, Bernard Yannou, Yann Leroy, and François Cluzel. 2019. "Management of the End-of-Life of Light and Heavy Vehicles in the U.S.: Comparison with the European Union in a Circular Economy Perspective." *Journal of Material Cycles and Waste Management* 21(6):1449–61. doi: 10.1007/s10163-019-00897-3.

Signoratti, Vince. 2022. "Interview with Vince Signorotti, Vice President, Government Relations, EnergySource."

Situ, Lixin. 2009. "Electric Vehicle Development: The Past, Present & Future." Pp. 1–3 in *2009 3rd International Conference on Power Electronics Systems and Applications (PESA)*.

Slattery, Cailin, and Owen Zidar. 2020. "Evaluating State and Local Business Incentives." *Journal of Economic Perspectives* 34(2):90–118. doi: 10.1257/jep.34.2.90.

Slattery, Margaret, Jessica Dunn, and Alissa Kendall. 2021. "Transportation of Electric Vehicle Lithium-Ion Batteries at End-of-Life: A Literature Review." *Resources, Conservation and Recycling* 174:105755. doi: 10.1016/j.resconrec.2021.105755.

S&P Global. 2019. *Lithium Sector: Production Costs Outlook*. S&P Global Market Intelligence.

Spitzmüller, Laura, Valentin Goldberg, Sebastian Held, Jens C. Grimmer, Daniel Winter, Milena Genovese, Joachim Koschikowski, and Thomas Kohl. 2021. "Selective Silica Removal in Geothermal Fluids: Implications for Applications for Geothermal Power Plant Operation and Mineral Extraction." *Geothermics* 95:102141. doi: 10.1016/j.geothermics.2021.102141.

Stearns, Jenna, and Corey White. 2018. "Can Paid Sick Leave Mandates Reduce Leave-Taking?" *Labour Economics* 51:227–46. doi: 10.1016/j.labeco.2018.01.002.

Stringfellow, William T., and Patrick F. Dobson. 2021.in *Technology for Lithium Extraction in the Context of Hybrid Geothermal Power*. Stanford University, Stanford, CA: Lawrence Berkeley National Laboratory, Energy Geosciences Division.

Tadesse, Bogale, Fidele Makuei, Boris Albijanic, and Laurence Dyer. 2019. "The Beneficiation of Lithium Minerals from Hard Rock Ores: A Review." *Miner. Eng.* 131:170–84. doi: 10.1016/j.mineng.2018.11.023.

Tal, Gil, Adam Davis, and Dahlia Garas. 2022. "California's Advanced Clean Cars II: Issues and Implications."

Thomason, Sarah, and Annette Bernhardt. 2018. *The Union Effect in California #2: Gains for Women, Workers of Color, and Immigrants*. UC Berkeley Labor Center.

Tsuji, Karl. 2022. *Global Value Chains: Graphite in Lithium-Ion Batteries for Electric Vehicles*. *Office of Industries Working Paper ID-090*. US International Trade Commission.

Turner, Clara, Marco R. Di Tommaso, Chiara Pollio, and Karen Chapple. 2020. "Who Will Win the Electric Vehicle Race? The Role of Place-Based Assets and Policy." *Local Economy* 35(4):337–62. doi: 10.1177/0269094220956826.

USGS. 2023. *Mineral Commodity Summaries 2022*. Washington, D.C.: U.S. Geological Survey.

Warren, Ian. 2021. *Techno-Economic Analysis of Lithium Extraction from Geothermal Brines*. NREL/TP-5700-79178, 1782801, MainId:33404. Golden, CO: National Renewable Energy Laboratory. doi: 10.2172/1782801.

WEF. 2021. *Digital Traceability: A Framework for More Sustainable and Resilient Value Chains. White Paper*. World Economic Forum.

Weisgall, Jonathan M. 2023."Lithium Valley and Geothermal Expansion." Presented at the Critical Minerals in California: Building the Supply Chain for Tomorrow, January 18, UC Riverside Palm Desert Campus.

Whitfield, Graeme. 2023. "Britishvolt Sold for Just £8.6m after Racking up Losses of More than £150m." *Business Live*, March 14.

Whiton, Jacob, and Greg LeRoy. 2023. *Power Outrage: Will Heavily Subsidized Battery Factories Generate Substandard Jobs?* Washington, D.C.: Good Jobs First.

Woody, Maxwell, Gregory A. Keoleian, and Parth Vaishnav. 2023. "Decarbonization Potential of Electrifying 50% of U.S. Light-Duty Vehicle Sales by 2030." *Nature Communications* 14(1):7077. doi: 10.1038/s41467-023-42893-0.

Worker, Jaimie, Sebrina Owens-Wilson, and Ben Beach. 2016. "Good Jobs in a Clean Energy Economy through the Clean Power Plan." *The Clean Power Plan for All Collaborative*.

Zabin, Carol, Roxane Auer, Mijin Cha, Robert Collier, Richard France, Jenifer MacGillvary, Holly Myers, Jesse Strecker, and Steve Viscelli. 2020. *Putting California on the High Road: A Jobs and Climate Action Plan for 2030*. UC Berkeley: Center for Labor Research and Education.

Zabin, Carol, and Karen Chapple. 2011. *California Workforce Education & Training Needs Assessment for Energy Efficiency, Distributed Generation, and Demand Response*. UC Berkeley: Donald Vial Center on Employment in the Green Economy.

Zabin, Carol, Maggie Jones, and Betony Jones. 2022. *Putting San Diego County on the High Road: Climate Workforce Recommendations for 2030 and 2050*. Inclusive Economics.

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