GREENING THE GOLDEN WORKFORCE: PROGRESS AND PATHWAYS TOWARD GREEN JOBS LEADERSHIP

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# TABLE OF CONTENTS

Abstract ......................................................................................................................... 3
Introduction .................................................................................................................. 4
  1. Measuring Green Jobs Over Time ........................................................................ 6
  2. California's Progress as a Green Employer ...................................................... 9
  3. Projected Growth in Green Employment .......................................................... 10
  4. California's Competitive (Dis)Advantages in Green Jobs .............................. 16
  5. An Innovation-Led Green Jobs Strategy .......................................................... 19
Conclusion .................................................................................................................. 30
APPENDIX .................................................................................................................. 31
Methodology ............................................................................................................... 31
The mission to create more green jobs in California remains important as the state recovers from the COVID-19 pandemic and hurries to meet climate goals laid out in Assembly Bill 32 (The Global Warming Solutions Act of 2006). This research paper reports on the size and scope of California’s green labor force, current growth trends, and prospects for growing its sustainable economy.

We use a modified version of the U.S. Bureau of Labor Statistics’ (BLS) Green Goods and Services (GGS) survey to identify employment in industries producing environmentally friendly goods and services. We estimate the state’s current green labor force includes 372,984 workers. While this is impressive in absolute terms, it implies California’s Green Economy is smaller than the average state’s and would need to add 58,977 jobs by decade’s end to catch up.

Encouragingly, we show the state is on track to accomplish just that. If current trends in Motor Vehicles, Transmission, Distribution and Storage, Fuels, and Energy Efficient Manufacturing continue, California will reach the U.S.-state average number of green jobs by decade’s end. On the other hand, solar and wind generation is poised to become less labor intensive even as it expands, increasingly downshifting into a less reliable source for green employment. The state’s ability to grow its Green Economy will depend on how many green jobs it can create outside of green energy in the exportable section of its economy.

In the second half of this research paper, we propose strategies and tactics that might lead to more exportable green jobs. At a high level, the state should seek to grow the labor force of innovative firms already based here. While other states seek to attract high-tech green firms, more clean-tech ventures are already headquartered in California than anywhere in the world. However, average employment at these firms is low because they tend to focus on research more than prototyping and small-run manufacturing. Rather than attract high-tech green firms, the state should seek to scale-up those already here.

We contemplate policy interventions in Zero Emission Vehicles (ZEVs) and the Circular Economy. The state has a burgeoning ZEV cluster in Southern California that could potentially employ hundreds of thousands of blue-collar workers. Manufacturing extension and workforce development programs would charge efforts that are already underway, supporting the addition of up to 63,000 ZEV jobs by 2030. Secondly, the state can seek to grow its Circular Economy, a more incipient sector attempting to shrink reliance on global supply chains through waste diversion. By encouraging more demand for recycling and similar services, and by promoting technological development in this area, the state can create jobs that directly contribute to the greening of the state economy.
California’s economy faces two generational challenges. The first is resilience through a series of economic shocks set into motion by COVID-19: a sudden economic contraction, a rapid recovery, high inflation, supply chain challenges, rising rental and home prices, and uncertainty in commercial real estate, just to name a few. California continues to lag the nation in its employment recovery. As of May 2022, there were 300,000 fewer people employed in the state compared to February 2020, and joblessness among less educated workers continues to be exceptionally high. Secondly, there is a generation-defining decarbonization mission. To achieve state-mandated greenhouse gas reduction targets by 2030, California needs to cut emissions 40% below its 1990 levels — a target the state is currently in danger of missing.

Previous studies have demonstrated that the transition to a greener economy is not at odds with a job creation mandate. To be clear, a greener economy will require phasing out employment in traditional energy industries such as Oil, Gas and Coal. However, analysis of the entire labor force suggests the effects of green energy can be net-positive, adding jobs and improving average wages. Separate policy discussions have proposed making displaced workers “whole” through direct assistance and job training programs, hinting at the possibility of a complete, prosperous, and fair energy shift.

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1 The unemployment rate for those with no partial college education or college degree was 4.5 percent in February 2022 compared to 2.2 percent for those with a bachelor’s degree (BLS, 2022).
3 Weber, 2020
4 Bivens, 2015
5 Zabin et al., 2020; Bivens, 2015
This report seeks to understand California’s prospects for adding green jobs to its economy while simultaneously working to meet carbon emissions reduction goals. In line with previously cited studies, it finds the state does not have to choose between post-pandemic economic resilience and economy-wide decarbonization. This is mainly for three reasons: the state has demonstrated an ability to generate substantial green employment; green employment is trending upward in key sectors; and the state’s strong innovation economy primes it to expand the scope of the green labor force into new areas.

If the state must follow through on these complimentary factors, it will have to forge its own green jobs strategy. California’s economy is uniquely innovative, yet its cost of living is unusually high, meaning operations that might be viable elsewhere will not work here. Furthermore, the state cannot rely on traditional engines of green jobs growth (such as solar energy). Besides the fact that the growth potential of these industries is often lower, California has already reached a certain level of maturity in these industries; therefore, efforts to further develop their workforces would have significantly diminished returns. Although this presents a challenge for California, it also presents an opportunity since California’s advantages in the Green Economy space make it uniquely positioned to achieve the goals set out in this research paper.

The paper proceeds in five sections, beginning with a brief methodological description of how we measure the Green Economy (Section 1).

The segments that follow use this method to understand California’s current green labor force, with Section 2 examining progress to date across sectors (demonstrating that the state still has work to do) and Section 3 considering trends over the next eight years. The state is poised to add even more green jobs to the economy, albeit not quite enough to become a specialist in relative terms. To do so, it will need to create around 89,000 additional green jobs in new sectors by 2030.

The last two sections focus on how the state might accelerate its current green jobs progress. Section 4 proposes that a green jobs strategy for California will differ than for most states because of the “headwinds” it faces in the form of higher business costs, as well as the “tailwinds” it receives from fostering a world-class innovation economy. Section 5 sketches out key attributes of a green jobs strategy for California, including key principles of workforce development and specific strategies for two high-innovation sectors: Zero Emission Vehicles (ZEVs) and the Circular Economy.
1. MEASURING GREEN JOBS OVER TIME

GREEN EMPLOYMENT AND JOB GROWTH

Measuring “green jobs” is fraught because there is currently no accessible green jobs survey in the United States or California. The federal government oversaw the Green Goods and Services (GGS) program between 2011 and 2013, which gave detailed estimates of green jobs throughout the country down to the six-digit North American Industry Classification System (NAICS) level. Unfortunately this was discontinued due to budget cuts. In 2016, the U.S. Department of Energy began administering an annual U.S. Energy and Employment Jobs Report (USEER) survey that tracks employment within key energy sectors not easily identifiable with publicly available data. After just two years, this study was spun off to the private sector and was thereafter only released in aggregate form as part of a report. Moreover, the USEER data only covers the energy sector, which only makes up a portion of the Green Economy and has limited historical coverage, meaning it is not suited for time-series analysis. For its part, the State of California conducted a “Green Economy Survey” in 2009 that estimated the size of the Green Economy that year, but it never produced any follow-up reports. Addressing this lack of data should be a priority for policymakers.

This study aims to provide reasonable estimates on trends in the Green Economy that can approximate administrative surveys. It relies on a customized estimation technique that combines the beneficial features of both the GGS and USEER surveys to create a complete historical account. For our purposes, the definition of green jobs matches the GGS standard referenced above. The GGS survey was administered by the U.S. Bureau of Labor Statistics (BLS) and defines green jobs as those producing and providing goods and services that benefit the environment or conserve natural resources, including those providing administrative and support services.

While this method yields realistic and defensible estimates, it relies on the assumption that the percentage of green jobs within each industry is the same in the study period as in 2011. This assumption is clearly problematic since between the 2010 and 2011 GGS surveys alone, there was fluctuation in the green percentage of several industries. This blind spot is not as relevant for solar power generation and other eternally green industries as much as industries like motor vehicles and energy-efficient appliances, which have tended to become greener over time. Because the economy-wide tendency is for industries to become greener over time, our estimates will tend to undercount the size of the Green Economy in California. For purposes of planning and projection, this is a more acceptable type of error.

In all cases, measurements of employment in the Green Economy are based on data from the Quarterly Census of Employment and Wages (QCEW) produced by the BLS. QCEW is the most current data available on employment by industry, and current data releases allow for the analysis of green jobs through the first quarter of 2021. All estimates in this report are based on QCEW data and weighted using the 2010 GGS.

To predict the shape of the Green Economy between 2022 and 2030, this study refers to the average growth of employment for each USEER category from 2010 - 2021, extending prior linear trends out to 2030. More details on existing data limitations and the estimation methodology used for this study can be found in the appendix.

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6 Green Goods and Services was an employment estimation program that calculated the number of green jobs down to four- to six-digit level NAICS codes through a survey of around 120,000 businesses.
7 After the 2017 report by the U.S. Department of Energy, the following three reports were then commissioned by two nonprofits: the National Association of State Energy Officials and the Energy Futures Initiative (in association with BW Partnerships, a research consultancy that carried out the analysis).
8 USEER follows a similar methodology to the GGS, where a survey is conducted to determine the proportion of companies within an industry that participate in certain energy-related activities.
9 The U.S. Department of Energy had retaken ownership of the USEER study in 2021, but the data is scheduled to be released after the authoring of this report.
ASSESSING GREEN ECONOMIC DEVELOPMENT

The main purpose of this research paper is to understand whether California can make substantial progress in adding green jobs to the economy by 2030, the next major milestone year targeted by complementary climate and clean-energy state mandates. Progress can be defined in absolute and relative terms. The total number of green jobs in the economy at a given time is a straightforward indication of how well it can pursue the twin goals of carbon emissions reduction and workforce development. California may be the biggest economy in the country, but its economy has also been heavily involved in oil and gas; in many ways, it might be expected to face difficulties transitioning to a fully decarbonized economy and workforce. Therefore, any absolute progress in green employment would be significant.

Beyond total employment, it’s important to understand the density of green employment among all jobs: If you randomly select a job from the California economy, how likely is it that it would be green? To understand this aspect of green employment, this study analyzes the Location Quotient (LQ) for each related industry category. The LQ for a given category is defined as:

\[
\frac{\text{Observed Sector Employment in California}}{\text{California Total Employment}} \div \frac{\text{Observed Sector Employment in U.S.}}{\text{U.S. Total Employment}}
\]

LQs are widely used as measures of job concentration because they are easy to interpret. When an area has an LQ of 1.0 in an activity, it employs as many workers there as would be expected based on the size of its labor force. Therefore, 1.1 means it employs 10% more workers in an activity than would be expected and is somewhat specialized, and 0.9 employs 10% less than would be implied by its labor force size. The LQ is a useful measure in the context of this study because it allows for meaningful comparisons across regions with different populations. If California had a green jobs LQ of higher than 1.0, it would rightly qualify as a specialist in the Green Economy. On the other hand, if its LQ were below 1.0, it would be punching below its weight.

Of course, when it comes to California’s environmental progress, the average is usually not enough. By their nature, California’s climate goals are not contextualized in terms of “average.” For instance, Assembly Bill 32 (The Global Warming Solutions Act of 2006) does not direct the state to achieve average emissions by 2030, and the state’s renewable portfolio standard (RPS) target does not call for renewable standards relative to other states.

For these reasons, California should target a specialization level somewhere above 1.0. But what is a defensible goal? In selecting such a level, it is useful to examine the state’s specialization in other activities. Table 1 shows 2021 employment LQs for the state across large industry categories. Natural Resources and Mining is at the very top of the list (LQ of 2.14), but this would not be a good benchmark because the mining industry tends to be distributed depending on the location of natural resources rather than anything else. Information, including information technology (IT), is second at 1.66. However, IT products and services, like natural resources, tend to be more tradable than green jobs such as power generation. There is a large gap between second- and third-place on the table, and it is toward this gap that this research paper suggests the state’s Green Economy aims. A proposed LQ of 1.2, meaning California is 20% more specialized in green jobs than the average U.S. state, would ideally fill this gap. It is somewhat aggressive since it would be the third-most specialized sector among those listed in Table 1; but then again, so are the state’s climate and clean-energy targets. Moreover, 1.2 is a lower level than the state enjoys for narrower industry groups.
Other sectors that are famously synonymous with California have much higher employment LQs, such as Grape Vineyards (6.37) and Wineries (4.79), Internet Publishing (3.56), and Motion Picture and Video Production (4.19). Thus, 1.2 is a somewhat arbitrary, but defensible, target for green jobs specialization and one that happens to be realistic without being assured (as will become clearer). The next two sections investigate California’s current progress in green jobs formation.

### TABLE 1: CALIFORNIA’S CURRENT LOCATION QUOTIENTS (LQ) IN KEY INDUSTRIES

<table>
<thead>
<tr>
<th>Industry</th>
<th>CA Employment (LQ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural resources and mining</td>
<td>2.14</td>
</tr>
<tr>
<td>Information</td>
<td>1.66</td>
</tr>
<tr>
<td>Proposed green jobs target</td>
<td>1.2</td>
</tr>
<tr>
<td>Professional and business services</td>
<td>1.07</td>
</tr>
<tr>
<td>Goods production</td>
<td>1.02</td>
</tr>
<tr>
<td>Leisure and hospitality</td>
<td>1.01</td>
</tr>
<tr>
<td>Education and health services</td>
<td>1.01</td>
</tr>
<tr>
<td>Total (all industries)</td>
<td>1</td>
</tr>
<tr>
<td>Services accommodation</td>
<td>1</td>
</tr>
<tr>
<td>Other services</td>
<td>1</td>
</tr>
<tr>
<td>Construction</td>
<td>0.98</td>
</tr>
<tr>
<td>Trade, transportation, and utilities</td>
<td>0.92</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>0.88</td>
</tr>
<tr>
<td>Financial activities</td>
<td>0.83</td>
</tr>
</tbody>
</table>

Source: QCEW Quarterly Census of Employment and Wages; Analysis by UCR Center for Economic Forecasting and Development
In 2021, California had 372,894 green jobs, which represented 10.9% of total green jobs in the country and 2.25% of all jobs in the state (far outpacing every other state). The number of green jobs has shown a steady upward trend over the past couple of decades and has increased by 44,130 positions since 2010. While the pandemic period has experienced a decline of approximately -15,000 green jobs (about -5% between 2019 and 2021), this change was consistent with trends in the state economy (-4.55% over the same period).

The relative picture is currently less bright. While it’s a large figure, California’s 372,894 green jobs do not imply a high density. In 2021, California only had a Location Quotient (LQ) of 0.93 in green jobs, meaning there were fewer green jobs (proportional to total employment) in California than in the United States. This implies the state is -106,145 jobs short of having an LQ of 1.2. Moreover, this LQ decreased by almost 7 percentage points during the 2010s decade.
The linear trend analysis is somewhat more optimistic, both in the aggregate and on a sector-by-sector basis. The pandemic period may have disrupted many areas of the economy, but in the context of a decade-long trend, the pandemic lull appears to be more of an aberration. This section takes stock of linear trends in the Green Economy and leading green subsectors.

### Projecting Overall Green Employment

Based on historical trends, California is expected to add 58,977 green jobs by 2030, reaching a total of 431,871 jobs. Encouragingly, this 15.8% increase is expected to outpace the growth of green jobs in the United States, which is forecast to increase to 3,702,761 (8.2%). As a result, California’s green jobs LQ will increase to 0.99, meaning the state will have roughly the same proportion of green jobs to all jobs as the nation. Despite this LQ increase, the data still points to a worrying conclusion: based on current trends, California will not become a green jobs specialist by 2030. To achieve the ambitious target of an LQ of 1.2 or higher, California must add 89,343 green jobs by 2030.

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**Figure 2: Green Employment Progress and Projections (2010 - 2020)**

Source: QCEW Quarterly Census of Employment and Wages; Analysis by UCR Center for Economic Forecasting and Development
Traditionally, many of the green jobs in the economy were in energy generation (Solar, Wind, Transmission, Distribution and Storage), which retains some of the more mature green technologies. These sectors employed an estimated 238,000 people in California in 2021, and they will likely still experience employment growth over the next decade. However, California is not a clear specialist in any power sector, with Solar employment having the highest LQ at 1.03.

**TABLE 2: CALIFORNIA’S SPECIALIZATION IN GREEN JOBS**

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>JOBS IN CA</th>
<th>JOBS IN U.S.</th>
<th>LOCATION QUOTIENT (LQ)</th>
<th>JOBS SHY OF 1.2 LQ</th>
<th>TREND</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Green Goods and Services (GGS)</td>
<td>372,894</td>
<td>3,421,701</td>
<td>0.93</td>
<td>106,145</td>
<td>Upward</td>
</tr>
<tr>
<td>Solar</td>
<td>40,692</td>
<td>339,090</td>
<td>1.03</td>
<td>6,780</td>
<td>Downward</td>
</tr>
<tr>
<td>Wind</td>
<td>6,452</td>
<td>56,830</td>
<td>0.98</td>
<td>1,504</td>
<td>Upward</td>
</tr>
<tr>
<td>Fuels</td>
<td>3,018</td>
<td>39,286</td>
<td>0.66</td>
<td>2,482</td>
<td>Upward</td>
</tr>
<tr>
<td>Green Transmission, Distribution &amp; Storage</td>
<td>18,775</td>
<td>181,008</td>
<td>0.89</td>
<td>6,566</td>
<td>Upward</td>
</tr>
<tr>
<td>Energy Efficiency</td>
<td>168,788</td>
<td>1,510,520</td>
<td>0.96</td>
<td>42,685</td>
<td>Upward</td>
</tr>
<tr>
<td>Motor Vehicles</td>
<td>16,471</td>
<td>99,042</td>
<td>1.43</td>
<td>-</td>
<td>Upward</td>
</tr>
</tbody>
</table>

Source: QCEW Quarterly Census of Employment and Wages; Analysis by UCR Center for Economic Forecasting and Development

Encouragingly, California’s linear trend is positive in six of the seven studied subsectors. It suggests that even without deliberate action on the scale of what is contemplated in Section 5 of this research paper, the state should add to its absolute number of green jobs across most of the Green Economy.

California employed 40,692 people in the Solar industry in 2021. This represented 10.9% of total green jobs in the state. Though Solar employment has been a strength of California over the past few decades, annual job growth began to plateau starting around 2016 - 2019 and declined quickly from 2020 - 2021 due to the pandemic, decreasing about 10% from a high of more than 45,000 jobs in 2019. This resulted in California having an LQ of 1.03 in 2021, or -6,780 jobs shy of a 1.2 LQ.

The plateau in 2016 - 2019 can be attributed to two major factors: labor productivity increases and a shift in Solar industry employment from installations and developers to operations and management. Now that many projects requiring construction and installations have finished and are transitioning to operations and maintenance, employment growth should stall. Between 2010 and 2016, Installation and Developers employment in the United States had been growing by an average 25.7% annually. In 2017, though, this growth rate turned negative.

Labor productivity in the Solar industry reached a record level in 2020. The ratio of kilowatts (kW) per Solar worker went from 100.3 in 2017 to 207.5 in 2020, and the average solar system size increased 30.3% between 2019 and 2020. These increases in labor productivity mean fewer workers are required to meet the same demand. So although solar installations nationally have increased (going from 11,080 megawatts in direct current in 2017 to 19,221 in 2020), labor productivity growth has outpaced demand. As a result, total Solar workers in the United States decreased from a high of 260,077 in 2016 to 231,474 in 2020.

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10 Based on an analysis of data from the National Solar Jobs Census (SEIA, 2020; pp.9-11).
11 Category introduced in 2018.
In 2019, California employed approximately 6,273 workers in Wind energy. This number has been slowly rising since 2011, increasing by more than 1,000 jobs in that time. California’s Wind employment is only slightly lower proportionally to the United States’ wind employment, with an LQ of 0.98.

In the past decade, California experienced steady growth in Green Transmission, Distribution and Storage (Green TDS) industry jobs, from just over 14,000 in 2011 to 18,775 in 2021 — a 36% increase. While this progress is undoubtedly helpful for the state, it only brought its Location Quotient (LQ) to 0.89, meaning California would have had to increase its workforce by roughly 35% to be considered a specialist in 2021. Despite consisting of only around 11% of green jobs, growth in the Electrical Contractor industry (68,050 jobs) — both residential (18,087) and non-residential (49,963) — has been a major driver of the increase in Green TDS jobs since 2011. Though there was a slight employment decrease in 2020 within Green TDS, it bounced back to its pre-pandemic level in 2021. Green TDS has been a major field within the Green Economy, both in terms of employment and strategic importance as the world transitions away from fossil fuels. It can determine the relative successes of many other green sectors.

As with Green TDS, Energy Efficiency employment in California grew substantially since 2011 — from 138,000 people to 178,000 by 2019. Unfortunately, employment experienced a small decline in 2020 coinciding with the pandemic, causing a drop in investments within energy-efficient buildings, equipment, and vehicles. By 2021, Energy Efficiency employment stood at 168,788 workers, giving California an LQ of 0.96, or -42,685 jobs shy of specialization in the sector.

Fuels employed just 3,018 workers in California in 2021, making it the smallest sector studied. These jobs gave California an LQ of 0.66, almost -2,500 jobs short of being a specialist.

**FIGURE 3: SECTORAL EMPLOYMENT PROGRESS AND PROJECTIONS (2010 – 2020)**

**EMPLOYMENT PREDICTION IN ENERGY EFFICIENCY JOBS NEXT 10 YEARS**

![Graph showing employment prediction in energy efficiency jobs from 2015 to 2030.](source-url)

Source: QCEW Quarterly Census of Employment and Wages; Analysis by UCR Center for Economic Forecasting and Development

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12 Represents green jobs proportion of all fuel-based electricity generation, production, distribution, and storage.
EMPLOYMENT PREDICTION IN FUEL JOBS NEXT 10 YEARS

Source: QCEW Quarterly Census of Employment and Wages; Analysis by UCR Center for Economic Forecasting and Development

EMPLOYMENT PREDICTION IN SOLAR ENERGY JOBS NEXT 10 YEARS

Source: QCEW Quarterly Census of Employment and Wages; Analysis by UCR Center for Economic Forecasting and Development
EMPLOYMENT PREDICTION IN TDS JOBS NEXT 10 YEARS

Source: QCEW Quarterly Census of Employment and Wages; Analysis by UCR Center for Economic Forecasting and Development

EMPLOYMENT PREDICTION IN WIND ENERGY JOBS NEXT 10 YEARS

Source: QCEW Quarterly Census of Employment and Wages; Analysis by UCR Center for Economic Forecasting and Development
Based on historical trends, California is projected to add jobs in Solar (0.1%), Wind (18.3%), Fuels (44%), Green TDS (26.9%), and Energy Efficiency (28.5%). Combined, these categories are projected to increase by a total 56,082 jobs. Although a positive sign, these sectors, as they become more widespread, have also begun to employ more workers around the country. Modest increases in the number of these jobs in California is not enough to transition the state to becoming a specialist in these sectors. The United States, based on historical trends, is predicted to increase jobs in Solar (15.1%), Wind (19%), Fuels (23.5%), and Energy Efficiency (21.1%) while Green TDS is not expected to grow nationally. As a result, California will only increase its LQ in Green TDS, Fuels, and Energy Efficiency to 1.12, 0.76, and 1.01 by 2030, respectively.

There are indications that California’s renewable energy portfolio will expand, leading to marginally higher employment in Construction and Installation. In May of 2021, the federal government authorized commercial-scale offshore Wind development in California. Furthermore, the federal government separately projects 44,000 additional full-time jobs by 2030 with new offshore developments\textsuperscript{13}. An analysis from REACH (a Central Coast-based regional economic action coalition) suggests 15,925 total full-time equivalent (FTE) jobs could be created in California related to development of the offshore wind project anticipated in northern San Luis Obispo County\textsuperscript{14}. Of these, 3,490 would be direct jobs.

The overall trend is mixed. On one hand, the state’s 372,894 Green Economy jobs are more than any other state can boast, and this labor force is expected to grow at nearly double the national average by 2030. On the other hand, the state’s below-average LQ means it would need to add 26,305 jobs to achieve average green job employment in 2021 and reach a green jobs LQ of 1.0. It is likely current trends will allow California to become an average green job employer by 2030. However, to become a green-jobs specialist with a green employment LQ of 1.2, the state will need to add 89,343 green jobs to its economy by 2030 (on top of its projected total of 431,871).

\textsuperscript{13}White House, 2021
\textsuperscript{14}REACH, 2020
4. CALIFORNIA’S COMPETITIVE (DIS) ADVANTAGES IN GREEN JOBS

For California to achieve the ambitious target of a 1.2 green jobs Location Quotient (LQ), it will need to successfully generate green jobs in newer areas, especially those beyond power generation. In selecting which green jobs to target, the state should focus on activities where it has a competitive advantage. This section argues the state is at a disadvantage when it comes to attracting more standardized activities from more mature industries even though it is a world leader in green innovation and technology. In contemplating targets for green economic development, California should focus on activities that depend more on its strong technology ecosystem.

CHALLENGING TRENDS

Three trends have stymied the formation of green jobs in California in recent years. These may already explain why the Solar industry and some subsectors are experiencing employment declines, and they may threaten the state’s ability to realize the linear growth projected in the previous section.

First, the state’s green workers may be bearing the brunt of labor-saving economic efficiencies, especially in power generation. As solar and wind technology improves, wages per-gigawatt of energy produced drops. This labor-saving aspect of new technology is very good news from the standpoint of a green energy adoption, as it will lead to greater proliferation of renewable energy. But it also means the state might lose some green-jobs gains to creative destruction.

The second problem concerns initial-versus-ongoing costs. As green energy infrastructure is brought online, there will be significant employment related to green construction and installation; but if the growth of building or housing construction plateaus, the economy should expect to shed these jobs. The decline in Energy Efficiency jobs that was referenced previously appears to be driven by losses in Construction. Non-residential plumbing and HVAC contractors (-5,714), Non-residential electrical contractors (-2,081), and Non-residential drywall contractors (-4,021) and land subdivision workers (-2,753) account for 40% of all losses in Energy Efficiency.

Finally, labor costs are higher in California than anywhere else, outside of New York, Washington D.C., and Hawaii. California has already lost more semiconductor and related device manufacturing jobs (-8,166) than any other type of Energy Efficiency jobs over the past four years. The loss of green manufacturing jobs like these highlights a profound paradox in green workforce development: the manufacturing sector is one of the best sources of green jobs because it is relatively labor intensive, but this labor intensity also makes firms more sensitive to the cost of living than they might be in other industries. With labor costs rising across the country, the state’s ability to compete for such jobs is under even more strain. While the 10-year trends for Energy Efficiency are positive, it is possible that growing labor costs will change the overall competitiveness of that sector, leading to actual declines.

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15 This is a common occurrence across industries, especially those in their nascency.
16 Morris et al., 2014
17 MERIC, 2021
CALIFORNIA’S GREEN ECONOMY WITHIN THE PRODUCT LIFE CYCLE

These challenges — increased labor efficiency, plateauing construction and innovation, and a high cost of living — can all be reconciled with what some economists call the Product Life Cycle (PLC).\(^{18}\) The PLC is a conceptual model (See Figure 4) describing the relationship between the level of competition in an industry and the technological sophistication of its underlying products. For all successful products eventually achieving commercial success, there will be initial phases of product development and scaling-up, where the producer is more protected from competition. This could be related to intellectual property protections, but it is certainly also a function of its unique command of a technology.

As a technology matures, competitors learn to mimic or “patent around” it, and the initial competitive advantages melt away. Technological maturity also leads to product demand from less adventurous markets, which leads to a higher scale of production and different demands by producers. The combined effect of these forces may cause firms to reevaluate their relationship with the surrounding economy.\(^{19}\) They may be pushed away from their initial location if labor costs no longer allow them to compete, or even pulled toward new places where they can build larger plants or pay lower wages. More importantly, the areas where high technology enterprises emerge usually tend to be conducive to innovative activities such as research and development or technology commercialization. For these reasons, they contain “clusters” of new firms.\(^{20}\) In such places, high labor costs can be justified if they allow firms to attract a more skilled workforce.

FIGURE 4: THE PRODUCT LIFE CYCLE (PLC)

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\(^{18}\) Tichy, 2011

\(^{19}\) Henderson et al., 1995

\(^{20}\) Klepper, 2007; Markusen, 1995
The PLC may be a simplified model, but it provides a satisfying explanation for recent trends in California’s Green Economy. Solar Power and Energy Efficiency are relatively mature technologies. Their labor-saving efficiencies and slowing growth are telltale signs of an industry changing how it interacts with labor markets, either by drawing on less labor per-unit of output or changing its geographic footprint. Simultaneously, the industry has maintained its strength in research and development. The state boasts:

- Four of the top-20 universities in the world, according to Times Higher Education\(^{21}\).
- Six of the top-10 U.S. universities, as ranked by Forbes\(^{22}\).
- The second-most patents per-capita by state (FRED, 2019).
- The seventh-highest concentration of scientists and engineers in the country\(^{23}\).

The state is also the leading global funder and commercial hub of technology. Table 3 shows venture capital investment by state as of 2021. As a venture investor, California spends more than three-times New York, which takes second-place. A great deal of this is centered in the Bay Area, which is the preeminent venture capital region of the world and the magnet for one-fifth of investment.\(^{24}\)

**TABLE 3: LEADING STATES FOR VENTURE CAPITAL INVESTMENT (2021)**\(^{25}\)

<table>
<thead>
<tr>
<th>STATE</th>
<th>VENTURE FUNDING (BILLIONS)</th>
<th>POPULATION (MILLIONS)</th>
<th>PER CAPITA FUNDING</th>
</tr>
</thead>
<tbody>
<tr>
<td>California</td>
<td>$135.10</td>
<td>35.4</td>
<td>$3,417</td>
</tr>
<tr>
<td>New York</td>
<td>$41.90</td>
<td>20.2</td>
<td>$2,073</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>$30.60</td>
<td>7</td>
<td>$4,353</td>
</tr>
<tr>
<td>Texas</td>
<td>$6.90</td>
<td>29.2</td>
<td>$237</td>
</tr>
<tr>
<td>Washington</td>
<td>$6.80</td>
<td>7.7</td>
<td>$881</td>
</tr>
<tr>
<td>Illinois</td>
<td>$5.30</td>
<td>12.8</td>
<td>$416</td>
</tr>
<tr>
<td>Florida</td>
<td>$4.70</td>
<td>21.5</td>
<td>$218</td>
</tr>
<tr>
<td>Colorado</td>
<td>$4.60</td>
<td>5.8</td>
<td>$799</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>$4.60</td>
<td>13</td>
<td>$354</td>
</tr>
<tr>
<td>Georgia</td>
<td>$3.20</td>
<td>10.7</td>
<td>$298</td>
</tr>
<tr>
<td>New Jersey</td>
<td>$2.80</td>
<td>9.3</td>
<td>$296</td>
</tr>
</tbody>
</table>

Source: PitchBook; Analysis by UCR Center for Economic Forecasting and Development

This advantage might be even more pronounced in “clean tech” investment, which is directed toward renewable energy and energy efficiency. As reported in last year’s California Green Innovation Index, California firms were responsible for 76% of all U.S. clean-tech investment. Clean Tech is currently the leading sector in the state’s venture capital investment scene. The state hosted $7.8 billion in venture investment in 2020, $5.7 billion of which was in Clean Tech.

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\(^{21}\) Times Higher Education World University Rankings can be accessed here.
\(^{22}\) Forbes rankings can be accessed here.
\(^{23}\) Khan and Falkenheim, 2013
\(^{24}\) Florida and Hathaway, 2017
\(^{25}\) Source: Crunchbase News
This section proposes a high-level strategy for “leveling up” as a green employer. It begins by suggesting the basic objectives a green jobs strategy should pursue in any jurisdiction. Any green jobs plan should seek to take advantage of existing strengths, be tailored to the size of the challenge, and recommend specific courses of action. It then spells out a strategy for California that conforms to this rubric by targeting areas within the Green Economy that are growing, which are also labor intensive and accessible to the state’s most vulnerable workers.

GUIDING PRINCIPLES FOR CALIFORNIA’S GREEN ECONOMIC DEVELOPMENT

The practice of local economic development often comes down to choices about which industries to target with resources. A city’s economic development division must determine which firms qualify for a tax incentive. The community college must identify industries with growing demand for its graduates. Even the firm’s management must determine product lines and areas to invest in. Here, we propose several key axioms to guide the development of more green jobs in California.

ENCOURAGE ACTIVITIES EARLIER IN THE PRODUCT LIFE CYCLE (PLC) AND SUPPORT OTHERS

The implications of the product cycle for a green jobs strategy are straightforward. As the state identifies new green job areas, it should target industries with products that are relatively early in the PLC. These areas are most likely to benefit from the state’s research and commercialization resources and less likely to be driven away by high costs of labor and land.

The PLC implies many current green jobs are vulnerable to creative destruction and offshoring. Section 1 provided early hints that subsectors within Solar and Energy Efficiency may be vulnerable, but only a dedicated analysis can identify a full list of such jobs. Public support for vulnerable workers should begin before they are displaced from the labor market.

SCALE-UP CLEAN TECH VENTURES

California’s deep pool of clean-tech ventures is its biggest asset in green workforce development. These are among the most promising new green technology companies in the world as evidenced by the $7.8 billion invested in California in 2020. For many states, economic development is either about courting growing companies from somewhere else or building them locally. California already has a deep pool of innovative firms in the state — firms that have already committed to the state for some of their operations and will at least contemplate investing more here as they expand.

The Golden State’s main challenge lies in converting ventures into jobs. The average clean-tech venture headquartered in the state is not very large, based on our data analysis from PitchBook Data Inc. There are 597 venture capital-backed firms that exited from the venture system (entered the traditional economy) between 2007 and 2021 and have at least five employees. The combined total employment of these companies was 237,543, and of these, 99,239 (41.8%) were employed at Tesla. Among these, the median firm employs just 40 workers.

While Tesla recently relocated its corporate headquarters to Texas, it was based in California when it exited and is considered Californian in this analysis.
Several observers have noted that the U.S. venture financing system is generally better at incubating manufacturing firms than connecting them with necessary resources. Among these resources are access to specialized engineering talent, key markets, and “patient capital” — investors who operate on longer time horizons than venture capitalists. Efforts to backfill these resources may pay off. Even beyond the Manufacturing sector, it is important for economic development in California to be understood as a challenge of cultivation more than incubation.

**TARGET LOWER-PARTICIPATION LABOR MARKETS**

Workforce development seeks to generate more jobs by either increasing labor demand or supply. However, the labor market will respond differently to these changes depending on the local employment level. When employment participation is relatively low, increases in the demand for implicated workers is more likely to lead to lower unemployment. If unemployment is lower, then higher labor demand will tend to encourage migration of workers from outside of the local economy.

Generally, the California labor market is segmented by educational attainment. Employers needing workers with college degrees face labor shortages, but workers with a high school degree or less facing chronic unemployment. This basic trend reflects a broader related movement where technology and trade make more educated workers more productive as they increase competition among less educated workers.

We have seen this “skill-biased technical change” already affecting the Green Economy. More efficient solar systems mean fewer operators, who are likely to be less educated; yet this phenomenon also probably means bigger markets served by more managers and engineers. When possible, California should create green jobs within labor markets that are adversely affected by technological change, especially those related to renewable energy and energy efficiency.

**PROMISING TARGETS FOR GREEN WORKFORCE DEVELOPMENT**

The state holds two promising targets for green workforce development in Zero Emission Vehicles (ZEV) and the Circular Economy. The first of these is already generating fast economic growth in the state but might still be getting overlooked in local policy discussions. The second is a more speculative area, but it’s one that might make the state’s economy significantly more resilient to ongoing supply chain disruptions. Here, this research paper argues these sectors are promising candidates due to their position in the PLC, the number of ventures they have attracted, and the kinds of jobs they might generate.

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27 Ezel, 2020; Grove, 2010
28 Adler, 2019; Reynolds et al., 2013
29 Bartik, 2005
30 Johnson et al., 2014
31 Autor et al., 2003
The commercialization and scaling-up of ZEVs represents the single most promising opportunity to add thousands of new green jobs, and one that is already paying off. The development of California’s ZEV industry arguably began in 1990 when, as a part of the Low Emission Vehicle (LEV) Program, the state mandated that major auto companies make 2% of their sales exhaust-free by 1998. At the time, the technological capacity of the industry was minimal, and General Motors (GM) was the only major producer with a concept car. But the regulation appears to have led to significant improvements in ZEV capabilities.32

Today, ZEVs are the centerpiece of a $244 billion global industry that sold 5.6 million units in 2021 — 7.2% of all new cars.33 By any metric, the ZEV industry is in the early portion of its product cycle. Carmakers are rapidly developing technologies to extend charging length and range, broaden product selection to the commercial and industrial areas, and lower the cost so it’s affordable even without a subsidy. In such an environment, it is technological sophistication (more than access to inexpensive inputs) that is driving market performance. If California were not already excelling in this area, more focus might be appropriate here because of how young the ZEV sector is.

As it turns out, California is already the center of gravity for ZEV investment and commercialization. Based on our PitchBook Data analysis, most venture investment in the state was in “Transportation and Mobility” and led by Rivian, which brought $2.5 billion in investment for its ZEV fleet. These findings also demonstrate that overall Transportation and Mobility investment increased year-over-year. Investment in Transportation and Mobility has experienced a 500% increase in California since 2016. In its recent 2021 Budget Act, the state committed $3.9 billion toward ZEV acceleration through 2023-24, and an additional $6.1 billion over five years is proposed in the 2022-23 budget.

Current employment trends are also positive for ZEVs. Our motor vehicle projections for Green Goods and Services (GGS), a sector that mostly includes ZEVs, suggests motor vehicle employment in California is expected to reach 18,502 workers by 2030, representing a 12.3% increase from 2021.

![FIGURE 5: CALIFORNIA EMPLOYMENT PREDICTION IN MOTOR VEHICLES BASED ON HISTORICAL TRENDS](source)

Source: QCEW Quarterly Census of Employment and Wages; Analysis by UCR Center for Economic Forecasting and Development

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32 Burke et al., 2000; Turrentine and Kurani, 1996
33 Bloomberg NEF, 2021
The ZEV industry is already scaling-up in precisely the way we advocate. Such ventures already account for 200,885 workers worldwide, and the average venture is experiencing annual employment growth of 14.96%, implying an expected addition of 63,313 ZEV jobs to these companies based on current growth alone by 2030.

We should expect much of this growth to be concentrated in the Golden State because Southern California already has a strong ZEV employment cluster. Eleven of California’s ZEV exits (startups entering the traditional economy) are located in Southern California. In fact, the number of automotive establishments in and around Los Angeles is comparable to Detroit.\(^{34}\)

The presence of clusters of ventures, especially away from the traditional startup hub of the Bay Area, usually indicates the area provides a favorable environment for producers. Moreover, Los Angeles has the most workers in occupations related to ZEV production\(^ {35}\) (51,690) in the nation. The next-highest metro nationally has 45,120 (New York City) and statewide has 15,420 (San Francisco)\(^ {36}\).

In the case of Southern California, access to the Ports of Los Angeles and Long Beach may be a key factor. About 40% of U.S. imports and 25% of U.S. exports pass through these ports\(^ {37}\) — but the area’s workforce might be more directly related. Southern California has an unusually high number of blue-collar workers for a city of its size.\(^ {38}\) Indeed, there are more than 900,000 production workers within 35 miles of the center of Los Angeles County\(^ {39}\). At the knowledge-intensive end of the labor force, the strength of local universities (especially CalTech, USC and UCLA) helps anchor engineers to the area.

For all its strengths, Southern California’s labor market is by no means overheated. At the end of 2021, its unemployment rate was 6.8% — one percentage point higher than the state’s and 2.9 points higher than the U.S. average. Ever since the region’s Aerospace Manufacturing sector contracted in the 1990s, it has struggled to generate new manufacturing demand.\(^ {40}\) As such, one would expect for the economy to be in a better position than most California regions to absorb green manufacturing.

A more skeptical view of California’s ZEV employment emphasizes the example of Tesla. This firm famously moved its headquarters to Texas and opened its largest 6,500-employee “gigafactory” in Nevada, not California, where it already had a facility. The firm was drawn there by very generous tax incentives,\(^ {41}\) which the State of California declined to match. While it is important for state officials to be sensitive to the costs of doing business in their state, this is less concerning than some may think. The state should not fret when a firm’s standard operations decide to relocate, as long as it is able to incubate and scale younger and new firms closer to the technology frontier. It appears to be doing that.

\(^{34}\) Data from QCEW.
\(^{35}\) Defined as occupations with similar skill sets, knowledge bases, work values, and education levels.
\(^{36}\) Data from U.S. Census’ annual Occupational Employment and Wages Statistics 2021 report.
\(^{37}\) LAO, 2022
\(^{38}\) Florida and Adler, 2018
\(^{39}\) According to an analysis of the American Community Survey by Beacon Economics’ Sam Maury-Holmes.
\(^{40}\) Storper et al., 2015
\(^{41}\) Alexander and Organ, 2015
ZEV POLICY OPTIONS

We recommend two policy directions for the ZEV industry. First, the state should consider offering financing programs for the scaling-up of ZEV manufacturing, modeled after those abroad. In Israel, loans for such upgrading are guaranteed by the government and repeated as loans are repaid. Such schemes are potentially very attractive for former ventures that have exited the venture capital system and therefore might not be able to offer much equity to late-stage investors. As a start, the California 2021 Budget Act’s ZEV package included $250 million for ZEV manufacturing grants.

Similarly (but separately), the government can provide so-called “manufacturing extension services” to small and medium-size businesses. These would allow manufacturers to find and train scarce labor, connect with distributors and new markets, incorporate new technologies into their practice, or just generally conduct business at a higher level. For example, the California Manufacturing Technology Consulting’s (CMTC) Manufacturing Extension Partnership (MEP) recently worked with EnviroKinetics (a company specializing in emissions control, heat recovery and automation packages) to develop an implementation plan for the company to become ISO 9001 certified. Case study research on such programs finds they can be 10 times as effective as traditional tax incentives (Bartik, 2020; 2005). The Hollings MEP, a network of centers across all 50 states providing $140 million annually in federal funding and resources for manufacturers, generates an economic and financial return of more than 14-to-1 for the federal government.

CIRCULAR PRODUCTION SYSTEMS

At the time of this report, the world economy is struggling to cope with the massive supply chain disruption brought on by the COVID-19 pandemic over the past two years. As a result, rising commodity prices (especially energy and food) and a war in Europe have led to price spikes. In the United States, the annual inflation rate had increased to 8.5% in March 2022, the highest rate since 1982. The Federal Reserve’s estimates suggest shipping costs will continue to rise into next year. The current moment is forcing some to wonder if economies like the United States and California rely too heavily on global supply chains.

In this context, some observers are looking to alternative models that might increase self-sufficiency for final products and inputs. The Circular Economy (CE) represents a bold vision that would eliminate waste and pollution, regenerate natural systems, and keep products and materials in use. Some of its proponents see it as a necessary revolution in how the economy draws on inputs. This research paper approaches these ideas with a cautious enthusiasm and leaves aside the question of whether the current economic system should be remade, while recognizing the potential of waste reduction in the CE.

As it turns out, California’s economy stands to benefit greatly from specializing more in circular activities, especially circular technologies, recycling, and high-density farming. Economic development should promote demand for these activities. A more circular production system would rely less on other areas for goods and waste management, as well as employ more Californians in green jobs.

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42 Adler, 2019
43 Shapira, 2001
44 Robey et al., 2018
45 FRED, 2022
46 Winck, 2022
An initiative targeting the CE would represent a different kind of approach, taken from the ZEV strategy above. Most notably, ZEVs are clearly in their growth phase of the PLC, but the CE is so new that even its boundaries are somewhat fuzzy. On the other hand, the CE is attractive, even compared to ZEVs in that it’s directly linked to the state’s climate goals. More circular production systems will directly reduce carbon emissions by lowering the construction and transportation of brand-new inputs.

California’s 2021 Budget Act already acknowledged this link, including $270 million toward supporting the CE and utilization of waste as a resource. By creating more demand for recycling, reuse, and conversion jobs, the state will simultaneously lower the amount of shipping done through or on behalf of the state, as well as the amount of energy needed to process and store waste. This provides a great case study in terms of industrial and job growth potential that is well aligned across a variety of state goals and needs.

**UPS AND DOWNS OF A CIRCULAR ECONOMY (CE)**

If traditional economic activity follows a straight-ahead path from extraction to production to consumption to waste, then a CE:

...replaces the end-of-life concept with restoration, shifts toward the use of renewable energy, eliminates the use of toxic chemicals which impair reuse and return to the biosphere, and aims for the elimination of waste through the superior design of materials, products, systems and business models.

In a purely Circular Economy, products are used more than consumed. They do not end their lives in landfills or incinerators. They are continuously reborn through cycles of collection, maintenance, and reuse and recycling that will lower demand for brand new commodities. Such a system would optimally be administered in “closed geographic loops” where, after use, products return to their initial point of production. Ideally, such systems would be highly localized to reduce trade and other transaction costs.

A CE promises greenhouse gas savings. As last year’s California Green Innovation Index (GII) makes clear, more than 12% of the state’s greenhouse gas emissions come from non-passenger vehicle transportation such as heavy trucks, rail, and aviation; an additional 2% comes from landfills. By lowering demand for these services, a CE would counteract the need to develop more efficient vehicles or curb transportation and waste through taxation and regulation. The CE would be organized so that less transportation and landfills were required by the economy.

There are immense barriers to realizing such a system. The modern global economy is organized based on principles of specialization and comparative advantage. Elongated global supply chains may be less attractive now than a decade ago, but the economy continues to rely on them because they provide more kinds of goods to more types of consumers at a lower cost. The same applies to products after their initial use. For too many products, it is cheaper to destroy them than reuse them. For a circular economy to be realized, there will have to be meaningful developments in the development of related technologies and industries. Fortunately, some of these can be recognized here in California, and these may be the source of new jobs.

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47 MacArthur, 2014:15
48 Next 10, 2021
GROWTH OPPORTUNITIES

The prospects for a functional CE are improving each year as new ventures emerge in material science and recycling. In PLC terms, we are witnessing the incubation of possible new product classes that might make circularity possible. Favored technology/industry groups in this sector include Waste Reduction, Collection, Utilization, and Recycling, Low Greenhouse Gas Technology, Green Construction Materials, Carbon Utilization, and Alternative Farming methods. Moreover, a CE calls for a reimagining of how people design and interact with products, with Rental and Leasing and Repair and Maintenance services becoming key industries for maximizing product utilization and lifespans\textsuperscript{48}. Many of these industries present ideal opportunities for California to specialize in with respect to certain CE technologies.

As shown in Figure 6, over the past six years California has generated $1.025 billion in venture capital in the Waste Reduction, Reuse and Repair, and Maintenance sectors, which are vital to the proper functioning of a CE. This is the most of any single region, with only the rest of the United States as a whole accumulating more. This does not mean, however, that California’s leadership in this area is a foregone conclusion. In fact, in 2021 Redwood Materials, a battery recycling company in Carson City, NV, received $700 million in later-state venture capital — almost 70% of what California has received in the past six years.

\textbf{FIGURE 6: VENTURE CAPITAL INVESTMENT IN WASTE REDUCTION AND REUSE AND REPAIR SINCE 2015}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{venture_capital_investment.png}
\caption{Venture Capital Investment in Waste Reduction and Reuse and Repair since 2015}
\end{figure}

Source: PitchBook; Analysis by UCR Center for Economic Forecasting and Development

Much of California’s venture capital has been in Alternative Farming Methods, which has accounted for $545 million since 2013. Specifically, this money has gone largely into Vertical Farming, which could be a key cog in the CE. It allows for high-density farming, which is less wasteful of water and pesticides — a solution particularly attractive in densely populated and urban areas. This could also cut down on transportation costs and food waste.

Digitalization, as well as new technologies (aquaponic, urban farming, and precision farming) and circular behaviors, can transform this sector, increasing irrigation efficiency\textsuperscript{49}, reducing pesticide use, and optimizing fertilizer consumption.

\textsuperscript{48} Rental and Leasing allows for one product to be shared among users, maximizing its utilization. Repair and Maintenance keeps products in use longer.

\textsuperscript{49} Fu and Zhang, 2022
There are also signs of growth among other types of CE industries. In 1998, there were more than 2.9 million American workers employed in industries involving recycling, rental, repair, treatment, and maintenance, and by 2015 there were over 3.4 million. On its face, 17% growth is exceptional enough. But as Figure 6 suggests, this growth was not equal across three relevant industry types: Business to Consumer, Local Supply Chain, and Supply Chain Traded Services. Local Supply Chain and Business to Consumer jobs are the kinds of “indirect” positions that tend to grow as the industrial base of an economy expands. For instance, the number of hair stylists in an area, which is a Business to Consumer occupation, is usually proportional to local demand. On the other hand, Supply Chain Traded Services jobs are proportional to global or national demand, so these jobs can grow as large as demand allows. This can lead to growth of the local economy, which would, in turn, grow the amount of non-Supply Chain Traded Services jobs. In the context of ZEVs, these jobs would be in research and development, production of vehicles and their components, and corporate positions overseeing these processes. These jobs can be expected to form part of the economic base itself. They bring in money from the outside that can be used to support services in and outside of the Green Economy.

Between 1998 and 2015, California’s Local Supply Chain CE jobs have grown significantly while Business to Consumer Jobs have barely increased. Jobs usually involving trade between counties (machinery rental and leasing, materials recovery facilities, etc.) experienced the fastest growth, and locally serving jobs (solid waste collection, consumer electronics repair and maintenance, etc.) grew somewhat less as a group. Crucially, this suggests CE jobs with higher economic development potential are growing. These Supply Chain Traded Services jobs represent significant economic potential as their growth is not directly linked to the size of an area’s economic base.

In addition to being key CE jobs, occupations in traded and circular industries are also predominantly green, according to our Green Goods and Services (GGS)-based estimates.

**TABLE 4: PERCENTAGE OF TRADED, CIRCULAR ECONOMY (CE) JOBS THAT ARE GREEN**

<table>
<thead>
<tr>
<th>INDUSTRY</th>
<th>% OF GREEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazardous waste collection</td>
<td>90.1</td>
</tr>
<tr>
<td>Materials recovery facilities</td>
<td>77.6</td>
</tr>
<tr>
<td>Miscellaneous waste management services</td>
<td>67.2</td>
</tr>
<tr>
<td>Other waste collection</td>
<td>90.1</td>
</tr>
</tbody>
</table>

Source: QCEW and Green Goods and Services Survey; Analysis by UCR Center for Economic Forecasting and Development
California currently employs 34,432 workers in such industries, up 17% since 2015. Economic development efforts targeted at these sectors might increase this specialization, adding to the number of green jobs in the state. Such traded jobs might not fall within the ideal “local closed-loop” pattern of economic activity that some would advocate, but they achieve the most immediate CE objective — extending the lifespan of goods already in circulation while providing jobs along the way.

One area where California could successfully create locally serving jobs is in recycling. Creating a thriving recyclable materials market may work as a sort of import substitution. Virgin materials would be substituted for recycled and reused materials, much of which could be made locally. To get a sense of recycling industry job creation potential, the U.S. Environmental Protection Agency’s (EPA) Recycling Economic Impact model\(^{52}\) was applied to the state’s material consumption figures, which estimated how many recycling jobs might be created if the state did not export any waste it generated in 2020. For reference, California exported approximately 13.2 million tons of recyclable material to Taiwan, China, Korea, Malaysia, and Vietnam and locally transformed 2.3 million tons\(^{53}\) out of a total 77.4 million tons of waste in 2020.\(^{54}\)

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\(^{51}\) Data gathered a system for classifying industries by their segment (Business to Business or Business to Consumer) and pattern of trade (local or regionally-traded) developed by Delgado and Mills (2020).

\(^{52}\) U.S. EPA, 2016

\(^{53}\) Includes only Transformation activity.

\(^{54}\) CalRecycle, 2021
Figure 7 shows the underlying data by material category, suggesting up to 119,000 mostly locally serving jobs would be created in California. A study by the Tellus Institute\(^\text{55}\) estimated that reaching California’s 75% waste diversion goal\(^\text{56}\) could create 110,000 direct jobs. Additionally, CalRecycle estimates\(^\text{57}\) that composting creates (on average) four jobs for every 1,000 tons of waste diverted, while landfills generate one per 1,000 tons on average. In 2018, 21.9 million tons of potentially compostable material was sent to landfills, \(^\text{58}\) meaning there’s a potential net gain of 65,700 jobs if all of this material was composted. The CLRE report\(^\text{59}\) commissioned by the state similarly recommends recycling as a path to green job creation. Job growth in recycling is dependent on California improving diversion rates through new laws and continued enforcement of existing policies. The 75% diversion rate goal was supposed to be achieved by 2020; the state’s current diversion rate stands at just 42%\(^\text{60}\). There is significant opportunity for policy and industry innovation to drive progress on this goal while creating job opportunities.

### Table 5: Employment Effects of Waste Input Substitution

<table>
<thead>
<tr>
<th>MATERIAL CATEGORY</th>
<th>2020 TONS</th>
<th>MULTIPLIER</th>
<th>ESTIMATED EMPLOYMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ferrous Metal</td>
<td>5,209,189</td>
<td>0.005</td>
<td>26,046</td>
</tr>
<tr>
<td>OCC and Kraft Paper</td>
<td>4,976,543</td>
<td>0.0017</td>
<td>8,460</td>
</tr>
<tr>
<td>Other Misc. Paper</td>
<td>1,463,159</td>
<td>0.0017</td>
<td>2,487</td>
</tr>
<tr>
<td>Non-Ferrous Metal</td>
<td>922,774</td>
<td>0.0822</td>
<td>75,852</td>
</tr>
<tr>
<td>Unsorted Mixed Paper</td>
<td>368,445</td>
<td>0.0017</td>
<td>626</td>
</tr>
<tr>
<td>Plastics 1 and 2</td>
<td>111,996</td>
<td>0.0295</td>
<td>3,304</td>
</tr>
<tr>
<td>Worn Clothing</td>
<td>103,703</td>
<td>0.00173</td>
<td>179</td>
</tr>
<tr>
<td>High Grade Paper</td>
<td>74,659</td>
<td>0.0017</td>
<td>127</td>
</tr>
<tr>
<td>Mixed Plastics 3-7</td>
<td>48,404</td>
<td>0.0295</td>
<td>1,428</td>
</tr>
<tr>
<td>Batteries</td>
<td>20,690</td>
<td>0.0359</td>
<td>743</td>
</tr>
<tr>
<td>Tires/Rubber</td>
<td>14,439</td>
<td>0.0076</td>
<td>110</td>
</tr>
<tr>
<td>Glass</td>
<td>1,837</td>
<td>0.0104</td>
<td>19</td>
</tr>
<tr>
<td><strong>Total Recyclable Material</strong></td>
<td><strong>13,315,838</strong></td>
<td></td>
<td><strong>119,382</strong></td>
</tr>
</tbody>
</table>

Source: ILO, 2018; Analysis by UCR Center for Economic Forecasting and Development

The International Labor Organization found in 2018 that a transition to a CE would see worldwide total employment grow 0.1 percent above the business-as-usual scenario by 2030, resulting in around 6 million topline additional jobs, with sub-employment in services and waste management increasing by 50 million and 45 million jobs, respectively\(^\text{61}\). The CE employment impact literature is similarly positive, with 18 of the 28 studies finding a net-positive impact on employment over the next few decades, while only three found a net-negative impact\(^\text{62}\). Much of the increase in jobs is attributed to employment shifts to high labor-intensive sectors, such as recycling.

\(^{55}\) Tellus Institute
\(^{56}\) AB 341: 75% diversion from landfills by 2020.
\(^{57}\) CalRecycle, 2020
\(^{58}\) Data from Waste Characterization Disposal Facility-Based Study (2020).
\(^{59}\) Zabin, 2020
\(^{60}\) CalRecycle, 2020
\(^{61}\) ILO 2018
\(^{62}\) OECD, 2020
Similar to ZEVs, frontline recycling jobs are primarily filled by non-degree workers who need them the most. In a survey\(^63\), 98% of Refuse and Recyclable Material Collectors responded that a new hire needed a maximum of a high school diploma or equivalent to perform a job in their industry. More importantly: recycling and maintenance/repair occupations are in the same career cluster\(^64\) as manufacturing occupations, meaning there could be a substitution of recycling and repair/maintenance jobs for manufacturing jobs lost due to the transition to a CE.

California already has developed nation-leading specializations in occupations related to the CE in the Stockton and Inland Empire regions. These two metros boasted 58.3 and 53.3 CE-related jobs per 1,000 people\(^65\) in 2021, respectively, which are the two highest concentrations in the country\(^66\). These are both nearly twice the jobs per 1,000 people in Visalia (29.0), the next-highest area in the state.

### CIRCULAR POLICY TOOLS

California’s public policymakers have already recognized they have an outsized role to play in promoting development of more recycling, repair, and remediation jobs. In 2011, the state passed Assembly Bill 341 (a major landfill diversion effort), which requires commercial enterprises to arrange for recycling services and local governments to start public programs. Beginning in 2022, Senate Bill 1383 required all jurisdictions in the state to provide waste collection for organic waste for all residents and businesses. These policies provide an important broad-based approach to increasing the demand for recycling and reducing waste, but they do not necessarily support the development of new CE technologies or local employment. If the government decides to revise these programs, policymakers might contemplate a scheme that rewards adoption of certain processes or local sourcing. An alternative approach would eschew these “carrots” in favor of a tax on waste services that would reflect the true environmental costs of waste, including carbon emissions. With a tax in place, there would be even more impetus to adopt CE technologies.

The state has already taken some steps to require various products to be made with a certain percent of recycled material, such as plastic bottles. However, these goals will likely need to be significantly increased to develop a thriving secondary materials market\(^67\). In economic literature, the most common step for reaching a CE is implementing a gradually increasing virgin-materials tax over the next few decades, coupled with a corresponding decrease in labor taxes.

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\(^{63}\) O*NET Data Collection Program Survey

\(^{64}\) Career Clusters, as defined by O*NET, contain occupations in the same field of work that require similar skills. These allow workers to understand the necessary knowledge, competencies, and training for success in a particular career pathway.

\(^{65}\) Data from U.S. Census Bureau’s annual Occupational Employment and Wages Statistics 2021 report.

\(^{66}\) Third place: Dalton, GA (50.4 jobs per 1000 people)

\(^{67}\) Paben, 2022
CONCLUSION

The green jobs agenda has captured the imagination of many California policymakers because, in theory, it allows for workers to benefit from a green energy transition. The analysis presented here suggests this mission is anything but naive. Ultimately, California has created many green jobs, but the state has significant room to grow in becoming a specialist in the sector. Consider the following:

• The state has already become a national leader in green jobs. It currently employs an estimated 372,894 green employees. There are already more green workers in the state than there are total workers in Ventura or Santa Barbara counties. The state has added a full 44,000 green jobs since 2010.

• Current linear trends are favorable for the state. It is expected to add more than 58,000 green jobs to the labor market by 2030 if current trends hold. Moreover, California’s green job projections have it outpacing the country as a whole. If current trends are realized, California will arrive close to having a specialty (LQ>1) in green jobs.

• The state can realistically realize gains outside of its current economic base. Zero Emission Vehicles (ZEVs) in particular may bring more than 63,000 jobs to the state.

• In addition, there may be opportunities to add tens of thousands of jobs in and around the Circular Economy (CE).

As strong as the state’s current position is, this research paper has also made it very clear policymakers should not be complacent:

• The state’s first-place position as a green jobs employer belies the fact it does not (yet) have an above-average concentration of these jobs.

• Linear trends are not assured, and some industries might struggle to maintain their current growth as older green technologies mature.

In order to make the most of its opportunities, the state’s leaders should take seriously the challenge of expanding the Green Economy into new areas and scaling its strong venture capital ecosystem so it is also a leader in early-stage manufacturing and engineering.
APPENDIX

METHODOLOGY

Limitations to existing green jobs data: though the U.S. Energy and Employment Jobs Report (USEER) uses survey results to make proportional calculations based on the U.S. Census Bureau’s Quarterly Census and Employment (QCEW) data, it only publishes the final jobs numbers for each identified energy sector. It does not make public the calculations or intermediate data used to reach the final estimate, unlike the Green Goods and Services (GGS) survey. These two studies represent the only publicly available data on green jobs in the United States and California, and they are only for 2010 - 2011 (GGS) and 2015 - 2019 (USEER).

Approach to overcoming data challenges: To overcome these methodological challenges, this study relies on a customized green jobs estimation technique that combines the beneficial features of both the GGS and USEER to create a complete historical accounting of green jobs. The original GGS crosswalk provides estimates for the percent of employment in each North American Industry Classification System (NAICS) industry that, based on survey results, was directly involved in the production of green goods and services, including administrative and support activities for 2010 and 2011. The research team simulated this approach, using QCEW data going back to 1990, to update the GGS crosswalk of NAICS codes at the four- and six-digit level to include new NAICS codes that would reasonably be understood as part of the Green Economy. For industries counted in the original crosswalk, the mean of the two annual data points was taken, and new industries added were deemed to be comprised of 100 percent green jobs. The QCEW data was then subset based on the industries in this crosswalk, and the industry proportions are applied to each period studied. The green jobs (Green Goods and Services Jobs) is then the summation of the results. For example, Solar electric power generation (NAICS 22114) was estimated to have a mean of 97.9 percent green employment in 2010 - 2011. This percentage was applied to each period of QCEW data from 1990 to 2021. We use this number as our estimation of total green jobs in a region.

In order to make use of the most up-to-date data (USEER), this study additionally tries to recreate the USEER categories by constructing a crosswalk that matches NAICS codes to USEER categories, defined as Solar, Wind, Nuclear, Fuels, Transmission Distribution and Storage, Energy Efficiency, and Motor Vehicles by hand, and it applies the crosswalk to QCEW data in the same way discussed above.

The USEER categories, given their focus solely on the energy sector, do not give a complete accounting of the Green Economy. USEER provides a valid estimate of energy subsectors, but green industries disconnected from the energy sector, such as Agriculture, Waste Management/Recycling and Retail Trade, are excluded from USEER reporting. As a result, there is a gap between the total estimation of green jobs through GGS and USEER. In California, this gap is roughly 20% (depending on the year), with the GGS total being roughly 80,000 jobs greater than the total USEER estimation. Furthermore, our recreation of the USEER data does not match perfectly with the original. This is likely for two reasons: First, USEER calculates a proportion of jobs in each NAICS industry based on the percentage of respondents in the surveyed industry involved in energy or motor vehicles activity or related activity, whether green or not (whereas we count only green jobs). Second, because USEER uses a survey, it is able to count workers at companies who are involved in energy and motor vehicles yet considered part of a disparate NAICS industry. For example, a Finance company with 500 people that manages a Solar company’s accounting would be counted in USEER, but it would not be counted in our estimates. This also means that because our annual Green Innovation Index (GII) relies on USEER data for the green jobs analysis, this study and the GII will have different employment estimates for certain industries. We wish we could match the numbers for consistency, but the lack of data availability has required us to take this path.
REFERENCE LIST


BLS 2022. High School graduates with no college had unemployment rate of 4.5 percent in February 2022.


Next 10. 2021. “Green Innovation Index”.


The UC Riverside School of Business Center for Economic Forecasting and Development opened its doors in October 2015 and represents a major economic research initiative in one of California’s most vital growth regions. The Center produces a wide variety of research both independently and in collaboration with academic, business, and government partners. Research products include monthly employment analyses, quarterly regional economic forecasts, a quarterly business activity index, a white paper series, and a major regional economic forecast conference, hosted annually.

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