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Capturing the Growth Opportunity of the Bioeconomy Across California: Elements of a State Bioeconomy Roadmap

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Section I: Introduction: The case for the bioeconomy as a strategic sector for California

California – which represents the world’s fourth largest economy overall – is at an inflection point. For decades, the state has seen unparalleled economic growth in a diversified range of sectors that have leveraged its location on the Pacific coast with access to Asian and western state markets, huge and growing consumer base, mild climate, higher education system, and – most profitably – innovation ecosystem. But California’s economy faces challenges from increasing geopolitical, economic, and climate risk, all of which threaten the state’s current economy. At this moment, it is more important than ever that the State California move from its relatively passive position of watching (and regulating) growth, toward more active economic development strategies that increase resilience in the face of growing risks, while also helping to move the state toward a more sustainable and inclusive future.

The move toward a more comprehensive and long-term economic strategy to build out key sectors and industries in a large economy is usually referred to as “industrial policy.” In this chapter, we argue that it is time for California to lean into industrial policy, and specifically to prioritize growth of the circular bioeconomy as a key opportunity to leverage key assets, support significant energy transition, and address climate resilience goals, and open up new job and business opportunities across every region of the state.

On the risk side, the state is facing and experiencing converging pressures. Climate impacts including wildfire, extreme heat, and water scarcity, are already reshaping where the state grows and the economic opportunities within each region. At the global level, climate impacts combined with shifting geopolitical realities are creating deep uncertainty in trade markets and supply chain flows. At the same time, California’s rural regions, many initially built on the back of natural resource extraction (timber, agriculture, oil and gas), are seeing declines in those industries due to these same global forces. It is a moment when the state needs to look up and find a new path toward greater economic resilience, rather than leaning in on the status quo.

Luckily, California has significant assets on which to build a new and more robust and resilient economy for the future. California is home to abundant natural resources, financial expertise, and human capital—all which undergird its strong leadership in agriculture, manufacturing, and biotechnology. While these sectors are still vulnerable

to the shocks described above, longstanding investment in their workforce, infrastructure, and innovation can be the basis for new sectors and ideas.

The bioeconomy– the use of a wide array of bio-based inputs to produce products as diverse as fuel, energy, food ingredients, chemicals, plastics, and building materials – sits at the intersection of California’s economic assets and offers an opportunity to drive greater growth *and* resilience.

California is home to nearly 50 million bone dry tons of biomass across forest residues, agricultural residues, municipal solid waste, food processing byproducts, and plant materials.¹ Today, many of these products are left sitting on the side of forest or farm roads, often emitting methane or even spontaneously combusting from heat-generating anaerobic processes. Forest material that is not collected is often staying on the forest floor, creating new fuel for megafires and attendant utility and insurance costs. But if the state can marry this biomass to its considerable innovation system and manufacturing base, California has the potential to develop a globally competitive bioeconomy that can both solve a waste and environmental problem as well as drive high-value economic activity across the state.

In short, a bioeconomy can turnkey risks and liabilities into opportunities. Forest overgrowth can become woody biomass for a range of bioproducts from fuels to building materials. Agricultural waste that was once burned in the fields can be transformed into a diversity of bio-based materials and products. Organic waste that must otherwise be processed in expensive facilities can be transformed into energy and industrial inputs as part of closed-loop circular systems. All of these processes can be turned toward new consumer products that have the potential to drive the energy transition, by replacing petroleum with more sustainable bio-based products in everything from transportation fuels to building materials to clothing to pharmaceuticals.

Just because the state has the relevant feedstocks, innovation processes, and consumer base to anchor the bioeconomy does not mean that the economic benefits the sector produced will be broadly shared. As in any economic growth strategy, a strategic focus on growing a competitive bioeconomy must deliberately put California on a path toward truly “high-road” economic growth: investment into high-quality jobs, start-up business opportunities, domestic production throughout the supply chain, and real investment into both rural and urban economies.²

In short, a strategic investment into growing California’s bioeconomy represents a unique, “win-win” opportunity to invest in the state’s future by driving high-road, regional economic growth that simultaneously delivers on the state’s climate agenda.

¹ See: <https://www.energy.ca.gov/data-reports/california-power-generation-and-power-sources/bioenergy/biomass-energy-california>

² For a discussion about the definition of “high road”, see Joel Rogers (1990): <https://highroad.wisc.edu/wp-content/uploads/sites/2056/2020/05/1990-What-does-22high-road22-mean.pdf>

Few sectors align climate goals, shared prosperity opportunities, and regional economic resilience this directly.

What it will take: The critical role for a State of California Industrial Policy

Yet these opportunities cannot and will not be achieved without proactive state-level vision and strategic intervention. To fully capture the bioeconomy opportunities requires industrial policy: a focus on asset mapping, market analysis, and implementation support including facilitate interagency coordination and investment, regulatory streamlining, and coordinate with and across affected regions.

As noted above, California has enjoyed decades of growth without significant economic planning. The state's role has mainly been to track this growth, find ways to leverage it for general fund revenues, and regulate it where necessary to ensure clean air and water—all of which it has done exceptionally well. But the time has come to move from reaction and management to action and implementation. This will require California officials to affirmatively map a strategy for the bioeconomy that flows from feedstocks through to consumer purchase, and to overcome real pinch points on implementation, including how to manage biomass to avoid wildfires; support farmers and forest managers to adapt to new regulations; and reduce methane and other greenhouse gas emissions from forest, agricultural, and urban wastes.

Additionally, the state needs a proactive strategy to capture the full value chain of the bioeconomy and related industries. This sector is competitive for California in part because of the huge amount and diversity of biomass feedstock. But raw materials are only one piece. California will need to capture value at every stage: extraction, processing, manufacturing, and final sale—a shift from many of the state's existing growth sectors, where early-stage innovation and late-stage consumption stay in state, while manufacturing and supply chains go out of state or overseas.

As a result, California needs a focused state level strategy that aligns the complex array of actors, industries, and policies necessary to foster a globally competitive bioeconomy throughout California. The prize is massive: a successful bioeconomy strategy could strengthen the economies of California's diverse regions, reduce greenhouse gas emissions, enhance statewide wildfire resilience, develop markets for biomass waste streams, create high-quality manufacturing jobs, and improve community health.

This chapter proceeds as follows:

- Section II: How the bioeconomy supports a wide range of California goals: The case for a state interest in a bioeconomy strategy
- Section III: What are the assets of California that support its potential competitiveness in the bioeconomy?

- Section IV: What are key challenges to overcome: Why California’s latent advantage remains unrealized
Section V: Why now: The specific opportunities
Section VI: Elements of a State Bioeconomy Strategy
- Section VII: Conclusion

Overall, this chapter identifies that California can and should pursue the growth of the bioeconomy as a strategic sector.

SIDEBAR: Defining the circular bioeconomy

The bioeconomy is a broad, umbrella term for several related industry sectors innovative products, services, and processes that transform biological resources or “biomass” (meaning plants and microorganisms) into needed products. These outputs can include fuels, building materials, plastics, chemicals, solvents, food ingredients, and alternative proteins. Importantly, the bioeconomy can reduce the use of fossil fuels as a feedstock in the production of industrial products like chemicals, plastics, and fuels. In a “circular bioeconomy,” materials that would otherwise be wasted (like material removed from the forest to reduce wildfire risk, or material left over after agricultural harvesting) become inputs to develop useful products. This preserves resources, can enhance ecosystems, and reduces waste disposal in landfills, the atmosphere, and bodies of water.

This is a sector with significant economic potential. The National Academies of Science, Engineering, and Medicine estimate that the bioeconomy is currently 5.1%, and has the potential to become 7.4%, of U.S. GDP making it a multi-trillion-dollar industry nationwide.³ Globally, some projections also estimate the future global bioeconomy could be worth \$4 trillion to \$30 trillion.⁴

Section II: How the bioeconomy supports a wide range of California goals: The case for a state interest in a bioeconomy strategy

Advancing the bioeconomy can simultaneously help meet a wide range of existing and long-standing state and regional goals. Success for California’s bioeconomy is win-win. A viable bioeconomy helps achieve key economic, climate, public health, and other goals and targets with minimal downsides or tradeoffs.

Economic and Workforce Development

From a traditional economic perspective, the bioeconomy offers California a strong opportunity to achieve a range of state business investment and workforce development goals. The fullest expression of the state’s economic development

³ <https://nap.nationalacademies.org/read/25525/chapter/6>.

⁴ Hodgson, A., Alper, J., Maxon, M.E. 2022. The U.S. Bioeconomy: Charting a Course for a Resilient and Competitive Future. New York, New York: Schmidt Futures. <https://doi.org/10.55879/d2hrs7zwc>

priorities is articulated in the California Economic Blueprint, released in 2024 by the Governor’s Office of Business and Economic Development (GO-Biz) as part of the broader California Jobs First program⁵. As described in the blueprint, the state’s north star is to “Help create, attract, and increase access to good-paying jobs.” This will be accomplished through four goals:

1. Support sustainable and equitable growth across regions and populations.
2. Invest in the workforce for the sectors of the future.
3. Create an attractive environment for and with job creators.
4. Strengthen California’s innovation economy and entrepreneurial culture.

Investment in the bioeconomy—a sector highlighted by 8 of 13 economic regions in their own Jobs First strategies--specifically supports the Blueprint goals as follows:

Goal 1: Support sustainable and equitable growth across regions and populations

The bioeconomy is inherently place-based. It relies on agricultural residues, forest biomass, organic waste streams, and regional industrial assets that are distributed across California’s diverse geographies. Because biomass is unwieldy to transport (both heavy and taking up a lot of space), it is best processed within 50 to 75 miles of its origin.⁶ As such, it is a strong contender for domestic processing and use, since many parts of the supply chain must be localized and also not subject to the same geopolitical shifts that impact global delivery of fossil fuel feedstocks. Additionally, biomass is readily available across the state so growth in this sector supports economic diversification in a wide range of regions -- rural, agricultural, and urban feedstocks are all in play for feedstock generation and initial processing; innovation and manufacturing can build on infrastructure in other key areas; and final consumption will be statewide but especially in population centers. Because this sector is ultimately feedstock- and manufacturing-dependent, it offers opportunities in regions that have been left behind in California’s recent tech-centric growth, including the Central Valley, the Sierra, the state’s far north, and the Inland Empire.

The sector also has the potential to provide family-supporting jobs, especially in biomanufacturing and bioindustrial operations generally exceeding the state median, and to provide pathways into middle-skill technical careers. These roles include process technicians, lab technicians, maintenance mechanics, plant operators, and quality control specialists. Bioeconomy facilities can be sited near feedstock sources, supporting job creation in rural communities.

The sector is already recognized as a strategic priority in the State Economic Blueprint and (as noted above) in 8 of 13 economic regions. In 2025, the state invested \$10 million to advance an innovation campus in the Central Valley.

⁵ See: <https://jobsfirst.ca.gov/wp-content/uploads/Economic-Blueprint.pdf>

⁶ See: <https://energy.sustainability-directory.com/learn/what-are-the-logistical-challenges-of-transporting-woody-biomass/>

Goal 2: Invest in the workforce for the sectors of the future

The bioeconomy provides opportunities for growth in a wide spectrum of occupations that align with future workforce demand. These include bioprocess technicians, fermentation specialists, laboratory analysts, chemical engineers, industrial maintenance mechanics, automation technicians, and environmental compliance specialists. Many of these roles require precision lab work and applied technical skills that are less susceptible to displacement by automation compared to routine or repetitive tasks. This means the bioeconomy provides a hedge against the current state estimates that automation may replace 30% of the current hours worked in traditional industries.⁷

The sector also offers new pathways for incumbent workers who have overlap in skills and training. This includes workers in some of the industries most susceptible to climate impacts and other economic risk, including oil and gas refining and food processing, where workers have transferable skills that can be applied in bioindustrial facilities. As those sectors transition, the bioeconomy offers a pathway into new bioproduction roles. The bioeconomy has the added benefit of seeing job growth in many of the same regions whose economies are in transition from agriculture, forestry, or oil and gas – an important factor in an economy where there is relatively little economic mobility, and where much of the workforce is culturally or personally tied to their current regions.⁸

Investment in the bioeconomy therefore reinforces the California Economic Blueprint’s call to align workforce systems with emerging sectors, with the added benefit of this specific sector being one that is likely to stay domestic rather than being offshored. The state also has the potential to support partnerships between industry, K–16 collaboratives, community colleges, and universities that can help ensure that curriculum development, apprenticeships, and industry-recognized credentials reflect real-time employer demand. In aligning these economic and workforce assets, the state can strengthen its talent pipeline for a sector that intersects biotechnology, advanced manufacturing, and clean energy.

Goal 3: Create an attractive environment for and with job creators

Bioeconomy growth requires industrial siting, infrastructure development, and commercialization facilities across multiple regions of the state and to each part of the value chain. In the bioeconomy this includes:

⁷ See page 12: <https://www.gov.ca.gov/wp-content/uploads/2025/04/2025-CA-Master-Plan-for-Career-Education.pdf>

⁸ Gordon, Kate. 2024. “Managing the Energy Transition: A Place-Based Approach”. Available at: <https://carnegieendowment.org/research/2024/08/managing-the-energy-transition-a-place-based-approach>

- 1) feedstock aggregation and nearby processing, including dairy digesters in agricultural areas, facilities converting woody biomass into marketable products in forested or agricultural regions, anaerobic digestion plants processing organic waste
- 2) Innovation campuses designed to bridge the gap between laboratory research and commercial-scale production.
- 3) Offtake agreements for end use (like SAF at the major airports).

All three are important to ensure a robust build out of the value chain for the bioeconomy across California.

These facilities must also operate within California's environmental regulatory framework, including CEQA. As noted in the state's Blueprint, job creation and environmental protection are not mutually exclusive. However, predictability and timing certainty are critical for firms evaluating capital-intensive investments. Bioindustrial projects often involve significant upfront costs and depend on synchronized approvals related to air quality, water use, waste handling, and land use.

Strengthening the competitiveness of project investments in the bioeconomy will require simplifying and coordinating existing incentive programs, clarifying regulatory pathways, and reducing approval timelines without weakening environmental standards. This is becoming more politically palatable within California, especially given how CEQA reforms in 2025 included specific provisions to support streamlining for advanced manufacturing.⁹

Goal 4: Strengthen California's innovation economy and entrepreneurial culture

Growing the bioeconomy also supports a direct path to leverage and expand California's strong innovation ecosystem. Universities within the UC and CSU systems, in partnership with national labs and investment from innovation programs within federal agencies (such as the Department of Defense's DARPA, the Small Business Administration SBIR/STTR Programs, and the ¹⁰, form the backbone of the state's research and development infrastructure. These institutions generate intellectual property, spin out startups, and train the next generation of scientists and engineers.

Expanding the bioeconomy creates a direct pathway to commercialize research emerging from these institutions within California, rather than seeing it manufacturing and scale-up exported out to other states and countries. Shared pilot facilities as part of an "innovation campus" can reduce the gap between laboratory discovery and industrial production. They also encourage entrepreneurial activity by lowering capital

⁹ See: SB 131 https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202520260SB131

¹⁰ Note: NSF has an Regional Innovation Engines program. One of their developmental awards went to a California collaborative in the Central Valley. However, that collaborative was not ultimately successful in securing a full engine investment. <https://www.nsf.gov/funding/initiatives/regional-innovation-engines> and <https://www.nsf.gov/funding/initiatives/regional-innovation-engines/portfolio/nsf-engines-development-awards>

barriers for early-stage firms. In this way the bioeconomy strengthens the full innovation lifecycle: from research and idea generation to commercialization to manufacturing.

Co-locating innovation and manufacturing also creates strong feedback loops, as lessons learned in the manufacturing process are communicated back to innovators who then improve technologies in response.¹¹ This feedback loop creates best-in-class research and development work, which in turn can result in patents and frameworks California can export to other countries with their own interest in the bioeconomy.

In addition to meeting the state's core economic development and job creation goals, the bioeconomy has strong potential to advance a number of other key state goals and targets, especially those related to decarbonization and climate resilience. Meeting these goals ultimately strengthens California's economy by making it more likely to survive increased climate impacts and both state and global policy change.

Climate mitigation & Decarbonization

California has long been a leader in its approach to economy-wide decarbonization (often referred to as “climate mitigation” because of the importance of reducing carbon and other greenhouse gases in order to slow the march of climate change). The state has set some of the most ambitious targets in the country, including reducing greenhouse gas emissions 40 percent below 1990 levels by 2030 and achieving 90 percent clean electricity by 2035. The state has also committed to reducing methane emissions 40 percent below 2013 levels and diverting 75 percent of organic waste from landfills (SB 1383). Going beyond decarbonization to actually driving carbon removal from the atmosphere, the state's most recent goal is to reach full “carbon neutrality by 2045.

Growing the state's bioeconomy sector directly advances decarbonization goals by supporting the transformation of organic waste and agricultural residues – many of which are currently aggregated but not processed, and therefore directly contributing to the state's methane emissions -- into bio-based products such as renewable fuels, low-carbon building materials, and soil amendments. These products have a huge benefit in their potential to actually displace petroleum-based products, which can drive down demand for fossil fuels across the state (and, if exported, the globe). In addition, as described in more detail below, a strong bioeconomy can create a market for forest biomass that creates wildfire risk, therefore helping to deter fires that would otherwise put massive greenhouse gas emissions into California's atmosphere.

These benefits are directly connected to the economic and workforce goals described above. Creating new markets for biomass through a comprehensive bioeconomy

¹¹ See Zysman, John and Cohen, Stephen S. (1987), *Manufacturing matters: the myth of the post-industrial economy*. Basic Books. Also see Pisan. Also see Pisano, G. P., & Shih, W. C. (2012). *Producing Prosperity: Why America Needs a Manufacturing Renaissance*. Harvard Business Review Press.

strategy drives investment into forest, agricultural, and municipal waste management, enabling the state's climate commitments to become industrial development opportunities, not compliance burdens.

Air Quality & Public Health

Across California, agricultural practices, forest conditions, and municipal solid waste management have direct and measurable impacts on air quality and public health. A viable bioeconomy can help address these impacts by creating productive uses for organic waste streams that currently contribute to pollution.

In the San Joaquin Valley, agricultural burning has long contributed to elevated levels of PM2.5 and ozone precursors in one of the most polluted air basins in the nation. In 2003, the Legislature passed legislation to phase out most agricultural burning in the region, and in 2024 the California Air Resources Board advanced a complete phase-out schedule.¹² The region frequently records some of the highest fine particulate levels in the United States. Elevated PM2.5 exposure is associated with increased asthma prevalence, cardiovascular disease, and premature mortality, and childhood asthma hospitalization rates in many Valley communities exceed the state average. Reducing open burning is therefore essential for public health.

However, the success of the burning ban is contingent on viable markets for orchard removals, crop residues, and other agricultural biomass streams. Without economically feasible alternatives, growers face limited options for managing woody and organic waste. A functioning bioeconomy can create durable end uses for this material in advanced materials, renewable fuels, and other bio-based products, reducing particulate exposure while supporting more diversified regional economies.

A similar dynamic exists with dairy and livestock manure, a significant source of methane emissions and localized air quality impacts. Technologies such as anaerobic digesters can convert manure into renewable natural gas or electricity, generating on-site energy while reducing methane emissions and odors. More advanced bio-based processing can produce soil amendments or other value-added products. As with crop residues, these systems require stable demand, infrastructure, and coordinated policy signals to move from isolated projects to durable market activity.

In forested regions, accumulated fuels combined with climate change have produced larger and more intense wildfires. Smoke from these fires now represents one of the dominant sources of fine particulate pollution in the state, affecting communities hundreds of miles away. Major smoke events have led to school closures, increased respiratory illness, and spikes in emergency room visits. Reducing fuel loads through forest thinning and biomass removal improves air quality and public health. Creating

¹² See: <https://ww2.arb.ca.gov/our-work/programs/agricultural-burning/san-joaquin-valley-agricultural-burning>

markets for low-value woody material as feedstock for biofuels, bioenergy, and bio-based materials helps make this removal economically feasible.

Municipal organic waste presents another air quality and climate challenge. Food waste, yard trimmings, and other biodegradable materials generate methane and localized pollutants when landfilled. Expanding composting, anaerobic digestion, and other bio-based processing pathways can mitigate these impacts while transforming organic waste into economic inputs.

Across agriculture, forestry, and municipal systems, the bioeconomy provides a mechanism to convert pollution liabilities into productive assets.

Climate resilience and land conservation

California's climate strategy increasingly recognizes that resilience requires both conservation and active management of natural and working landscapes. The state has adopted a "30 by 30" commitment to conserve 30 percent of its lands and coastal waters by 2030, and it has set a target of treating at least one million acres of forested land annually to reduce wildfire risk. Since 2019, the state has committed more than \$10 billion to wildfire prevention and forest resilience programs, with utilities such as PG&E investing an additional \$15–20 billion in wildfire mitigation and vegetation management, which represents a substantial increase in forest management spending compared to pre-2018 levels.

These programs generate significant volumes of low-value woody biomass through thinning, fuel reduction, and vegetation management. Without long-term markets for bio-based products, removal remains costly and uneven. A functioning bioeconomy can create durable demand for forest residues in engineered wood products, renewable fuels, bio-based materials, and related applications. By creating end uses for this material, the bioeconomy helps align wildfire mitigation objectives with industrial development.

A similar logic applies to agricultural working lands. Orchard removals, crop residues, and dairy byproducts can serve as feedstocks for conversion into marketable products, generating supplemental income streams for farmers. This is particularly important in regions affected by the Sustainable Groundwater Management Act (SGMA), which requires groundwater basins to be brought into balance—meaning withdrawals must not exceed long-term recharge. As irrigated acreage is reduced to comply with SGMA, agricultural regions face structural economic adjustment. Bio-based industries can help diversify revenue sources and support soil amendments and practices that enhance water retention and carbon sequestration.

Providing additional income streams for working landscapes reduces pressure to convert agricultural and forest lands to fragmented urban development patterns that undermine conservation goals. In this way, the growth of a circular bioeconomy

supports wildfire mitigation, water sustainability, carbon management, and the state's 30x30 commitment. Rather than treating conservation and economic development as competing priorities, it integrates them.

As this chapter demonstrates, achieving these state goals will only occur if the state can leverage its policy mandates to help communities and market actors to transform its existing biomass into inputs that have viable markets in a growing bioeconomy. This is the win-win nature of the bioeconomy as a sector that not only supports regional economic diversification but also climate mitigation, air quality enhancement, and climate resilience.

Section III: What are the assets of California that support its potential competitiveness in the bioeconomy?

When analyzing the growth potential for new economic investments across a particular geography, whether nation or state or region, it is standard practice to do an “asset map” of that geography. An evaluation of California's assets, both natural and manmade, underscores the huge potential for the bioeconomy as a growth sector across the state's diverse regions.

California is home to a wealth of resources that can feed a thriving bioeconomy. A competitive bioeconomy draws from a range of sectors and assets across the entire value chain, from feedstocks to processing to end-use. In particular, the state has a huge opportunity to ramp up bioindustrial manufacturing which sits at the intersection of biotechnology, agriculture, and manufacturing—all core strengths of the California economy.

An agricultural powerhouse, the state produces 400 different commodities, including half of all fruits and vegetables grown in the U.S. with annual exports exceeding \$23 billion. This makes California the most crop diverse and most agricultural productive state in the nation, with a unique combination of diverse and abundant sources of sustainable biomass for feedstock innovation. One important aspect of California's agricultural sector is its dependence on tree crops, which can be the source of significant woody biomass, as well as its large dairy industry with its attendant organic waste streams. Both these areas of California agriculture are also particularly climate-sensitive as well, underscoring the importance of diversifying the economy in the regions heavily dependent on tree crops and dairy farms.¹³

Long a manufacturing powerhouse, California boasts more than 45,000 manufacturing establishments which employ over 1.2 million workers—though it's important to note that manufacturing jobs have dropped from 12 to 7 percent of the state's overall employment since 1990. The state's specific strengths in manufacturing are based on its unique geographic assets (both its climate and its location on the Pacific Rim) and

¹³ See: https://riskybusiness.org/uploads/files/RiskyBusiness_Report_WEB_09_08_14.pdf TK California report link

include aerospace and defense, food processing, pharmaceuticals, semiconductors and industrial chemicals. Manufactured exports from 2021 to 2024 averaged between \$175 and \$185 billion annually.¹⁴

California is also home to 33 million acres of forested land – one-third of the state’s land mass. Of that, the Federal Government owns 58%, the state 3% and the remainder in private holdings.¹⁵ This means that collaboration between the state and federal government on land management is necessary for preparing the state for wildfire resilience and maintaining healthy forests.

One of the state’s most significant assets is its human capital. The workforce of 19 million people transcends that of many nations, in part due to an education system that can lean in quickly to train workers for in-demand industries – and is particularly strong in the realm of food manufacturing.¹⁶ Over 80 percent of all college students in California attend public institution, half of whom are at a community college (who are equipped to be much more responsive to employer demands). There are over 1.9 million students in community college, nearly 500,000 at a CSU, and 300,000 at a UC. The state investment annually in this public higher education system totals more than \$23 billion with numerous UC’s ranked among the top Universities in the country.

The state’s history of economic and technological innovation is also key to bioeconomy development, especially as this sector will continue to require major technological breakthroughs if it has any hope of achieving price parity with fossil fuels in the industrial economy. California’s core innovation assets to support the bioeconomy include national labs and research universities, a world-leading biotech sector, and massive agricultural production and research capacity.

As explained earlier in this chapter, California’s history of climate and environmental policy has led to regulatory drivers that require change, such as bans on burning and waste diversion mandates. As noted above, California also has a policy and market environment supportive of technologies that accelerate the transition to a net-zero carbon economy. Yet while regulation shapes markets, it does not on its own result in the creation of a new viable market.

Regional leadership in the bioeconomy

As noted earlier, the importance feedstocks makes the bioeconomy more place specific than other sectors. In addition, workforce and infrastructure are regional, and project siting and selection requires local approvals. Together this means that local and regional leadership is key to realizing a bioeconomy opportunity. There have already been a variety of promising bioeconomy plans and projects in communities and

¹⁴ See: <https://www.ppic.org/blog/californias-trade-landscape-is-shifting-not-shrinking-so-far/>

¹⁵ See: <https://www.gov.ca.gov/2020/08/13/california-u-s-forest-service-establish-shared-long-term-strategy-to-manage-forests-and-rangelands/>

¹⁶ https://craig.fresnostate.edu/documents/ubc-documents/cencal/2019/CCBR_FoodBevManu_Web.pdf

regions, especially those that have been searching for new economic activity to replace declining or climate-stressed resource-based industries. These include forested regions focused on woody biomass utilization; agricultural regions focused on agricultural waste, biomanufacturing, and methane reduction; and urban regions focused on organic waste and manure, sustainable fuels, and advanced materials.

Some of these specific regional projects and proposals include the following:

In northern forested regions, the focus has been on viable woody biomass utilization opportunities. For instance, the North Coast Resource Partnership Pilot is one of five state-funded regional pilot projects, and recently released a woody biomass that identifies a set of subregional woody biomass utilization projects along the north coast.¹⁷

In agricultural regions such as the Central Valley, there is a focus on diverse agricultural waste streams and a specific effort focused on bridging gaps between R&D and commercial scale manufacturing of bio-based products. Sector intermediary BEAM Circular is working with a coalition of over 100 partners, co-led by UC Merced and Lawrence Berkeley National Lab and backed by a public-private capital stack with local and multi-national industry partners, to advance this effort. Elsewhere in the Central Valley, efforts have zeroed in on reducing methane emissions and diverting organic waste from landfills.

Two of the state's big airports – LAX in Los Angeles and San Francisco International – are expanding the use of sustainable aviation fuel made from non-petroleum feedstocks. Already, the private operator Signature uses entirely blended sustainable aviation fuel at its SFO and LAX locations, a blend that reduces the greenhouse gas emissions by nearly 80% compared with conventional jet fuel.¹⁸ Additionally, the Truckee airport, is the only airport in the US to offer only blended sustainable aviation fuels (30 percent biofuels and 70 percent conventional).¹⁹

In Inland California, four U.C. campuses (Berkeley, Davis, Merced, and Riverside) are jointly addressing bioeconomy challenges with goals to minimize waste, prioritize workers, enhance productivity, and manage water effectively.²⁰ The U.C. Division of Agriculture and Natural Resources (UCANR) – a leader in biotech and food systems research for 150 years – is undertaking an effort to launch a FutureFood Engine in Northern California and Nevada and was listed as an NSF Engine semifinalist.²¹ Additionally, UC Merced and partners at BEAM Circular had also pursued the NSF Engines funding, though despite an initial development award, did not make it to the

¹⁷ See: https://northcoastresourcepartnership.org/site/assets/uploads/2025/04/Forest_Biomass_Report_V6.pdf

¹⁸ See: <https://www.signatureaviation.com/news/signature-aviation-at-lax-now-100-percent-supplied-by-blended-saf>

¹⁹ See: <https://truckeetahoeairport.com/environment/sustainable-aviation-fuel>

²⁰ <https://brie.berkeley.edu/supporting-inland-california%E2%80%99s-bioeconomy-through-innovation-and-development>

²¹ <https://www.nsf.gov/news/nsf-advances-29-semifinalists-second-nsf-regional-innovation>

semifinals.²² In fact, when the 15 finalists were announced in September 2025, none were from California.²³

While individual regions have significant assets that can be leveraged to support parts of the bioeconomy supply chain, no region is home to a complete set of feedstock availability, processing infrastructure, and customer base. As a result, regions must work together to achieve a strong statewide bioeconomy. But today, regional projects and proposals are not well-coordinated across multiple regions. Nor do they match the scale of the opportunity. And at times there may be conflicts as multiple regions pursue similar opportunities.

Further, regions acting along is insufficient as regions face structural limits across accessing funding and capital markets, financing major infrastructure, sorting through the state's regulatory complexity, and coordinating across interregional supply chains. Without a clear state vision and roadmap to a comprehensive bioeconomy strategy, these individual regional projects risk staying too small to scale. And if there are limited resources, competition for investment between regions in similar areas could limit the state's potential.

The bottom line: place-based strategies for a competitive bioeconomy require statewide coordination to succeed.

Section IV: What are key challenges to overcome: Why California's latent advantage remains unrealized

California has unmatched bioeconomy assets. But those assets will not on their own result in the creation of a viable industry. California is a global leader in innovation and strong at building consumer markets through regulation. But the state is less consistent at capturing the full supply chain of manufacturing that follows. That pattern is evident in clean energy, where the state has excelled at innovation and installation of systems but seen much of the related manufacturing leave for nearby states or overseas. A similar pattern may emerge in the bioeconomy, without strong state coordination and investment.

Fundamentally, California has latent rather than realized advantage when it comes to the bioeconomy. Presence of feedstocks does not automatically lead to innovation in processing. Process innovation does not automatically lead to product commercialization. A significant challenge is that the state is not internally coordinated when it comes to economic development—perhaps because it has seen record growth without coordination for over 50 years, unlike many less fortunate states. As a result, procurement is fragmented. Capital remains insufficiently aligned to project priorities. Without intentional alignment and investment in scale-up, California risks continuing to invent technologies that are manufactured elsewhere.

²² See: <https://news.ucmerced.edu/news/2023/uc-merced-led-project-wins-1-million-nsf-engines-development-award>

²³ See: <https://www.nsf.gov/tip/updates/nsf-selects-15-finalists-advance-next-round-its-second>

In this section below, these challenges are organized into three core buckets:

- Institutional and governance,
- Regulatory, and
- Industry and market.

Institutional challenges relate to how the state, and its regions are organized and governed. This refers to the roles and authorities of different agencies, the reliability and durability of funding, and the specific tools to support economic development and project delivery. Regulatory challenges are about process and predictability, including permitting timelines, CEQA, air district approvals, and interconnection with energy systems. Industry challenges are focused on the operational realities of building the sector itself, including technology readiness, feedstock aggregation, manufacturing infrastructure, capital alignment, and market development. The state and its regions can play a critical role in addressing all three.

Institutional and governance challenges

The first challenge is fragmentation across governance. California lacks a unified approach to sector-based economic development. Energy, climate, natural resources, and economic development responsibilities are spread across multiple state agencies. Overall, there is no single entity responsible for long-term bioeconomy growth and supply chain development.

The state has supported important but discrete efforts to create a circular bioplastic economy to reduce plastic pollution, as well as a renewable energy strategy through the California Public Utilities Commission known as [BioMAT](#) that encourages large investor-owned utilities to buy wholesale power from small renewable bioenergy projects — though the latter has been controversial as these projects generally rely on combustion to turn biomass to energy.

Other relevant efforts include the Department of Conservation's [forest biofuels](#) pilot program, the Office of Land-Use and Climate Innovation's [feedstock supply pilot program](#), CAL FIRE's [wood products program](#), and IBank's [Climate Catalyst Fund](#). But to date, these various programs have proceeded in separate agencies and under disconnected authorities.

These efforts demonstrate interest. But they do not constitute a coordinated strategy. Unlike many peer states and similar-sized countries, California does not have a consolidated economic development structure with clear authority to align infrastructure, workforce, financing, and regulatory processes around sector growth. Funding is often episodic and program-specific rather than durable and sector-focused. Financial tools are not always aligned with the underwriting requirements and long timelines of emerging bioindustrial facilities.

The result is that while pilot projects advance and demonstrations occur, scaling to full manufacturing capacity remains stalled. Entrepreneurs face uncertainty about which agency leads, which funding stream applies, and how long approvals will take. Regional initiatives may move forward. But without consistent statewide coordination they cannot secure the infrastructure and regulatory alignment required for scale.

Regulatory Challenges

The second set of challenges concerns process and predictability in the regulatory landscape. California's environmental tools and regulations have been key to protecting the state's air, water, and natural environment. But they are increasingly also used to limit industrial growth, including the transition to clean energy and the bioeconomy (let alone to support environmentally necessary infill development). The uncertainty in project approvals affects the ability to build facilities, especially as California Environmental Quality Act (CEQA) review, regional air district permitting, county and city land use processes, and utility interconnection requirements operate across multiple jurisdictions and timelines. These processes are rarely synchronized.

The issue is not that environmental standards are too strong, but that they are uncoordinated and often politicized, leading to fundamental uncertainty across industrial development regulatory processes. Without more clarity in regulatory timelines and requirements, it is nearly impossible for private capital to align with development schedules. As a result, California often loses out on even the most climate- and environmentally-friendly development to other states.

For bioeconomy projects, especially first-of-a-kind facilities, regulatory uncertainty directly affects financing. Capital providers must assess not only technology risk but also timeline risk. When permitting pathways are unclear or extended, projects become harder to finance even if demand exists. This is particularly true given the narrow margins on which bioeconomy facilities operate, given that they are investing in a product that is trying to compete with long-subsidized fossil fuels.

Political opposition also remains for certain components of the bioeconomy, including bioelectricity programs such as the Bioenergy Market Adjusting Tariff (BioMAT), due to some use of combustion. In the BioMAT program, there are three categories of projects: biogas (anaerobic digestion) from wastewater/municipal waste, dairy and agricultural bioenergy, and byproducts from woody forest biomass, which often uses combustion or gasification for power generation. Some argue that the combustion is necessary as a transitional technology. But there is also significant local concern, which has slowed investment in these projects. This reduces the potential for new projects to support forest thinning, methane reduction, or waste diversion.

As noted previously, the California experience of significant economic growth for the past century has led many state planners and policy makers to focus more on regulating the harms from industry, rather than on supporting competitive industrial

growth. Although the state's economic successes were due in part to geographic and natural resource advantages, not state action, the mindset that jobs and economic growth will continue nonetheless persist. This history of regulation over planned growth means it is often easier to stop projects than to build them. As has long been noted among California policy circles, in California everyone has a veto, but no one has an override. That dynamic is especially consequential for manufacturing facilities that require coordinated approvals across agencies. Without greater predictability and coordination, the state's innovation leadership will continue to outpace its deployment capacity.

Industry and Market Challenges

The third set of challenges facing bioeconomy development in California is the reality of industry and market conditions that are not quite ripe for some parts of the sector to thrive. Market development for bio-based products remains uneven, given these products must compete with established fossil-based alternatives supported by mature infrastructure, federal subsidies, deep lobbying pockets, and global supply chains protected by military might. State-level policy mandates can create demand signals, but for the sector to have durable competitive strength, it has to be able to drive down costs while attracting long-term capital and political support.

One major cost challenge is the simple aggregation and transportation of biomass feedstock. Biomass is dispersed across farms, forests, and waste streams. Aggregating sufficient volume at consistent quality and price requires coordination across many small sources, combined with a transportation network capable of moving diverse types of biomass at cost. This coordination challenge has the structure of a classic collective action problem: no individual farmer, timber operator, or waste hauler has sufficient incentive to invest in aggregation infrastructure on their own, because the benefits (e.g. a functioning feedstock market) flow to all participants whether they invest or not. Each actor waits – rationally – for others to move first. As a result, the market fails to develop and feedstock supply remains fragmented, inconsistent, and expensive relative to fossil-based alternatives, even in regions where the raw material is abundant.

Infrastructure gaps compound the aggregation challenge. This includes costs to upgrade energy systems and transportation access. For example, consider the Redwood Coast and Shasta-Trinity regions of Northern California: millions of tons of woody biomass are generated annually through forest thinning operations aimed at reducing wildfire risk, yet both regions lack the road infrastructure to move that material at scale, the electrical grid capacity to power conversion facilities, and the workforce to staff them. The biomass then sits with the potential to burn. This pattern of abundant feedstock left in forests due to the absence of co-located processing infrastructure repeats across the Sierra Nevada. Quite simply, in rural forested regions, there is limited processing infrastructure and insufficient workforce capacity to convert biomass into higher-value products. Unlike fossil fuel supply chains, which were built

out over decades with sustained federal investment, bioeconomy infrastructure has no comparable legacy base to build from. Most facilities are often the first of their kind in each region and thus have to build out the entire infrastructure from scratch

Financing also remains mismatched to development timelines. Emerging bioindustrial facilities require patient capital. Underwriting requirements and risk tolerance do not always reflect the realities of first-of-a-kind manufacturing projects.

In sum, these institutional, regulatory, and industry challenges explain why California's bioeconomy remains an unrealized opportunity.

The state has the feedstocks. It has the research capacity. It has climate policy drivers that create demand. What remains incomplete is the alignment required to build and retain manufacturing capacity at scale.

If California does not invest in scaling biomanufacturing capacity, particularly in agricultural regions where feedstocks are concentrated, it will continue to generate innovation while other states capture production. Moving from latent to realized advantage requires deliberate coordination across governance structures, regulatory processes, infrastructure investment, and market development.

Section V: Why now: The specific opportunities

Federal retrenchment on industrial policy on the bioeconomy creates opening for California to lead

If done right, Federal support can accelerate progress for new industries. But shifts in federal policy create risks while shifting focus creates an opportunity.

The bioeconomy had previously received increased national attention, including through a defense strategy. The Biden-Harris Administration tracked \$63 billion in new investments in biomanufacturing over four years – including \$1.6 billion in California.²⁴ The previous White House also laid out a research, coordination, and regulatory reform agenda for biotechnology and biomanufacturing, which was partially implemented²⁵ before being repealed by the Trump Administration in February 2025.²⁶

While this may be a setback for national coordination on the bioeconomy, it also represents an opportunity for California – as the nation's largest state economy, innovation engine, and agricultural producer – to seize the leadership mantle. California cannot wait for national alignment.

²⁴ https://bidenwhitehouse.archives.gov/invest/?utm_source=invest.gov

²⁵ <https://fas.org/publication/implementing-bioeconomy-executive-order/>

²⁶ <https://www.lawbc.com/president-trump-revokes-2022-ao-on-advancing-biotechnology-and-biomanufacturing/>

As a reflection of California stepping into the breach due to federal inaction, California has developed bilateral agreements and MOUs with dozens of countries, including in particular bioeconomy and clean energy leaders globally, including Denmark, Sweden, and Japan.²⁷ The efforts detailed in this book reflect some of that.

California's new state level leadership in economic development

Through a timely innovation, California is in the midst of an experiment in place-based, regional economic planning: California Jobs First, Governor Gavin Newsom's signature economic development initiative.²⁸ The initiative originated in 2019 with the launch of *Regions Rise Together*, an initial framework for the state focused on more inclusive and sustainable regional economies. COVID-19 created economic shock waves across the state, which led to a new political appetite for regional recovery and rebuilding; this ultimately resulted in the legislature proposing, and the Governor's office refining, a "Community Economic Resilience Fund" that provided planning and implementation dollars to every region. The program, renamed a few years later as the "California Jobs First" program, is often touted by the Governor's office as the first major regional economic development strategy in the state's history.

Regional support for economic development



Every economic region in California has built new and inclusive governance structures for economic planning and cross-sector civic and governmental collaboration as part of the California Jobs First process. Over 10,000 Californians have participated in the regional tables over the past four years. While there is no doubt that some stakeholder

²⁷ See: <https://www.gov.ca.gov/2025/08/22/california-and-denmark-sign-new-partnership-on-climate-technology-efforts/>

²⁸ See: <https://www.labor.ca.gov/regional-investment-initiative/>

groups could have been more engaged (e.g., local governments or key employers in some regions; labor and community representatives in others), the overall program has touched a wide diversity of people and organizations, many of whom had not been part of economic development conversations in the past.

Each region has produced a [strategic plan](#) that outlines its key assets, challenges, and opportunities. Regions have also prepared more detailed implementation, and activation plans to support up to three initial growth sectors of their economies. These early results show an appetite for more coherent, long-term economic planning, and demonstrate the ability for regions across the state to plan holistically and pursue shared strategies.

8 of 13 economic regions across California are identifying the bioeconomy as a priority sector

A majority of the regional economic strategies and plans in California elevate bioeconomy as a strategic sector. This includes forest and agricultural biomass and bio-industrial manufacturing as potential anchor economic strategies.

For example, in the North San Joaquin Valley, [North Valley THRIVE](#), the Jobs First team serving the North San Joaquin Valley, [identified](#) the circular bioeconomy as one of four priority sectors. (See Chapter 12/TK in this volume for a case study of those efforts).

In the Central San Joaquin Valley, the strategy included a focus on circular manufacturing strategy as well as bioenergy, including from bio-based-feedstocks (e.g., agricultural waste, animal waste, forest and lumber waste, industrial and commercial waste, food waste).²⁹

The [Sierra Jobs First regional plan](#) advocates for partnership with other regions to process and utilize woody biomass and statewide coordination on the bioeconomy workforce.³⁰ Their plan also included working lands strategy and an interest value-add wood waste materials.

The Redwood Region includes a working lands strategy with biomass related activities such as biochar.³¹ The North State includes a natural resources sector and strategies to support growth of value-add wood waste materials.³²

Even in the more urban regions there are elements of a bioeconomy strategy. The [Bay Area regional plan](#) notes the challenges in scaling up biotechnology and biomanufacturing innovations within the region, due to high costs and workforce

²⁹ See: <https://www.s2j2initiative.org/>

³⁰ See: <https://sierrajobsfirst.org/strategic-plan/>

³¹ See: <https://ccrp.humboldt.edu/regional-plan-part-2>

³² See: <https://sierrainstitute.us/wp-content/uploads/2025/09/North-State-Strategies-main-10-31-24.pdf>

limitations. The Capital Region includes a focus on food bioeconomy and food tech as well as biotech.³³

These regional strategies reflect the place-based specificity of the sector. Feedstocks must be gathered and processed locally. Aggregation and transport of biomass is the single largest expense for bio-based industries.³⁴ Yet, as noted, entrepreneurs also need access to wider markets, a trained workforce, and capital resources.

The bottom-line: Regions cannot fill all these needs on their own and, as of now, there is not a proposal for a statewide strategy in the bioeconomy, despite it being a priority sector for five regions that cover the vast majority of the state's rural, forested, and agricultural regions.

Section VI: Elements of a State Bioeconomy Strategy

To realize the advantages in the bioeconomy, California requires an updated industrial policy. This is not to be confused with firm-level selection. Rather, the industrial policy needed for the bioeconomy requires a clear partnership between the state and its regions, the deliberate coordination within state agencies and at the regional level, a clear assessment and modification of regulations, as well as careful and deliberate investment in infrastructure upgrades as well as consistent market signals (including procurement). Together these actions will accelerate the bioeconomy sectoral development.

This approach will also maintain leadership in both economic and climate objectives. This is critical because effective industrial policy has to align with climate realities as an economic imperative. Also climate policy will help drive it to success (see above re forest and ag waste management). This makes it sound like climate goals are not fundamental.

In the case of California's bioeconomy, the challenge this strategy must overcome is not the absence of innovation, but the absence of alignment across governance systems, regulatory processes, and industrial capacity. A state industrial policy strategy must therefore address three interdependent challenges described above: institutional coordination and governance, regulatory certainty, and industry and market dynamics.

Strategy 1: Form a Durable State–Regional Governance Partnership

First, an effective bioeconomy strategy requires institutional alignment between the state and its regions. California's economic development functions are distributed across agencies responsible for energy, climate, natural resources, workforce, and

³³ See: <https://www.weprosperitogether.org/wp-content/uploads/2024/10/We-Prosper-Together-Regional-Plan.pdf>

³⁴ https://foundationfar.org/wp-content/uploads/2023/06/Feedstocks-of-the-Future-Convening-Report_FINAL.pdf;
<https://www.sciencedirect.com/science/article/abs/pii/S0306261918316441>

infrastructure. Absent a coordinating mechanism, these authorities operate in parallel rather than as components of a coherent sector strategy. A state bioeconomy industrial policy must therefore formalize interagency coordination around shared sectoral outcomes and integrate those outcomes with the State Economic Blueprint and regional economic plans.

Equally important is the role of regions. The opportunities for the bioeconomy are shaped by feedstock geography, industrial land availability, labor markets, and infrastructure systems. A state strategy must therefore recognize and strengthen regional governance structures capable of integrating workforce, land use, infrastructure, and sector planning. One approach would be to establish regional economic councils in each region to maintain a strategy and identify priority investments and projects. These “Regional Economic Councils” could leverage and strengthen existing collaboratives and regional governance structures (Economic Development Districts, Workforce Investment Boards, Metropolitan Planning Organizations, Councils of Governments, and other civic groups and planning agencies), while also filling capacity gaps within lower resource areas.³⁵

This is a strategic vision focused on building an ongoing and durable partnership between the state and its regions. The state establishes strategic direction, funding alignment, and cross-agency coordination. Regions translate that direction into project pipelines while on their own working on interjurisdictional collaboration and implementation capacity.

Strategy 2: Establish more predictable and coordinated regulatory pathways

Second, a state bioeconomy industrial policy must address regulatory sequencing and predictability. This includes better clarification of CEQA streamlining for advanced manufacturing, managing the impacts of air quality standards, and local land use controls and permit (which are often the biggest source of delay).

This also includes proactive steps to help draw in public and private investment, including pre-permitted development zones and sites and technical assistance hubs. Other actions include establishing new funding tools and authorities to implement targeted economic growth strategies, including updated Tax Increment Financing and Resilience Districts, state-backed loan funds and other debt products at low or zero interest, cross-jurisdiction revenue sharing for industrial zones, zone-based incentives, and land transfer mechanisms. Further, when there is effective regional coordination it is easier for there to be unified regional funding requests to state, federal, and private investors.

A successful industrial policy for the bioeconomy would also require improvements to regulatory clarity and timelines across agencies, early-stage guidance to developers,

³⁵ See: <https://cafwd.org/news/article/vision-state-regional-economic-partnership/>

and alignment between environmental review and infrastructure planning. Predictability in regulatory process reduces transaction costs and enables capital markets to price risk more effectively. In sectors where technology readiness is advancing rapidly, regulatory lag can become a structural barrier to domestic manufacturing capture.

One key path to ensure more effective pathways is for durable community and worker benefits to ensure broader public benefits and support.

Strategy 3: Build an integrated bioindustrial supply chain

Third, a state bioeconomy strategy must address the critical elements that industry faces to achieve economic competitiveness. The bioeconomy depends on feedstock aggregation across dispersed agricultural, forestry, and municipal waste systems. It requires infrastructure for energy, water, wastewater, and transportation aligned with production geography. It depends on capital structures capable of underwriting long development timelines and managing first-mover risk.

Some of these issues are coordination problems that require government intervention. Some are market problems that can be solved with new market entrants. The state's role is to reduce collective action barriers through data sharing, catalytic financing tools, aligned infrastructure investment, regulatory authority, and consistent demand signals. These are necessary to move from planning to project execution.

Regions play a complementary role by organizing supply chains, identifying priority projects, and integrating industrial development with land use and workforce systems.

Private investors and firms play a role in recognizing those market signals and taking a risk on building new facilities.

Some specific actions could include creating a state clearinghouse of economic development tools and best practices standards for investment, including toolkits for financing, permitting, and bioeconomy-specific playbooks tied to technical assistance and capacity-building. For those seeking funding, having a single online portal for state and regional economic, land use, and climate data relevant would be critical to helping produce funding applications.

In sum, the elements above define the outlines of a state bioeconomy industrial strategy. The objective is to create the institutional coordination, regulatory predictability, and investment conditions necessary for innovation, manufacturing, and consumer markets to emerge at scale.

Section VII: Conclusion

As outlined above, California can achieve a globally competitive bioeconomy through applying a targeted use of state-level industrial policy. This will simultaneously help

manage the state's significant biomass resources and turn them from liabilities into assets and thereby create employment and business opportunities in regions throughout the state.

In the United States, industrial policy has generally been the domain of federal action and investment. This is especially true in fields closely connected with aerospace and the high public spending defense-related industries.³⁶ California can learn from the history of federal industrial policy as well as experiences of other states.

Looking ahead, California must continue to draw lessons from Federal industrial policy as well as many other countries. This is because California's scale and ambition allows it to lead like a nation state. State leadership remains key for long-term success.

In closing, California has all the ingredients for a globally competitive bioeconomy. The remaining challenges are to better coordinate action between the state and regional levels while also taking seriously the need to adjust the state's regulatory apparatus to make it easier and quicker to build climate friendly facilities.

The bioeconomy is a replacement for fossil-based feedstocks. Feedstocks and opportunities exist in all regions of the state. Having a state coordinated strategy is key to realizing durable and inclusive bioeconomy growth.

³⁶ Markusen, Ann et al. (1991) *The Rise of the Gunbelt: The Military Remapping of Industrial America*. Published by Oxford University Press,