Transforming Southern California into a Clean-Tech Hub

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TRANSFORMING SOUTHERN CALIFORNIA INTO A CLEAN-TECH HUB

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“The role of government in clean tech is not to replace private enterprise. It is to find the gaps and fix them.”

Deval Patrick, Former Governor of Massachusetts
Abstract

In this report, we seek to accomplish several goals. The first, is to determine the feasibility of establishing a thriving cleantech cluster economy within the Southern California region. The second, is to determine what opportunities and challenges exist in pursuit of this effort. And the third, is to generate a set of policy recommendations to aid this goal. We determine that this endeavor is feasible; that California has many favorable factors to achieve this goal; but significant hurdles need to be addressed first. We also identify the specific policy actions that relevant stakeholders can take to assist in this effort.

In this report, we begin by providing a high-level overview of clean-tech cluster formation and define our context and definition of success. Next, we explore several case studies of advanced tech hubs, to understand what led to their success or failure. Then we analyze the current state of the clean-tech industry in Southern California, determine what resources it has available, and examine what challenges it still faces. Finally, through a process of literature review, case study, analysis, and expert interviews, we formulate a list of policy recommendations and guidelines for the public and private sector to collaboratively explore, in order to transform the Southern California region into a prosperous clean-tech hub.
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Introduction & Motivation

Introduction

California is a global leader in technology and innovation. Many notable corporations grew out of its robust economic centers, expanded their markets far beyond California, and were successful globally.

With the nation’s growing commitment to tackle climate change, many new clean-tech companies have planted roots within the southwestern US region, but without a highly concentrated, specifically curated, geographical hub. Federal and state-wide directives have been issued to build upon existing resources and provide new funding for a robust clean energy transition. The Governor of California’s Office of Business and Economic Development indicates that California is currently home to over 480,000 clean energy jobs and state spends over $3 billion annually to support clean-tech initiatives within its borders.1

Additional statewide commitments, such as achieving 100% clean energy by 2045, 45% GHG reduction by 2030, and the establishment of 100% Light-Duty ZEV sales by 2035, are all policies that serve to turn California into a regional powerhouse of clean-tech growth, aided greatly by the state’s culture of collaboration between public and private sector stakeholders. At the local level, the Southern California Association of Governments (SCAG) has declared urgency regarding the area's transformation into a “green region”. Accordingly, it has released several Natural Resource Plans, Climate Action Plans (CAPs), and Greenhouse Gas (GHG) Reduction programs.2

Congress has passed major legislation such as the Inflation Reduction Act in 2022, making an additional $369 billion fiscal commitment to energy security and climate change action.3 The bill includes $30 billion in tax incentives for companies to ramp up domestic solar panel and wind turbine production and deployment over the next decade.4 Three recently introduced laws: the Infrastructure Investment and Jobs Act, CHIPS and Science Act, and the Inflation Reduction Act include more than $500B of climate spending, which will triple US government expenditure on climate research and clean energy in the next 10 years.5

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1 California, State of. “Climate and Clean Energy: California Governor’s Office of Business and Economic Development.” California Governors Office of Business and Economic Development,
2 SCAG, 2009
4 Ibid.
5 World Economic Forum, 2022
Most importantly, there is strong federal and local governmental interest in fostering the development of a clean-tech hub in the Southern California region, and industry stakeholders are eager to capitalize on these government efforts. According to Gov. Deval Patrick: “The mood of the world has shifted towards clean-tech”, and the state can capitalize on its wide breadth of assets to build up a clean-tech cluster.

**Motivation**

We begin by examining some of the benefits, both local and global, that would arise following the development of a clean-tech hub in Southern California:

1. **Environmental benefits**: Clean-tech clusters can help to reduce greenhouse gas emissions and other forms of pollution, for Southern California and the rest of the world. Given the looming climate crisis, Southern California can help foster clean-tech clusters that can have a far-reaching impact in reducing global carbon dioxide emissions through technological research and breakthroughs.

   This will also be important in Southern California, which has historically struggled with air pollution due to its high population and heavy traffic. For example, according to 2022 air quality reports, the city of Los Angeles had the most polluted air in the US.\(^6\) By developing and deploying new clean-technologies, such as carbon capture, electric vehicles and renewable energy systems and storage, the region can reduce its environmental footprint and improve air quality.

2. **Economic benefits**: Clean-tech clusters can also provide multifaceted economic benefits by creating new jobs and attracting investment. Southern California is already home to many clean-tech companies and research institutions, and building a cluster would allow them to benefit from economies of scale and help foster collaboration and innovation, leading to the creation of new products and services and better business opportunities.

3. **Regional leadership**: Building a clean-tech cluster in Southern California could help the region to establish itself as a leader in sustainable technology. This branding could help to attract top talent and investment from around the world, which could in turn lead to further economic growth and job creation, creating a virtuous cycle of regional economic growth and prosperity. Clean-tech can create millions of high-paying jobs across the US\(^7\), which, along with taxes levied on tech companies lead to government revenues that can be used to provide public services to further bolster growth, development, and investment.

4. **Local Resilience**: Southern California is subject to natural disasters, such as earthquakes, wildfires, and droughts. Climate change is expected to bring more extreme weather events and

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\(^6\) NBC Los Angeles, 2022  
\(^7\) CleanTechnica, 2022
other challenges to Southern California. Clean tech can help to mitigate many of these risks. For example, building resilient energy systems that incorporate renewable sources of energy and distributed generation enabled by the clean-tech industry can help to ensure that the region has a reliable source of power during emergencies.

Given the potential of clean-tech clusters in Southern California, the interest from policymakers and its potential benefits to the region, it is very important to explore ways to foster the growth of a clean-tech hub in the region. In this paper, we will explore in-depth measures that public and private stakeholders can take to transform Southern California into a clean-tech hub.
Background

About Our Project

The purpose of this project is to inform our client, California 100, along with other regional policy institutions, of the potential benefits and economic impacts associated with establishing a clean-tech cluster within Southern California. In particular, we focus on the Inland Empire region in our study. Our analysis focuses on innovation and thought leadership is what enables our work to fit naturally with the mission of our client organization. More information on California 100’s prior work and overall mission can be found here.

Specifically, this paper serves to provide a comparative analysis of the strengths and potential enhancements that the region needs to embrace in order to generate a thriving economic cluster. We draw upon various theoretic models, case studies, interviews, and well-established research to inform our policy recommendations.

More importantly, we take into consideration the current needs of the market and assess the gaps within workforce, infrastructure, R&D, industry, and government to provide our client and policymakers with a set of policy recommendations that could help leverage available resources to grow Southern California’s clean-tech economy.

Defining Clean-tech

To conduct an effective analysis, it is crucial that we first define what we mean by “clean-tech”. For the purposes of this study, we utilize “clean-tech” as a broad and adaptive term that encompasses technologies central to, or closely coupled with, reducing the overall national or global greenhouse footprint. Since much of this footprint is a result of energy production or transportation—technologies in both sectors are of clear import. However, technologies aimed at addressing related issues like energy storage, energy efficiency, methane reduction, or direct greenhouse gas reduction are also relevant and can be placed under the clean-tech umbrella.

Because this term is broad and adaptive, it is important to outline some key examples of what qualifies as clean-tech in our study.
Included in our definition are well established primary power generation technologies such as: solar photovoltaics, solar thermal, geothermal, second generation nuclear, on- and off-shore wind, and hydroelectric. Additionally, prospective but developing power generation technologies fall into this category. For instance: tidal, biofuel, hydrogen fuel, third- and fourth-generation nuclear, flue gas carbon capture, and bio-photovoltaics. Power storage is also of particular importance for our analysis. Namely, technologies like large scale battery storage, green hydrogen, pumped hydroelectric, kinetic batteries, compressed air, and thermal storage are all considered clean-tech.

Transportation is another key sector in which clean-technologies are emerging, especially those coupled to the energy transition by a reduction in the use of combustion engines. These include, but are not limited to: electric cars, buses, trucks, and trains; associated battery technologies and charging infrastructure; hydrogen fuel cells; electric and biofuel powered aircraft; and innovative logistics management tools meant to increase transit efficiency. Other clean-tech technologies include: ocean or direct-air carbon capture and storage; grid efficiency technologies, both digital and physical; and improvements in household and industrial efficiency, such as smart lighting.

The study does not include in its definition of the clean-tech industry all other industrial and home technologies. Power generation technologies which produce net positive carbon, or other greenhouse emissions, are excluded. These are: coal, oil, natural gas, and ethanol; plus, associated extraction and refining technologies. There are also technologies that improve the overall thermodynamic efficiencies of these greenhouse producing sources, but we do not classify these as clean, despite their potentially positive contribution towards a national and global energy transition.

Finally, it is important to note that this list is not exhaustive, but merely provides a basic framework for what does, or does not, meet our operating definition of clean-tech.
Economic Clusters

Throughout our research, we have identified various industries through which the clean-technology market would have a direct impact. To ensure steady growth, expanding innovation, and targeted market evolution and impact, clustering the clean-technology economy presents itself as a viable mechanism to sustain and grow the industry. But before delving deeper into the region's geographic competitiveness, we want to first highlight the foundational elements of cluster economies, alongside the benefits and challenges they bring to industry.

The term “cluster economy” has been well-known among professionals and academics since the mid to late 1900s when the world-renowned Professor Michael Porter at Harvard University coined the term.\(^8\) According to the study conducted by Porter, clusters are geographic concentrations of companies that are interconnected within a specific industry working towards servicing a particular field. More specifically, we see that clusters become primarily prominent in terms of efforts that target the success of local, regional, and national economies in the utilization of diverse workforce, enhancing skills, and promoting innovative productivity.\(^9\) Clusters also lend themselves as avenues for knowledge spillover, economic growth, and the establishment of regional economic development hubs that become more productive and innovative, thereby increasing competitiveness.\(^10\)

A number of peer reviewed studies have uncovered numerous foundational elements for the establishment of economic clusters. The research examined in consideration of this paper suggests that the critical elements necessary for the success of a cluster do not solely emerge from sustaining businesses within a concentrated economic region, but rather take into account many stakeholders and external factors that directly or indirectly impact the operational capacity of a cluster by way of policy, fiscal access, and economic growth potential.

We have identified a variety of factors that serve as prominent components of successful clusters. This includes the number and strength of industry interlinkages, relative competitive advantage, institutional and enabling environments, workforce training, spatial expression, and firm composition.\(^11\) For instance, a study conducted by the well-known consultancy Guidehouse noted that multiple stakeholders emerge as familiar key players associated with industry clusters, such as the academic institutions within a

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9 Metropolitan Council, 2023  
10 West Virginia University, 2023  
11 GuideHouse, 2023
region, financial institutions, elected officials, utility providers, economic development boards, philanthropic efforts, and civic organizations.

As seen from the diverse composition of involved stakeholders, the establishment of a cluster necessitates a concerted effort between the public and private sectors to ensure effective and successful operations that continue to grow and promote development and innovation.

Given the importance of the cluster model framework and the extensive studies that have been conducted within the field, this paper leverages a wealth of existing literature to inform our policy recommendations relevant to cluster economy dynamics. Notable cluster experts such as Michael Porter and Analee Saxenian are authors whose work directly informs our research. Michael Porter's theory of cluster formation\textsuperscript{12} states that firms in related industries tend to cluster together in geographic regions to gain competitive advantages. According to Porter, these clusters benefit from several factors—such as access to specialized labor, suppliers, and services, as well as a critical mass of potential customers and partners—that allow firms to be more productive and competitive. Additionally, he notes that the proximity of firms within the cluster can facilitate knowledge-sharing and collaboration, leading to innovation and improved economic performance. Our mission is to apply this well-established work to our context of clean-tech in California.

In light of this, Southern California holds various characteristics that make it a viable candidate for establishing an economic cluster. We will provide a robust analysis of the first and second nature advantages that the region holds in relation to the establishment of a cluster that serves the examined industry. The paper also analyzes the geographic advantage, natural resource access, environmental and regulatory frameworks, workforce and institutional factors, educational quality, and access to capital as we consider the viability and methods of creating a cleantech hub within the Southern California region. In our analysis, we will focus on the Inland Empire region within Southern California in particular, discussed below.

\textsuperscript{12} Porter, Harvard Business Review, 2014
Zooming in on the Inland Empire

Fig 1: A Map of Southern California

Occupying a large portion of southern California, the Inland Empire of Southern California presents an unique location for centering the clean-tech industry due to its strategic position and historical background in manufacturing. With over 4.6 million residents\textsuperscript{13} the region is a vital logistics hub with an extensive network of highways and railways connecting Los Angeles to the surrounding area. Moreover, the Inland Empire has been diversifying its economy and is already making strides to become a leader in clean-tech. It will thus feature prominently in our analysis.

The region boasts a skilled workforce with a background in manufacturing, has several research universities and colleges actively engaged in clean-technology research, and local government agencies supporting clean-technology development. Several mainstay clean-tech companies like Tesla and First Solar are already operating within the region, alongside clean-tech research organizations such as the Air Resources Board and the UC Riverside Center for Environmental Research and Technology.

Developing a clean-tech economic cluster in the Inland Empire would bring several benefits, including increased economic activity, improved air quality, reduced reliance on fossil fuels, increased energy efficiency, and increased innovation. However, some challenges would need to be addressed, such as the need for more funding and skilled workers and competition from other regions like Silicon Valley and the Bay Area.

\textsuperscript{13} “2020 Census: Counting the Inland Empire.” n.d. Public Policy Institute of California.
Defining Success

To successfully develop a clean-tech cluster, we need to identify what constitutes a successful clean-tech cluster in order to track progress. History has proven to us that not all industry clusters are created equal and not all regions that house industry clusters grow or excel at the same rate or to the same degree. One region's metric of success for a cluster does not necessarily align with another's. However, in this paper, we identify some broad metrics for success in the context of a clean-tech cluster. The definition of success hinges on a high overall scale of local economic activity, a diverse workforce possessing complementary skill sets, together with high spatial density and a large number of linkages among local firms (e.g., Marshall 1890, Porter 1998).\(^{14}\) \(^{15}\)

Following Porter’s (1998) definition of a successful cluster, we identify three key criteria for a successful clean-tech cluster in Southern California:

1. Large Scale and High Density of Local Activity and Innovation
2. Diversity of Technologies
3. Positive Spillovers: Impact on Multiple Sectors of the Economy

We further identify the following metrics as general indicators of success:

1. **Growth in the Number of Patents**: Proxy for increase in innovation.
2. **Rapid growth in Regional Venture Capital funding**: Funding for early-stage startups help foster a strong cluster economy.
3. **Increased Share of Total Clean-Tech Dedicated Venture Capital Funding**: Reflects the growing importance of the region as a technology hub.
4. **Number and Total Market Capitalization of Clean-Tech Firms**
5. **Employment Metrics**: Number of clean-tech jobs seeded by the clean-tech cluster. Includes a combination of high-skilled and low-skilled workers.
6. **Degree of Knowledge Sharing**: Existence of formal and informal flows for technical knowledge, e.g., partnerships between existing firms, and reliance on shared local inputs, e.g. through a research university.

\(^{14}\) Alfred Marshall, 1920
\(^{15}\) Porter, Harvard Business Review, 2014
Case Studies

Case Study Motivation

To inform our analysis of Southern California’s potential pathway to becoming a clean-tech hub, it is beneficial to look at other relevant advanced technology cluster economies in order to learn about best practices identified in instances of success, and conversely, how to avoid pitfalls identified in instances of failure. In the following section we examine the Boston Biotech hub, Silicon Valley, and Masdar City, UAE. Each case study offers valuable lessons for our prospective analysis of Southern California and the Inland Empire.

The Biotech Hub in Boston

Over the past four decades, the biotechnology industry has taken hold in the Boston metropolitan area and made the region one of its primary U.S. based R&D hubs. The Boston area biotech sphere now boasts an impressive economic impact amounting to $21.5 Billion in 2022\(^{16}\) and provides upwards of 80,000 local jobs,\(^ {17}\) many of which are high-paying jobs. The industrial growth has been widely hailed as a boon for the area and is often considered as having helped reverse Boston’s moderate stagnation and decline in the later quarter of the 20\(^{th}\) century.

The history of Boston’s biotech cluster has both technological and structural origins. Primarily, discoveries in DNA and RNA science paved the way for increasingly versatile methods of drug and treatment development, this was the technical impetus that allowed structural forces to take up work.

The most direct sequence of events is often traced back to 1976. Following the emergence of new research methods, the city of Cambridge outlawed DNA research because of an unfounded fear of modified organisms contaminating water supplies. This restriction initially sent Biogen, a first-generation biotechnology firm, to seek lax regulations in Europe. The law was repealed the next year, and Biogen returned to become the first big biotech firm to make the Boston area its home. Shortly thereafter, in 1980, the supreme court upheld a lower court ruling that genetically engineered biological material was patentable. The same year, the US congress passed a crucial law guaranteeing the retention of

\(^{16}\) MassBio, 2022

\(^{17}\) MassBio, 2021
intellectual property rights to universities for their commercialized innovations spun out of federally granted research projects.

Private capital was also essential for small firms to scale up and produce products for the market. In the 1990s, the Boston area experienced a significant increase in the number of venture capital firms. The resulting financial environment provided startups with access to capital, which was crucial for scale-up. The regional industry continued to grow for the next decade and a half, but the cluster really took off in 2008 when the state government launched an initiative, backed by legislation, that promised over $1 billion for Biotech over the following decade. By 2018, at least $650 million of that initial pledge had found its way into the cluster, and a new Massachusetts government renewed the pledge by signing an act with outlays for an additional $620 million in bonds and tax credits over next coming half decade meant to drive education, research, and job training in life sciences.

Massachusetts used funding not only to address issues directly related to the biotech industry but also to strengthen the supportive networks that helped it thrive. For example, when faced with a housing and affordability crisis in Boston, Massachusetts provided funding for workforce training and technology-focused tax credits. It also connected mature, high-density innovation hubs with lower-density regions across the state and tax credits were offered to companies that expanded beyond Boston and Kendall Square into central and western Massachusetts. Notably, the Massachusetts government engaged diplomatically with companies from out of state, and actively courted them, helping to attract important stakeholders and to build a brand for the innovation cluster.

However, much of the growth was owed to the presence of preeminent research and educational institutions in the area. Spending programs provided grants and subsidies to scientific institutions whose products and research fueled industry growth, and most analyses of the Boston biotech cluster attribute its success to the presence of well-endowed universities and research centers with an academic focus geared toward the life sciences. Harvard, MIT, and Tufts provided world-class education to the next generation of startup founders and biotech employees, creating a steady stream of skilled technical workers.

Other institutions focused on utilizing research and discovery to bridge the gap from theoretical work to practical applications. For example, Mass. General Hospital, Brigham and Women’s Hospital, and the Dana Farber Cancer Institute served as conduits and markets for new and valuable biotechnologies. When these technologies demonstrated success, larger corporations were more likely to get involved and either acquire the project or help bring in new funding streams. This created terrific synergy across the range of small to large businesses, connecting researchers to implementers.

Further, the cluster's innovation goals were unique and targeted. When compared to the U.S.'s other major biotech cluster economy in the San Francisco Bay area, Boston biotech research projects had a

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18 Stendahl, 2018
19 Berke, 2022
20 Powell & Owen-Smith, 2004
greater proclivity to pick up so-called “orphaned” drugs, meant for already well-known and defined populations. This might have contributed to the generation of more deliverable products because the problems researchers worked on were more specifically defined.

Private and public-private collaborative organizations also played a large contributing role. Industry organizations dedicated towards economic advocacy for the sector, as well as groups dedicated towards fostering collaboration between the various institution types, started to spring up. Boston based companies and organizations used largely indigenous scientific advisory boards which may have helped keep expansion efforts confined to the cluster region, since local advisors had a vested interest in advancing the local biotech community. On frequent occasions, these Massachusetts based biotech organizations would host collaborative conventions like “partnership days” to foster a culture of open science that helped ideas to build off each other within the cluster.

The Silicon Valley Tech Hub

The establishment of Silicon Valley as a hub for computing, software, and hardware technology resulted from a confluence of factors that came together over time, largely aided by government investment and business-friendly policies. Its proximity to Stanford University and other prestigious educational institutions, the availability of venture capital, a culture of innovation, availability of a highly-skilled workforce, and the presence of extensive defense and electronics companies each played an integral role in the research and development effort for new digital technologies.

The formation of the tech cluster dates back to the establishment of the Stanford Industrial Park in 1951. The University dedicated land to house research and development in computing and digital enterprise, creating an anchoring point for startups. According to authors Michael Luger and Harvey Goldstein in their informative book *Technology in the Garden: Research Parks and Regional Economic Development*, "the evolutionary path of the Stanford Research Park is a consequence of changing university needs, the burgeoning post-World War II West Coast technology sector, the research capability and entrepreneurial spirit at Stanford University, the growing environmental consciousness of the surrounding community, and the adaptability of park planners and managers". The park's proximity to the university and other Bay Area educational institutions helped to create a pipeline of talent that provided startups with access to a pool of highly educated and skillfully trained graduates.

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21 Porter, Bunker-Whitting, & Powell, 2005
Companies like Hewlett-Packard and Intel were some of the earliest tenants of the Park and set the tone for the culture of innovation and entrepreneurship that would define the region for decades to come.\textsuperscript{25} The ecosystem also drew in like-minded innovators and entrepreneurs from across the world. This in turn drove up the demand for skilled labor and residential projects.

To further understand the fundamentals of the establishment of the Silicon Valley Cluster it is important to talk about the role of government policies, infrastructure, talent, entrepreneurship, and access to venture capital. The US government has played a significant role in supporting the growth of the technology industry in the region by providing funding for laboratory R&D, promoting entrepreneurship, and investing in critical infrastructure. One crucial example is the Small Business Innovation Research (SBIR) program, which provided funding to early-stage startups.\textsuperscript{26}

In terms of research infrastructure, the region has a network of world-class research and development facilities, including the Lawrence Berkeley National Laboratory (LBNL), Lawrence Livermore National Laboratory (LLNL), and the NASA Ames Research Center. These federal institutions have likewise played a crucial role in attracting top talent to the region and facilitated the growth of innovative projects in digital technology. Talent recruitment and workforce development played a separate but exceptionally important, integral role in the formation of the cluster. Specifically, the diversity of talent has contributed to the region's innovation and has helped to create a culture of collaboration, which has led to the development of some of the world's most innovative technologies.

Finally, entrepreneurship and access to capital were foundational elements for Silicon Valley. Both forces played an outsize role in the region becoming home to notable, globally-recognized firms. The access to venture capital helped fuel the growth of the region's technology industry by specifically enabling startups to garner investment in product development and operations scale-up.

\textbf{Masdar City, UAE}

Masdar City is our most current case, and thus has a less storied history. It is a planned city in Abu Dhabi, United Arab Emirates, designed to be a hub for clean-technology companies. The project was launched in 2006 with a budget of $22 billion, and it was met with much fanfare.\textsuperscript{27} But it has faced several setbacks and delays and its completion date has been pushed back multiple times. The city aimed to create a sustainable ecosystem of companies, investment, and workforce. It was supposed to

\textsuperscript{25} Anchor Electronics, n.d.
\textsuperscript{26} “Small Business Innovation Research (SBIR).”  Energy.gov
\textsuperscript{27} CleanTechnica, 2013
be completed by 2016, but only about 5% of its initial footprint planned out in 2006 has been built so far, and the project’s future is uncertain.\textsuperscript{28}

Some of the reasons behind why the city failed to live up to expectations were:

**High costs:** Masdar City required a significant investment of money to develop, and it was challenging to attract enough investors and partners to cover the costs fully. The initial budget of $22 billion was cut to $18.7 billion, and some of the original plans were scaled back and the date for finishing the city has been pushed back to 2030.\textsuperscript{29}

**Slow development:** The development of Masdar City was slower than expected, and some of the projects faced delays and setbacks. The original goal was to complete the project by 2016, but many of the facilities and buildings are still under construction as of 2023.

**Limited demand:** Masdar City was designed as a sustainable, zero-carbon city, which made it more expensive to build and operate than traditional cities. This approach made it challenging to attract residents and businesses to the city, and the demand for its services and amenities was limited.\textsuperscript{30}

**Lack of industrial diversity:** Masdar City was primarily focused on developing clean energy technologies and attracting companies in that sector. However, this limited the diversity of businesses and industries in the city making it less attractive to various potential residents and investors.

**Lack of amenities:** As of 2016, the city has around a dozen buildings, including the Masdar Institute, where the city’s 287 students lived. The city has a population of around 5,000 workers and 370 companies have offices in the Incubator building. There is one organic grocery store, one coffee shop and one bank.\textsuperscript{31} The lack of amenities make it difficult to attract high-skill workers to the city.

There is a saying in the clean-tech industry that “it takes a village to raise a clean-tech startup”. Masdar City is an example of a case where funding itself is not enough to build out a successful cluster.

\textsuperscript{28} Robbins, Yale360, 2021  
\textsuperscript{29} Herzog, Grist, 2021  
\textsuperscript{30} Flint, Bloomberg, 2020  
\textsuperscript{31} Malloonee, Wired, 2016
Case Studies–Lessons Learned

Based on the case studies presented above, we draw key findings and factors from the successful cases in Boston and Silicon Valley. Conversely, we analyze the absence or misapplication of these same factors in the case of Masdar City.

We propose 5 broad, key criterions for successful cluster formation, whose presence is beneficial for success, and whose absence is a recipe for problems:

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<th>Criteria</th>
<th>Silicon Valley</th>
<th>Boston Biotech</th>
<th>Masdar City</th>
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<tbody>
<tr>
<td>1. University and Research Center Leadership</td>
<td>Had a strong presence of academic and research institutions in the cluster environment. Stanford, Berkeley, NASA Ames, LLNL, LBNL, etc. all brought significant expertise to the world of computing and provided the means to advance hardware and software in collaborative research efforts.</td>
<td>Was built around a nucleus of research institutions like Harvard, Tufts, and MIT and was helped by mid-level pilot institutions like hospitals and professional institutes that could test biotech products in their entry-to-market phase.</td>
<td>Masdar Institute (MI) is Khalifa University’s sustainability-focused research institute in Masdar City. It lacked the caliber of established research institutions that seeded the other clusters.</td>
</tr>
<tr>
<td>2. Government Support</td>
<td>The Advanced Research Projects Agency (ARPA) funded research into new technologies that had the potential to be used for military purposes. This funding helped to support the development of early computers, semiconductors, and networking technologies.</td>
<td>Has had more than $1B in committed funds, dedicated program grants, subsidies, and supportive efforts for workforce training. Consistent efforts by state and local politicians to encourage corporate engagement and brand the area as a center for R&amp;D.</td>
<td>Was almost solely a UAE government enterprise. There were huge sums of funds poured in based off of ground up government initiatives and was likewise supported by significant government branding efforts.</td>
</tr>
<tr>
<td>3. Private Sector interest and funding</td>
<td>Dominated by private sector players who piloted a consumer</td>
<td>Substantial access to venture capital due to a large VC presence and</td>
<td>While over 300 firms had office spaces in Masdar City, there</td>
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<tr>
<th>driven economy for hardware and software technologies. Main efforts led by large companies like HP, Dell, IBM, and later by Apple, etc.</th>
<th>greater Boston finance community created shortly before the biotech boom. Once large companies sprung up, there was significant reinvestment and acquisition of smaller firms and R&amp;D projects by larger corporations.</th>
<th>were few startups or headquarters for successful, large clean-tech firms in the cluster.</th>
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<tr>
<td><strong>4. Formal and informal collaboration between primary stakeholders</strong></td>
<td>Pioneering efforts in informal processes of startup incubation and coworking spaces.</td>
<td>Creation of consortia, inter-institutional research groups, industry advisory groups, conferences and events. Creation of some coworking spaces. Active engagement from government representatives in events and conferences.</td>
</tr>
<tr>
<td><strong>5. Cultural norms for the free exchange of ideas and movement of experts across different roles</strong></td>
<td>Creative consumer driven culture characterized by open and free information sharing. Community centered engagement of researchers and entrepreneurs. Spirited by the general culture of openness in the greater Bay Area. Also characterized by general mobility of engineers across industry.</td>
<td>Less conducive to pure entrepreneurship than Silicon Valley, but with a much stronger emphasis on research collaboration across institutions. Fostered by norms of open science, proximity allowed many local community spots like coffee shops and workspaces to help bridge connections and mobilize researchers between organizations.</td>
</tr>
</tbody>
</table>
Analysis:

Section 1: Opportunities & Resources for a Clean-Tech Cluster in California

1. Natural & Existing Resources

California, and the Greater Inland Empire, have an immense wealth of natural resources from which to build a clean-tech manufacturing base and deploy new technologies for use in the field. These include commodity resources such as minerals and metals; geographic resources, including shorelines, windswept valleys, and rivers; and pre-existing technological assets, like mines, dams, wind farms, and solar farms—all of which can be utilized, expanded, or upgraded in concert with a growing regional effort.

Mineral Resources

California possesses commercially viable deposits of many integral minerals including silver, gold, lithium, boron, silica, and a slew of other rare earth metals. All of these minerals are critical to the manufacturing of advanced electronics central to a clean-tech economy. Included here are a few key examples of where these critical minerals are, and what they may be used for:

- Lithium is critical for battery storage and is found in abundance in southern California. The Salton Sea area is considered one of the richest lithium reserves in the world and is thought to be economically recoverable. Some limited extraction activities have occurred there since the 1970s.33

33 U.S. Geological Survey, 2023
- Boron and Borates are also pivotal components to multiple kinds of clean-technologies, including solar, wind, nuclear, battery storage, fuel cells, and electric motors.\textsuperscript{34} Kern County in Southeastern California is home to the Rio Tinto Mine, one of the world's largest sources of boron.\textsuperscript{35}

- Rare earth metals like neodymium, which are essential for intermediate products such as permanent magnets, are of increasing importance to advanced clean-technologies. These can be found in relative abundance in southern California and are extracted via the Mountain Pass Mine and processing facility in San Bernardino County (Royal Society of Chemistry, "Neodymium") (MP Materials, "What We Do").

**Geographic Resources and Existing Assets**

- California produced roughly \(\sim 7.5\)% of its 2021 total in-state produced electrical generation from hydropower, and during wet years, it can receive up to \(\sim 15\)% of its total electric consumption from hydropower, though this includes facilities located out of the state (California Energy Commission, "2021 Total System Electric Generation"). The state is home to approximately 250 hydropower generation sites and will continue to play a vital role in both power generation and water management.

- Wind farms produce a substantial amount of electricity for California but populate only a few key locations within the state—California’s topography can likely accommodate more. For instance, in the Inland Empire, the windswept valley of San Gorgonio Pass in Riverside County is formed via the funneling effects of nearby mountains; it has been home to large turbines since the early 1980s and can produce over 600MW with a relatively modest footprint.\textsuperscript{36} Similar confluences of dynamic airflows exist in other parts of the region and could potentially be utilized for the expansion of wind’s power generation share.

- There is also great potential for offshore wind asset placement given the state’s long coastline. As such, the California Energy Commission has indicated a plan to create 25GW of offshore wind production by 2045, signaling the scope of potential for advanced turbine development and manufacture.\textsuperscript{37}

- There are a half-dozen solar farms within the Inland Empire region and another half-dozen in Southern California. The state’s copious annual sunshine in the desert regions lends itself well to the placement of solar assets, and moreover, the entire southwest region has the potential to accommodate a huge expansion of solar assets in the coming two decades.

\textsuperscript{34} Borates Today, "Boron for Technologies of the Future", 2023  
\textsuperscript{35} California Geological Survey, "Minerals", 2023  
\textsuperscript{36} ScienceBase, "San Gorgonio Pass Wind Resource Area", 2023  
\textsuperscript{37} California Energy Commission, "CEC Adopts Historic California Offshore Wind Goals", 2023
Because of the Inland Empire’s wide, open spaces, energy storage facilities could be placed here as well. As storage technologies begin to mature, California can likely become a proving ground for many pilot sites for these increasingly vital technologies. Geologic features like caves and basalt deposits may provide opportunities for compressed air or low-grade thermal storage.

In concert with bold efforts to expand the state’s renewable energy generation and storage infrastructure, there is room to improve the efficiencies of the previous generation of power plants and energy farms. Updated bearings, electromagnets, motors, and placement plans can help increase the overall output of current assets. While some efforts to this effect have already occurred, a cyclical process of retrofitting will increase overall efficiency.

2. Research Institutions

Research institutions serve as vital production centers for high-skilled human capital, new and valuable ideas, and provide the facilities required to affirm proof-of-concept for emerging technologies. They are one of the most crucial components of any advanced technology cluster economy. To its benefit, California possesses an incredible wealth of advanced research institutions, underscored by world leading universities.

The state is home to three of the top ten US universities in both mechanical engineering and renewable energy research. Among these elite institutions are: UC Berkeley, whose Renewable Energy Laboratory and Energy Resources group conducts cutting edge work on both clean-tech and associated policy, notably in solar, wind, and advanced biofuels; Stanford University, whose Precourt Institute for Energy is considered among the world’s best, also boasts robust talent in solar and wind with additional groups focused on many forms of energy technology, including in geothermal; and the California Institute of Technology, which hosts the Resnick Sustainability Institute which is a research leader in renewable energy, energy efficiency, and clean-tech, more broadly.

Current data show that the vast majority of higher education students within the State of California attend public institutions. All of these universities in turn provide ample space for research and generate a reservoir of talent for an in-demand workforce. Thousands of engineers and scientists are entering the labor market each year from these schools and are finding employment around the state and region. Notably, there is room for expansion of these programs and institutes, whose current maturity can provide a stable base for future growth. By building up programs through greater enrollment and more advanced training, these universities can continue to provide the fundamental intellectual currency.

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38 Edurank.org, 2022; U.S. News & World Report, 2022
39 Berkeley Renewable & Appropriate Energy Laboratory, n.d.
40 Stanford University, n.d.
41 Resnick Sustainability Institute, n.d.
required to transform the clean-tech sector. This would require a concerted effort from the state and each of the school’s administrations.

California’s National Labs also play a critical role in clean-tech. The premier federal institution for clean-tech is the US Department of Energy’s National Renewable Energy Laboratory (NREL). NREL has a limited footprint in California, which could be expanded with proper state and federal support. Currently, NREL collaborates with two other national laboratories in California—Lawrence Berkeley National Lab, and Lawrence Livermore National Lab.\textsuperscript{42} NREL also has collaborative efforts with other in-state institutions like the California Independent Systems Operator. Likewise, they have listed partnerships with the California Center for Sustainable Energy, the California Energy Commission, and even with private firms like Tesla.\textsuperscript{43} Since the national laboratory complex already has a robust presence in California, there is an opening to expand on current institutional infrastructure and build out new capabilities.

3. Workforce and Training

When analyzing the necessary components for a potential clean-tech cluster within Southern California, the need for a highly trained workforce tops the list. Recent studies conducted within the United Kingdom have highlighted that as the clean-tech industry continues to grow, the demand for green skills is expected to become significantly desirable, especially in construction, manufacturing, and energy\textsuperscript{44}. Moreover, surveys among industry leaders indicate strong demand for green skills to achieve net zero targets.\textsuperscript{45}

Both the public and private sectors need to work together for workforce development and training. A significant role for public actors is to provide direction and coordination for skills development and training.\textsuperscript{46} Recent efforts include the establishment of incentive programs for educational and technical institutions to teach and equip current workers and emerging workforce members with the necessary skills needed for a transition into the green technology economy.

The technical skills required include data analytics, research and development, technical support, and product manufacturing skills, etc. Workers employ the majority of such skills within engineering and other scientific fields. In a study by Make UK, 72% of manufacturers ranked innovation skills as most needed to achieve sustainable manufacturing\textsuperscript{47}.

\textsuperscript{42} LLNL, 2021; LBNL, 2021
\textsuperscript{43} NREL, n.d.
\textsuperscript{44} The Guardian, 2023
\textsuperscript{45} WorldSkills UK, 2022
\textsuperscript{46} OECD, 2023
\textsuperscript{47} Make UK, 2021
There will also be a notable role of educational institutions when considering the sustainment and expansion of the skilled workforce for the industry. Southern California is home to 156 colleges and universities\(^{48}\), which include the University of California system, the California State University system, Community Colleges, and private universities. Community colleges and technical colleges play an often-understated role, by creating a robust avenue for developing specialized skill sets needed mostly in the production sphere of clean-tech. There is a need for equitable investment by the public sector to ensure that students can acquire the necessary skills and jobs upon graduation through a seamless process to encourage retaining academic talent within the region.

### 4. Quality of Living

Generally speaking, the quality of living in California, including within the Inland Empire, is quite high. As a logistics hub with room for growth, the Inland Empire provides pre-existing job opportunities to support a substantial middle class.\(^{49}\) The expansion of a southern California based clean-tech cluster into the area would only serve to provide more high-skill and high pay opportunities for residents.

Furthermore, the average cost of living is typically lower for the Inland Empire region than California as a whole. One of the great draws of California is access to nature. Short drives to soft sand beaches along one of the nation’s longest shorelines is a huge draw for young workforce professionals, and outdoor activities abound. The state is home to 9 national parks, 18 national forests, 5 national preserves, and 280 state parks—more than any other state in the union.\(^{50}\)

Southern California is also home to many artistic and cultural attractions. There are a wide range of galleries, museums, theaters, concert halls, amusement parks, sports stadiums, and world class culinary spots within driving distance to virtually any part of Southern California. Even areas in the more arid desert portions of the Inland Empire are within range of places like Palm Springs, which hosts its own artistic and culinary marvels.\(^{51}\)

One of the most important factors that add to this region’s overall quality of life is an environment of general diversity and community-centered norms. The area is a melting pot of different racial and ethnic backgrounds with a large Hispanic influence.\(^{52}\) Festivals and community events are commonplace among the many towns which dot the region and likewise add to a sense of shared purpose. All these points contribute to making the area a highly desirable place to live.

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\(^{48}\) CollegeSimply, 2023  
\(^{49}\) The Press-Enterprise, 2021; The San Bernardino Sun, 2023  
\(^{50}\) National Park Service, n.d.; California State Parks, n.d.  
\(^{51}\) Trip Advisor, n.d.  
\(^{52}\) U.S. Census Bureau, 2021
5. Housing

As mentioned, a clean-tech cluster requires highly skilled professionals, researchers, and entrepreneurs to innovate, develop and implement sustainable technologies. Housing availability is a key factor in attracting and retaining this talent pool. Without adequate housing options, the talent pool may look for opportunities elsewhere.

The Inland Empire has a strong stock of affordable housing options, compared to the rest of California. Data from the California Association of Realtors indicates that over the last decade, Riverside and San Bernardino scores significantly higher on the housing affordability index compared to California overall. In Q4 2022, San Bernardino scored 29% on the Housing Affordability Index, with a median home price of $475,000 compared to 17% Housing Affordability Index and median home prices of $822,320 for California overall.

![Percentage of Households Able to Afford Entry-Level Single-Family Home in San Bernardino County, Neighboring Counties, and California, 2011-2020](image)

**Fig: Percentage of Households Able to Afford Entry-Level Single-Family Home in San Bernardino County, Neighboring Counties, and California, 2011-2020.**

Note: Data are from the first quarter of the years presented.

While the housing stock in the overall SCAG region has slowed from 7% between 2000-2010 to 5% between 2010-2020, there is enough housing stock at present to keep housing costs within an affordable range.

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53 California Association of Realtors, 2023
54 California Department of Housing and Community Development, 2023
6. Incubators and Collaborative Organizations

Appendix C discusses in more detail the importance of incubators and similar collaborative organizations in forming a cluster economy.

In California, the non-profit called the **New Energy Nexus** provides a range of services to clean energy entrepreneurs, including funding, mentorship, networking opportunities, and access to resources and expertise.

The **Center for Environmental Research and Technology (CE-CERT)** is a research center at the University of California, Riverside that focuses on environmental research, technology development, and policy analysis. The center was established in 1991 and has since become a leading research institution in the areas of air quality, energy, transportation, and climate change.  

The **Los Angeles Cleantech Incubator (LACI)** is a non-profit organization based in Los Angeles, California, which accelerates the development of cleantech startups and provides entrepreneurs with the resources, mentorship, and networking opportunities they need to succeed. In partnership with the LA’s exceptional educational and research organizations – UCLA, USC, Caltech, and Jet Propulsion Laboratory – LACI helps accelerate the commercialization of clean-technologies in addition to accelerating new products developed by independent entrepreneurs.

7. Venture Capital

As of September 2021, the state of venture funding in clean-tech was showing signs of recovery after a slowdown that began around 2012. According to a report by the National Venture Capital Association (NVCA) and PitchBook, venture capital investments in clean-tech companies in the US reached $87.6 billion in 2022, an 89% increase from 2021. Clean tech companies in Southern California have received special attention from the VC ecosystem: In 2021, Pitchbook tracked over $6.4 billion in Southern California climate tech deals, increasing twice as much as in 2020.

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55 UC Riverside, n.d.  
56 Center for Environmental Research and Technology, 2022  
57 Pitchbook, 2022  
58 Dot.LA, 2022
$70.1B of Climate Tech Venture Funding for 2022, up 89% on 2021. Expect 2023 to moderate, but still exceed 2021 investment levels.

Global Climate Tech Venture Capital Funding, 2010 - 2022 in USD Billions

Venture capital serves both as a catalyst for entrepreneurial activity and a barometer of it. Early-stage investments made by venture capitalists, or VCs, allow them to profit from promising companies before they generate revenue. VCs seek out start-ups that have the potential to revolutionize industries or create new ones, making them a valuable source of information for other investors and corporate decision-makers seeking the next big thing.

VCs invest in portfolio companies at low valuations and work with them to promote growth and success. Typically, VCs aim to exit their investments in three to eight years, hoping to earn returns that are 5 to 20 times higher than their initial investment. While most venture-backed start-ups fail or break even, investors stand to gain significant returns when a company becomes successful.

By investing in risky start-ups that may not attract institutional investors or bank loans, VCs help spur the growth of new industries and companies that might otherwise struggle to secure funding. They play a vital role in helping clean-tech start-ups navigate the challenging second and third “valleys of death” of the demonstration and commercialization phases, and by providing industry-specific expertise and management, they can guide start-ups towards substantial growth.

The below SoCal based funds are investing in various areas and stages of climate-tech, ranging from energy and infrastructure to fintech and government:

HolonIQ. Global Impact Intelligence, 2022
Elevations Ventures, 2022

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59 HoloniQ. Global Impact Intelligence, 2022
60 Elevations Ventures, 2022
<table>
<thead>
<tr>
<th>Venture Fund</th>
<th>Fund Investment Focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fifth Wall Ventures</td>
<td>Climate Tech, Real Estate Tech, Retail</td>
</tr>
<tr>
<td>Blue Bear Capital</td>
<td>Energy, Infrastructure, Climate</td>
</tr>
<tr>
<td>Elevation Ventures</td>
<td>Sustainability</td>
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<tr>
<td>Angeleno Group</td>
<td>Clean Energy, Climate, Infrastructure</td>
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<td>Overture VC</td>
<td>Climate and Government</td>
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<td>2045</td>
<td>Climate-Tech</td>
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<tr>
<td>Keiki Capital</td>
<td>Decarbonization, Adaptation, Climate Fintech</td>
</tr>
<tr>
<td>Full Cycle</td>
<td>Climate Infrastructure Technology</td>
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According to Pitchbook, the most active VC investors in the startup data set by deal count in 2022 include Kleiner Perkins, Tao Capital Partners, Mission Ventures, GM Ventures, and Fidelity; none of which are based locally in Southern California but do have investments in the region.

8. Existing Startups
Southern California has a thriving ecosystem of established and new startups. Collaboration and innovation require a critical mass of startups to form a cluster. The presence of existing startups provides both an incentive for VC firms, other startups, and workers to move to the region, further accelerating cluster growth. Appendix D includes 5 examples of promising startups based in Southern California.

9. State and Federal Programs
The government of California and the federal government have served as prominent supporters of environmental sustainability and innovation in the United States.

State Programs
A variety of state programs and initiatives have been presented throughout the years that closely relate to the establishment and expansion of the clean-technology industry within California. Some examples are the Building Initiative for Low-Emissions Development, California Automated Permit Processing Program - CalAPP, California Electric Homes Program (CalEHP), Desert Renewable Energy
Conservation Plan, and the Renewable Energy for Agriculture Program. These programs directly attract clean-tech investors. More specifically, these directives and incentives help create an environment through which investors feel confident that the government is fully vested in the industry’s growth. Demand created through government policies creates markets for the industry and is crucial in generating further investment.

We have identified additional state funding opportunities through our interviews with the Governor’s Office for Business and Economic Development, where we learnt about various budgetary initiatives within this field, including $20 million for the expansion of Innovation Hubs in California, $245 million for workforce development, $6 billion for the growth of broadband infrastructure, $6.1 billion to subsidize the development and production of Zero Emission Vehicles and $500 million for the Climate Innovation Program through the Energy Commission which provides incentives geared towards achieving California’s ambitious climate goals.  

National Programs
The federal government plays an integral role in providing financial support and adopting national policy initiatives throughout the country. According to our interview with Trelynd Bradley, several federal initiatives have been identified with the potential for establishing a cluster. Some of these incentives include $20M through the Department of Energy (DOE) for new solar manufacturing projects that support domestic supply chains of critical materials, $40M through DOE for Wind Energy Tech Recycling Research and Development, and $10M through DOE prizes to projects for recycling of lithium-ion batteries.

10. Infrastructure and Utilities

The rapid growth that the Southern California region has witnessed throughout the past decades has helped establish many of the necessary foundations needed for the clean-tech cluster. Infrastructure and utilities play a valuable role. The elements that stand out the most are the transportation, energy, water management, and waste management infrastructures.

A study conducted by the Legislative Analyst Office of California (LAO) on the state's transportation infrastructure indicates that California witnessed a decrease in transit ridership as car ownership increased. The study also indicates that there is a direct relationship between gas prices and the public demand for public transportation, which fluctuates depending on the prices of gas.

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61 The Governor’s Office of Business and Economic Development (GO-Biz), n.d.
62 Legislative Analyst’s Office, 2018
63 Golaszewski, Paul, and Tom Van Heeke. “California’s Transportation System.”
Recent estimates indicate that the state operates an extensive network of highways and local streets and roads, consisting of almost 400,000 lane-miles of pavement and over 25,000 bridges, many of which are in Southern California and connect the region to its northern and southern counterparts. In addition to that, the Southern California region is home to tens of airports, which provide a unique access network within an hour’s travel of each other.\textsuperscript{64}

In our interview with former Governor Deval Patrick of Massachusetts, he emphasized how air transportation and access to private jet terminals give a region an edge when recruiting investors to form economic clusters. He mentioned that the proximity of Boston Logan Airport served as an unexpected attraction for investors in Boston, who were looking for easy travel access.

Southern California’s unique access to ports adds to its production, import, and export capacity. Sea ports such as Long Beach and Los Angeles Ports serve as important nexus points for trade, and newly formed logistics hubs closer to the Salton Sea would help in interstate trade and mobility of goods.

To understand the governing structure of the transportation outlay, an LAO report outlines that “there are two main types of regional transportation governing bodies that perform planning activities. First, the state has 18 Metropolitan Planning Organizations (MPOs) that are federally required planning bodies for every urbanized area in the state with a population over 50,000. These MPOs are comprised of representatives from local governments and transportation authorities in the designated area”.\textsuperscript{65} It is clear that the complex nature of governance poses a hurdle to infrastructure development. It is integral for the governing bodies to streamline processes of conducting new transportation projects to ensure efficient and rapid response.

Finally, the region has been a pioneer in renewable energy generation, with ambitious goals to transition to 100% clean energy by 2045.\textsuperscript{66} The clean-tech cluster would benefit from Southern California’s existing energy infrastructure, while also stimulating further investment in the sector. Opportunities include: expanding solar and wind energy generation, storage, and grid integration; developing innovative clean energy solutions, such as microgrids, energy storage, and smart grid technologies.

Overall, Southern California’s existing infrastructure and utilities provide a solid foundation for the establishment of a cleantech economic cluster. By investing in green transportation, renewable energy, efficient water management, and innovative waste management solutions, the region can support sustainable economic growth, create new jobs, and address environmental challenges.

\textsuperscript{64} California Maps, n.d.
\textsuperscript{65} Golaszewski, Paul, and Tom Van Heeke. “California’s Transportation System.”
\textsuperscript{66} California Energy Commission, n.d.
Section 2: Challenges for a Clean-Tech Cluster in California

1. Local Government Coordination

In this segment, we analyze the local and state government coordination potential and hurdles. It has been evident from the conducted research that the Southern California region still faces significant challenges in coordinating and aligning efforts of various levels of government to fully capitalize on the potential of a clean-tech cluster.

One issue that stood out to us was the challenge of regulatory fragmentation within jurisdictions. During our interview with Tina Andolina from Senator Ben Allen’s Office and Trelynd Bradley from the Governor’s Office for Business and Economic Development, both industry experts highlighted the significant hurdles that the local governments (cities) pose regarding zoning limitations and the fragmentation of regulations across these jurisdictions.

Southern California is home to numerous cities, each with its own unique regulatory environment, making it difficult to establish a unified approach to economic development. This fragmentation can hinder the efficient allocation of resources, slow down decision-making, and impede collaboration between different government agencies. In the fast-paced clean-tech industry that aims to maximize profit, efficiency, and expedited processing, such regulatory measures create significant hurdles in terms of navigating through city regulations to ensure adequate compliance. The current fragmented system also hinders the interconnectivity of industries, impacting operations and limiting the fluidity of collaboration.

Furthermore, the analysis highlights that there is a clear inconsistency of policies and priorities for each of the government entities that serve the region. For example, while we observe that the Los Angeles region has excelled in capital and workforce development, the San Bernardino region falls short in these two categories. The policies adopted in each region do not align based on their needs, and this creates an evident inconsistency that fosters a challenging environment. Another example is that state-level policies that prioritize job creation and economic growth conflict with local governments goals on environmental conservation or addressing social inequalities. Again, this lack of alignment can make it difficult for clean-tech clusters to thrive and grow in the region.
Further challenges include the competition between localities and insufficient communication and information-sharing. Competition is the most prevalent in localities with significant financial capacity. This competition can create a zero-sum game where a city's gain is another's loss, leading to a suboptimal outcome for the region overall. Moreover, this rivalry can prevent local governments from cooperating and sharing best practices, ultimately hampering the development of economic clusters. As businesses explore options for place-based investments, the current competitive system would defeat the collaborative environment needed to foster the desired cluster.

Without efficient communication channels, different entities may work in silos and make decisions based on incomplete or outdated information, which has been evident as we spoke with the industry leaders who indicated that this had been a recurring issue and that they tend to lack information on the operations of localities and their desired strategies.

2. Lack of Capital

While venture capital funds are often cited as key to the success of clean-tech firms, studies addressing the clean-tech boom and bust in the early 2000s, often termed Cleantech 1.0, offer multiple explanations for venture capitals’ historic poor performance in cleantech and particularly in clean energy start-ups.

1. **Long timelines to Reap Rewards**: Developing new clean energy technologies is capital-intensive and slow to scale, resulting in unattractively long payback periods. Meanwhile, the average fund life is roughly 10 years.

2. **Low Returns**: Numerous start-ups in the clean energy industry operate in fiercely competitive markets with slim profit margins, posing a challenge to achieve the substantial returns that VCs aim for. Additionally, many of these start-ups provide a product, such as renewable energy, that is challenging to distinguish from the energy generated by non-renewable sources.

3. **Significant risks**: Clean tech firms may not be attractive to VCs during the research and prototype development stages due to the low success rate in the demonstration and commercialization phases for the technologies.

4. **High barriers to entry in each technology’s niche market**

5. **International and Policy Volatility**: Investing in cleantech start-ups comes with extra risks as their production of a commodity is subject to the volatility of international markets and reliant on potentially unstable public policies.

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67 Hargadon and Kenney, 2012  
68 Nanda et al., 2015  
69 Migendt et al., 2017  
70 Maxwell School, 2022  
71 Noailly et al., 2022
As a result, clean-tech companies are often forced to sell out, or investors backed out too early for financial gain to be realized. While strong demand for clean-tech, public policy, global appetite, etc. are driving investment in clean-tech, it will be important to address these issues moving forward for sustained cluster growth.

In addition, there are three other important factors to consider:

1. **SPACs**: A significant portion of the increase in investment in climate technology during 2021 can be credited to a small number of major deals that were facilitated through special purpose acquisition companies (SPACs). Although SPACs have played a crucial role in enhancing liquidity for clean-tech companies, their continued significance as a source of investment in the medium term is uncertain. As per PwC, the funding obtained by clean-tech through SPACs has declined from its peak of US$9.3 billion in Q3 2021 to just US$800 million one year later.\(^2\)

2. **High interest rates**: The Fed’s interest rate hikes in response to the record inflation from 2022 onwards has been termed the “end of cheap money”. The impact of clean-tech funding is yet to be assessed.

3. **Misaligned funding and emissions reduction**: According to a PwC report in Q4 2022, VC investment in cleantech is still not aligned with carbon impact, reflecting an inefficient market for investing in climate outcomes.\(^3\)

### 3. Natural Resources

#### Mineral Resource Challenges

One issue that must be considered is that the supply chains of critical minerals relevant to the manufacture of advanced technologies are still largely dominated by a handful of East Asian nations. The existence of some of these crucial elements within California is promising for the country, but the state cannot simply claim first rights over their sale. The state will have to pay competitive prices relative to the rest of the United States for domestic access to these commodities, and proximity to source is not likely to substantially reduce the cost of the finished product. This will also not be a viable replacement for many of the individual minerals absent in the deposits at Mountain Pass. Economic access to these materials, and state industrial policy, needs to be continually monitored and amended in relation to rapidly changing federal trade policies concerning critical minerals.

Additionally, more common but essential elements like copper and nickel are not found in economically recoverable deposits within California. They are found elsewhere in the United States however and are

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\(^2\) PwC, 2022
\(^3\) PwC, 2022
thus subject to fewer supply chain constraints than other, rarer minerals. Ensuring robust supply chains to both domestic and foreign suppliers of these materials should be considered a challenge, even if a manageable one.

The state and industry will likely need to work together to perform an effective audit of indigenous mineral resources, and independently verify and protect its access to economically competitive sources of non-indigenous mineral resources.

**Geographic and Existing Asset Challenges**

The state has tapped most of its hydroelectric potential and more frequent climate change-fueled droughts and floods make its load capacity uncertain. There may be opportunities for efficiency improvements—as was done, for instance, on the Oroville dam in the 20-aughts—however, this is unlikely to greatly augment the existing 11GW capacity of California’s Hydro capacity.

Offshore wind farms are starting to appear more commonplace, but California has to contend with challenges of asset placement in deep water, avoid greatly disrupting wildlife, and prevent wind farms from becoming a visual malady for local residents who value their shoreline views very highly. It will also be an immense infrastructural challenge to build undersea transmission capabilities for offshore wind, especially when spread across such a large area of coastline.

Solar and onshore wind placement will have to compete with interests of natural protected zones. For instance, Mojave National Preserve covers a wide swathe of potentially valuable land for solar generation but has protections which limit its use for commercial activities. Fortunately, there is still plenty of available land within the same vicinity, but the underdevelopment of infrastructure like transmission lines, road, and utilities access, makes it difficult to expand the projects to new areas quickly.

**4. High cost of living**

Southern California is known for its high cost of living, driven by factors such as expensive housing, transportation, and overall living expenses which makes the living standards high to attain for average-paid workers. This also poses a significant challenge for establishing an economic cluster, particularly in the clean-tech sector in which a variety of industrial operations look to minimize expenses. This analysis evaluates the implications of the high cost of living on such a cluster and offers potential considerations to address these challenges.

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74 Bolstad, 2021
75 Hydro Review; U.S. Energy Information Administration, "Historical State Data", n.d.
It has been indicated through various studies and analyzes that housing affordability serves as the number one biggest hurdle to affordable housing in Southern California. The current housing outlook and analysis of the market have provided staggering statistics showing that the average household within the region hovers around $790,00 with a minimum income of $201,200 needed to make a monthly payment for a fixed rate mortgage of 6.8%.\textsuperscript{76}

There are several specific factors that contribute to the housing affordability crisis outlined above, such as the limited housing supply. Due to restrictive land-use regulations, such as zoning restrictions and growth controls, housing construction has not kept pace with demand, leading to a limited supply of available housing units.\textsuperscript{77} The constrained supply results in increased competition for housing, driving up prices and rents\textsuperscript{78}.

In addition to that, throughout the past couple of years, and especially following the production and trade shortages that became imposed by the COVID-19 pandemic which have resulted in construction material shortages, it has become further evident that the cost of construction in Southern California has increased due to factors such as labor shortages, rising material prices, and regulatory compliance costs. Higher construction costs translate into higher prices for new housing developments, exacerbating affordability issues \textsuperscript{79}. These increased costs are a burden that investors take into consideration as they have a direct impact on the costs of operation and profitability. The government has been making efforts to remedy such high costs by providing subsidies in various forms, but with that being said, governmental support has not been able to keep up with the rapidly rising prices in a manner that would sustain the presence and growth of new investors within the region.

Southern California brings through its spectacular weather, access to beaches, high-performing educational institutions, and various other factors that increase the demand to live in California; we have also seen that this has resulted in increased land costs. More specifically, Southern California's land cost has risen considerably due to high demand and limited availability.\textsuperscript{80} Developers must often pay premium prices for land, which are then passed on to homebuyers and renters, contributing to the high cost of housing, as highlighted by ULI in their comprehensive report.\textsuperscript{81} The increased cost of land, limited amount of lots available to buy and develop, and presence of large companies within the region present themselves as a hurdle in supporting small businesses to thrive within the region. Not only that, but in areas like Los Angeles, Orange County, and parts of San Bernardino County, we see that the limitation of land also creates a challenging dynamic for the establishment of a cluster as there is evident need for land rezoning which is a clear bureaucratic hurdle experienced within the region and that drives the high

\textsuperscript{76} California Listings, n.d.  
\textsuperscript{77} California Legislative Analyst's Office, 2015  
\textsuperscript{78} LAO, 2015  
\textsuperscript{79} Turner & Townsend, 2020  
\textsuperscript{80} Urban Land Institute, 2020  
\textsuperscript{81} ULI Americas, 2022
living costs as affordable housing supplies are limited. A recent study conducted by SoFi indicates that California in general stands as the fourth most expensive state in the country to live in with an average cost of living of $53,082 in 2022.82

5. Environmental Regulations

Environmental Regulations are vital to public and environmental safety. However, they may inadvertently pose a hurdle for the creation of a cleantech cluster base in California. Navigating regulations takes time and often expensive legal expertise. Making compliance more transparent should certainly be a goal, and provisions within each regulation should have their benefits weighed against overall benefit toward the clean-tech economy, since some environmental benefits of clean-tech manufacturing and deployment may not have immediate, local offsets. We outline here some of the regulations relevant to industry players.

The issue can be typified by two main buckets: regulations that affect manufacturing and processing, and regulations that affect asset placement. Both endeavors face many shared hurdles, but also face unique challenges. I will outline the regulations that are shared, and those which are not.

Shared Challenges

**CEQA (California Environmental Quality Act)**
- Requires that environmental impacts be addressed prior to groundbreaking and allows for legal challenges from local stakeholders.
- Requires that any large project or development present a list of alternative projects for consideration.
- Maintains environmental and species impact standards that go beyond some federal regulations.
- Contains many points that business may find difficult to navigate, ultimately costing time and allowing for the possibility of significant delays.

**CEC-Specific Regulations (California Energy Commission)**
- Oversees the permitting process for energy projects in the state and requires compliance with additional state standards, for instance, with the Renewable Portfolio Standard.
- Proof of compliance can become a legal and financial hurdle for some because it requires specific knowledge and expertise to navigate.

**ESA (Endangered Species Act)**
- Federal mandate which requires environmental assessment and overall compliance with preventative measures to reduce impact on endangered or critical species. This can include

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82 SoFi, 2022
regulations on damage to local habitats that affect species in ways typically unforeseen by simple inspection.

NEPA (National Environmental Policy Act)
- Federal standards and compliance measures that apply to any environmental damage ranging from chemical spills to occupation of habitats, etc.

Manufacturing and Processing Challenges Only

HWCL (Hazardous Waste Control Law)
- As it sounds, the HWCL ensures the proper control of all hazardous substances and chemicals. It contains standards for storage and disposal.

RCRA-DTSC (Resource Conservation and Recovery Act—Department of Toxic Substances Control)
- Contains additional requirements for the procurement and handling of all hazardous waste which may be of relevance to issues of energy storage technologies or solar panel manufacture and recycling.

Asset Placement Challenges Only

FLPMA (Federal Land Policy Management Act)
- Dictates the requirements and exceptions for placement of industrial assets on federal land. This can pose a hurdle, for example, to the placement of offshore wind energy with respect to protected marine zones, or for solar or onshore wind placement in federally regulated park, forest, or preserve lands.

CPUC (California Public Utilities Commission)
- Regulates and oversees crucial points for energy developers, such as utility rates, and requisite infrastructure investments.
- Large utilities tend to be helped by CPUC to reduce costs, but thus present a barrier to market hurdle for potential new players.

6. Natural Disasters

Quantifying the Risk of Flooding and Forest Fires in the Inland Empire
A major challenge for the Inland Empire is its vulnerability to natural disasters, in particular, floods and forest fires. We compiled data from the First Street Foundation Risk Factor Platform to identify residential and commercial properties and critical infrastructure (hospitals, police stations, fire stations, power
plants, communications infrastructure, etc.) that were at risk from floods and forest fires. We then calculated the percentage of these units that were in moderate risk from floods and severe risk from forest fires.

<table>
<thead>
<tr>
<th>Region</th>
<th>Flood Risk</th>
<th>Forest Fire Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% of Residential Properties at Moderate Risk</td>
<td>% of Commercial Properties at Moderate Risk</td>
</tr>
<tr>
<td>LA County</td>
<td>25.2%</td>
<td>36.9%</td>
</tr>
<tr>
<td>Orange County</td>
<td>21.2%</td>
<td>33.0%</td>
</tr>
<tr>
<td>Riverside County</td>
<td>19.7%</td>
<td>27.6%</td>
</tr>
<tr>
<td>San Bernardino County</td>
<td>15.4%</td>
<td>27.2%</td>
</tr>
<tr>
<td>Inland Empire Combined</td>
<td>23.2%</td>
<td>35.0%</td>
</tr>
</tbody>
</table>

Fig: Flood and forest fire risk in select counties in Southern California

Flood Risk
Overall, we found that the Inland Empire is at moderate risk from flooding over the next 30 years, which means flooding is likely to impact day-to-day life within the community. In addition to damage on properties, flooding can also cut off access to utilities, emergency services, transportation, and may impact the overall economic well-being of an area.

Forest Fire Risk
Overall, we found that the Inland Empire is at severe risk from forest fire over the next 30 years, which means forest fires are also very likely to impact day-to-day life within the community. In addition to damaging properties, wildfires can also cut off access to utilities, emergency services, impact evacuation routes, and severely impact the overall economic well-being of an area.

Adaptation Measures
The Southern California Climate Adaptation Planning Guide (2020) lays out an ambitious adaptation plan for dealing with environmental hazards and adapting to changing conditions. Clean-tech businesses

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83 Risk Factor Platform, n.d.
84 SCAG, 2020
will need to invest in adaptation measures, insurance, and need to plan for disruptions in operations due to these disasters. In order to attract clean-tech industries, local government entities such as the Southern California Association of Governments (SCAG) will need to take a leadership role in aggressive adaptation measures.

7. Research Institution Limitations

Despite California’s abundance of advanced research institutions dedicated to clean-tech, the state faces challenges in using them to their fullest potential. Similarly, it underutilizes assets which could be dedicated to the broader clean-tech enterprise, but which are not yet in service to this effort.

First, there is a need for engagement with community colleges to build a moderate skill labor force of technicians and operators. Second, there is a need for expanded efforts within the current leading institutions to broaden the scope of their research, and additionally, to build up their programs to match potential demand driven by a clean-tech cluster initiative. Third, there is no dedicated national laboratory for clean-technology to build off of.

As a note on this, national laboratories have historically served as nexus points for innovative R&D and often help to spin out new commercially viable technologies. NREL’s current footprint in the state is likely too limited to fill such a gap and there are hurdles to overcome in order to import a more robust NREL presence. Similarly discouraging, the extant national labs in California do not have equally robust programs dedicated to clean-tech. Their missions are driven largely by other pursuits in the physical sciences and would have to be amended, or added to, in order to pick up that slack. While a national laboratory is by no means a necessity for the successful development of a clean-tech cluster, their presence or absence is worthy of thoughtful consideration.

Other challenges exist, too. There is competition for talent within the pool of potential workforce candidates, and many may be drawn to the premier institutions located in other parts of the United States, or even to Northern California, away from the Inland Empire. The same thing can be said specifically about research faculty. Because institutional resources and prestige influence faculty recruitment, there is a need to increase the public prominence of the southern California region as a major player in the national and global clean-tech endeavor.

Further challenges arise for these institutions when having to deal with the large and complex regulatory frameworks that come along with federal and state research initiatives. Program requirements and grant applications can become quite burdensome, and while acting as an import check-and-balance, often hamstring new projects in the pipeline when trying to get started. Most universities have offices and organizations dedicated to helping research faculty navigate these policy and regulatory hurdles, but this results in both financial and temporal expenditures for the institutions.
Moreover, few of California’s institutional resources will reach their full potential if connections to market are limited or weak. Industry collaboration is key—this is true in two main respects.

First, there is a need to facilitate collaboration between larger companies and laboratories. Most large corporations are disincentivized to build research facilities from the ground up, because they involve large barrier costs and are typically only dedicated to single-use problem solving. Universities are often suited for fundamental research because they already have laboratories that are amenable to change, can host new laboratory equipment, and overall provide a large, fluid market for corporations to shop around in. By farming out fundamental research, companies save a good deal of time and effort. However, there are frictions on crucial topics like intellectual property transfer, institutional governance, and grant-contract negotiations. Most research universities have created offices of industry collaboration, but they often handle a huge flow of grants and contracts. In order to help increase the overall velocity of innovation, the state may wish to look at ways of lubricating these processes to decrease friction.

Second, there is a challenge to facilitate spin-offs and start-ups from within research institutions. Research faculty must be permitted by their institutions governance structure to pursue innovative small business endeavors, and costs to the startup must not be prohibitively high. Many Universities claim large portions of intellectual property rights to spin-off innovations from their laboratories, but this, in turn, disincentivizes the creation of institutionally linked startups. Further, there is a challenge in connecting these small businesses to venture capital. Research universities may need to consider new and creative ways of facilitating connections between their own researchers and VC firms. Some possible ideas to address this pitfall are to create additional conferences, consortia, and industry groups that connect all the relevant players, in order to build contacts among them.

Aside from the industry-oriented efforts listed above, additional challenges exist to both inter-institutional and intra-institutional collaboration. Because universities and labs work on many interrelated topics, it is inherently beneficial to connect researchers who may work constructively together. Because the UC system is so large, there are undoubtedly times when knowing what is going on across all ten campuses is difficult. While the UC system has created initiatives to connect solar research and campus sustainability across the greater organization, further efforts to synchronize inter-institutional efforts may be warranted. Similarly, there are often barriers across departments within research institutions—this presents the hurdle of intra-institutional collaboration. In order to help foster greater concerted efforts on clean-technology research projects, connections need to be made between, for instance, mechanical, systems, materials, and environmental engineering departments. Local institutional administrators can encourage this by making campus research initiatives more widely known, and positively shape their university policies to encourage official projects across departments and disciplines.
8. Keeping Businesses Within the Cluster

Finding creative ways to encourage the retention of businesses, both large and small, to plant deep roots within a Southern California cluster will have its challenges. Keeping startups around will be one part of this task, convincing large businesses to stay and build out manufacturing plants and corporate campuses will be another. At each scale, different factors may draw businesses away. Even after they have found their footing within the Southern California area, industry pressures can uproot companies and convince them to move elsewhere. To ensure longevity of the clean-tech hub, there needs to be a set of forcing functions which help to keep key players local.

One of the biggest obstacles that will arise is poaching. Spin-offs and startups coming out of incubators or research institutions within the cluster may be enticed by favorable terms of sale to larger corporations headquartered elsewhere. To prevent this from happening there may need to be real consideration of conditional assistance programs that would obligate recipients of state aid to keep portions of their business local upon scale up, or face penalties.

Additional concerns arise from the draw of externally located venture capital firms. Many small businesses can be convinced to move closer to their primary investors. Since there is generally greater access to capital and investment in urban areas, and particularly in other regions of the state, finding ways to ferment greater local access to venture capital or convince small businesses to stay will be a necessary challenge to confront.

Similar to the issues of keeping small companies in place, is the issue of keeping large corporations from supplanting themselves to other areas. This will require the assurance of stable supply chains and industrial utilities, local supply of the requisite workforce, and favorable regulatory environment.

One of the necessary components to this effort will be to create incentives that ensure business leaders feel a sense of local pride and investment in the affairs of the local community, both personally and professionally. There need to be mechanisms that create a sense of shared purpose that convinces businesses to stay, by ensuring that local individuals hold sway within companies and industry organizations, and likewise, that organizational leaders hold sway within local affairs. Only when companies feel truly invested in the welfare of the community, will they be rooted deeply, this requires making sure business leaders feel “at home” within the cluster.
## Key Takeaways for the Analysis

<table>
<thead>
<tr>
<th>Key Opportunities</th>
<th>Key Takeaways</th>
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</table>
| **Natural Resources** | ● Wealth of viable geographies for cleantech asset placement.  
  ○ Sunlit zones for solar, windswept valleys, offshore wind capacity, geologic features for energy storage.  
  ● Local or regional access to valuable mineral supplies.  
  ○ Lithium, Boron, Gold, Light Rare Earths, etc.  
  ● Existing solar, wind, hydro, nuclear plants suitable for efficiency upgrades and expansion.  
  ● Ports, airports, transitways suitable for upgrades or clean-tech pilot deployments |
| **Research Institutions** | ● Full University of California system with 9 campuses and Cal. State system with 23 campuses, with many focusing on various aspects of R&D.  
  ● Other leading non-state schools with focus on research and development of cleantech.  
  ○ Dozens of university research initiatives dedicated towards clean and renew energy tech.  
  ○ Extant universities offices for tech transfer and industry collaboration.  
  ● Cooperation with NREL on deployment and asset management in several parts of the start.  
  ● Home to several national or federal laboratories with work on clean-tech or climate including JPL, LLNL, and LBNL. |
| **Workforce and Training** | ● A highly-trained workforce with agile skillsets is needed for the establishment of a cleantech cluster in Southern California.  
  ● Green skills are becoming increasingly desirable in the technology industry, particularly in aspects of construction, manufacturing, and energy.  
  ● The gap in green skills is related to employers' ability to meet net-zero targets and transition to a clean economy.  
  ● Equal investment by the public sector is needed to ensure that |
Educational services provide the necessary skills and jobs for graduates and encourage retaining academic talent within the region.

- Surveys conducted among industry leaders indicate that there is a gap in green skills, which is hindering the transition to a clean economy and meeting net-zero targets.
- The University of California system has a unique edge in research and development, while community colleges and technical colleges provide specialized skill sets necessary for production lines in the clean-technology industry.

### Quality of Living
- World renowned natural beauty and recreation.
  - 9 National Parks, 280 State Parks, National Forest Lands and Preserves.
  - Hundreds of miles of beaches and scenic coastline.
- Easy access to quality arts and cultural attractions.
- Generally high wages, adequate infrastructure, and employment opportunities within the state and Inland Empire region.
- Notable diversity and strong sense of community fostered through local events and organizations.

### Housing
- Notable diversity and strong sense of community fostered through local events and organizations.

### Incubators and Collaborative Organizations
Southern California has access to great incubators and collaborative organizations for clean-tech entrepreneurs:
- The New Energy Nexus
- The Center for Environmental Research and Technology (CE-CERT)
- The Los Angeles Cleantech Incubator (LACI)

### Venture Capital Funding
Southern California has access to billions of dollars in venture funding, with a large number of active VCs.

### Existing Startups
Southern California has a thriving clean-tech startup scene, which can seed an industry cluster.

### State and Federal Programs (Tax Incentives)
- The government of California and the federal government are strong supporters of environmental sustainability and innovation, playing a significant role in the growth of the cleantech industry.
- Government policies and incentives create a favorable environment for investment, contributing to the development of cleantech clusters.
California's state funding initiatives include $20 million for Innovation Hubs, $245 million for workforce development, $6 billion for broadband infrastructure, $6.1 billion for Zero Emission Vehicles, and $500 million for the Climate Innovation Program.

**Infrastructure and Utilities**

- Southern California's rapid growth has laid the foundation for a cleantech cluster, with notable infrastructure components including transportation, energy, water management, and waste management.
- The region's transportation infrastructure is extensive, featuring highways, local streets, bridges, airports, and seaports, which promote investment in urban, suburban, and rural areas.
- Southern California has a diverse energy mix with natural gas, nuclear, and renewable energy sources, aiming to achieve 100% clean energy by 2045.
- The region has the potential for 34 of the initial 35 critical minerals listed by the U.S. Geological Survey, which is driven by ambitious climate goals such as 100% zero-emission vehicle sales by 2035.
- The complex nature of governance in transportation planning may pose challenges to further development, highlighting the need for streamlined processes and rapid responses.
- Investment in green transportation, renewable energy, efficient water management, and innovative waste management will support sustainable economic growth, job creation, and environmental problem-solving in Southern California. The cleantech cluster could serve as a model for other regions pursuing sustainable development.

<table>
<thead>
<tr>
<th>Key Challenges</th>
<th>Key Takeaways</th>
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<tbody>
<tr>
<td>Local Government Coordination</td>
<td>Southern California faces significant challenges in coordinating and aligning efforts for various levels of government to fully capitalize on the potential of establishing new businesses that would serve the economic cluster.</td>
</tr>
<tr>
<td></td>
<td>The challenge of regulatory fragmentation within jurisdictions is a significant hurdle to establishing a unified approach to economic development. The fragmentation can hinder the efficient allocation of resources, slow the decision-making process, and impede collaboration between different government agencies.</td>
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<tr>
<td></td>
<td>There is a clear inconsistency of policies and priorities for each of the</td>
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government entities that serve the region.
- Competition between localities and insufficient communication and information sharing create barriers to coordination and lead to independent work within localities.

<table>
<thead>
<tr>
<th>Natural Resource Limitations</th>
<th>VC firms faces the following challenges:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Critical mineral supply chains are still contingent on other nations and associated federal policy. California and regional mining and processing are not adequate.</td>
</tr>
<tr>
<td></td>
<td>• The state has tapped most of its available hydro resources and existing resources are increasingly irregular due to climate change.</td>
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<td></td>
<td>• Regulations constrain geographic asset placement in federal or state preserved lands, limiting viability in key areas.</td>
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<td></td>
<td>• Limited capacity for efficiency improvements to existing assets and infrastructure.</td>
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<tr>
<th>Lack of capital</th>
<th>VC firms faces the following challenges:</th>
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<tbody>
<tr>
<td></td>
<td>• Long timelines to Reap Rewards: New clean energy technologies are capital-intensive and slow to scale, with long payback periods</td>
</tr>
<tr>
<td></td>
<td>• Low Returns: Fiercely competitive markets with slim profit margins, pose a challenge to achieve the substantial returns that VCs aim for.</td>
</tr>
<tr>
<td></td>
<td>• Significant risks: Low success rate in demonstrating and commercializing clean-tech technologies.</td>
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<td></td>
<td>• High barriers to entry in each technology’s niche market</td>
</tr>
<tr>
<td></td>
<td>• International and Policy Volatility: Clean tech is subject to the volatility of international markets and potentially unstable public policies.</td>
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<tr>
<th>High Cost of living</th>
<th>VC firms faces the following challenges:</th>
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<tbody>
<tr>
<td></td>
<td>• Southern California’s high cost of living, driven by expensive housing, transportation, and overall living expenses, poses a significant challenge for establishing an economic cluster, particularly in the clean-tech sector.</td>
</tr>
<tr>
<td></td>
<td>• Housing affordability is the number one biggest hurdle to affordable housing in Southern California, with limited housing supply and restrictive land-use regulations contributing to the affordability crisis.</td>
</tr>
<tr>
<td></td>
<td>• Higher construction costs due to labor shortages, rising material prices, and regulatory compliance costs exacerbate affordability issues.</td>
</tr>
<tr>
<td></td>
<td>• Increased land costs due to high demand and limited availability contribute to the high cost of housing, making it difficult for smaller businesses to thrive in the region.</td>
</tr>
</tbody>
</table>
|                     | • Government subsidies have not been able to keep up with the rapidly
rising prices in a manner that would sustain the presence and growth of new investors within the region.
- Land rezoning is a bureaucratic hurdle experienced within the region, limiting affordable housing supplies and hindering the establishment of a cluster.

| Environmental Regulations | Numerous regulations administered by both state and federal government require complicated compliance regimes for approval of development. This adds costs, requires expertise, and extends timelines for project development.  
- Lacks a centralized or streamlined management and liaison process that favors large business.  
- State regulations and permitting processes are generally more stringent than neighboring states. |

| Natural Disasters | The region has a moderate risk from flooding over the next 30 years.  
- The region is at severe risk from forest fire over the next 30 years.  
- Current adaptation measures against natural disasters are inadequate. |

| Research institute limitations | Absence of NREL campus or comprehensive cleantech branches of LLNL, LBNL.  
- Difficulty managing tech transfer and industry collaboration from university R&D laboratories.  
- Difficulties in connecting startups and spin offs with VC providers.  
- Lack of integration between research university efforts and technical training programs within the community college system.  
- Need for increased physical mobility and collaboration across the UC and CSU systems and between departments within individual university campuses. |

| Keeping startups in Southern California | There are concerns that poaching by large companies will pull small businesses out of the cluster.  
- It is a challenge to get business leaders invested in the welfare of local communities.  
- Stable supply chains and workforce pipelines are required to ensure operational and growth potential. |
Concluding Analysis

Overall, through our analysis, we came to three important conclusions. The first, is that California possesses substantial natural, political, economic, and human resources that lends itself well to building a clean-tech cluster. We therefore assert that the state, in concert with industry, financial, local, and institutional stakeholders can plausibly achieve ambitious growth goals that would make Southern California a world leader in clean-technology enterprise.

The second, is that California, and in particular Southern California, still faces large and complicated challenges to effectively completing this task. Much of the problem lies in streamlining processes, creating connections, and reducing friction among the existing bodies and regulatory processes that pertain to advanced industry and technology research.

Third, California will have to build collaborative networks within the state and ally itself with other states to build out efficient supply chains and allocation of resources effectively. California is only one of multiple regional players in the south-west, and it has both unique advantages and faces unique constraints. The state is endowed with substantial comparative advantage in research and development, and in high tech manufacturing. However, to claim added value most efficiently, it will likely have to cede responsibility on industries like hard manufacturing, industrial processing, and asset deployment to neighboring states.

Taken together, and supplied with sufficient political and financial capital, the conclusions can inform a combined effort across the clean-tech enterprise that is likely to yield positive results. Notably, it will be a special challenge to fix the geography of this hub-and-spoke model cluster within the Inland Empire and will thus require significant state intervention and local community efforts to attract and support research and development efforts. However, the Inland Empire has advantages that other areas simply do not, namely room to grow, natural beauty, diversity, and community involvement. By engaging stakeholders in a concerted manner, there is opportunity to expand regional involvement in the clean-tech sector by focusing on strengths in manufacturing, logistics, and natural resources. Further, proximity to large urban areas gives this area a real chance of becoming a profitable and booming corridor of industry and innovation.

While these goals are undoubtedly ambitious and will require collaboration of many stakeholders. The final section of this report will outline several key policy actions that the relevant stakeholder can pursue to achieve this ambitious goal.
Policy Recommendations

State Government

Make Intentions Known

- We recommend that the California state government make its intention to create a clean-tech hub as a public tagline similar to what was adopted in Massachusetts. The state should focus on a concerted effort to build up the regional brand for their clean-tech innovation cluster with public advertisements and directed efforts to inform and attract business and research leaders. This could be achieved by highlighting the demand generated through the government’s ambitious policies and its recent successes in fostering an inclusive economic environment for clean-tech.

- The state should designate a specific point person, either the Governor or Lieutenant Governor, to champion the cause and have them lead a newly formed directorate organization to manage this broad effort. The designation of a government leader guarantees buy-in and it attracts investors who see it as the government’s commitment in clean-tech.

Cooperate Across Borders

- The state of California should seek to avoid costly competition with neighboring states, and we recommend that CA instead works to determine comparative advantages in R&D, resource extraction, processing, manufacturing, and fabrication. Specifically, the state should foster close collaboration with Arizona and Nevada in a joint effort to bring clean-tech industry into the southwest region, under the premise that a rising tide will lift all boats. California can maximize its share of the clean-tech value chain by monopolizing the R&D segment of the supply chain. Another potential manufacturing partner would be Mexico, with which the state has been developing economic and trade ties throughout the past decades.

- California should consider opening up and increasing the ease of access to foreign export markets that can help clean-tech firms in Southern California gain access to overseas markets. This would further the income generated by the state, create opportunities for increased manufacturing, and guarantee a spillover benefit from carbon reduction efforts at the global scale.
**Boost and Streamline Funding**

- The State Government should seek to solve the “Early-Stage Funding Gap” through additional financial investments targeted at small businesses that are looking to scale up. Likewise, the state should consider providing loan and lease guarantees and direct project finance for crucial aspects of the clean-tech industry. This recommendation focuses more on loans than grants as it would ensure that the state sustains its available capital for further use, given the current financial instability that the country is going through. The loans provided would be based on benchmarks achieved by the awarded businesses. They would accommodate low-interest rates to help alleviate the lack of funding stemming from the low presence of venture capital within the region.

- Subsidies and tax breaks would play an instrumental role in incentivizing startups. For most early-stage start-ups, tax breaks would not be a critical aid, since most start-ups lose money during their first several years. Yet, for companies that are further along, targeted tax breaks can make a crucial difference. Thus we recommend the establishment of two tax incentives with one for early stage start-ups that serves more as a tax return for operating within the state, and another tax incentive in form of a tax break based on the contributed carbon reduction impact a firm has performed throughout the year for the further established businesses.

**Rethink Regulations and Supply Free Compliance Advice**

- California should reevaluate state-level environmental regulations and consider building exemptions into them for clean-tech industry development projects under the premise that these projects will contribute to positive ecological offsets globally. Likewise, it should consider ways to expedite regulatory processes for clean-tech companies. Revisiting CEQA to address its challenges in the business establishment through waivers would encourage investors to consider California as their headquarters for operation and development.

- We also recommend establishing regional one-stop shops for small and medium-sized businesses, through which companies could apply for premium processing that streamlines regulatory compliance and permitting needs. This shop would promote government efficiency and would serve as a liaison between businesses and the various governmental entities to alleviate the bureaucratic hurdles that current policies present.

**Monitor and Update Research Goals**

- As a subdivision of the state’s directorate office for clean-tech development, there should be a group of specialists that continually evaluate crucial areas of research vital to state economic and clean-tech goals, and direct granting agencies to give preference to those crucial technologies.
Expand Research Capabilities

- Because California lacks a dedicated government-driven renewable energy or clean-tech research laboratory. The state should thoughtfully consider the establishment of a totally new premier research center. Such a facility could either be created solely by the state, and thus remain a state operated institution, or alternatively, the state could seek to cooperate with the federal government to establish a full scale NREL campus, or new NREL-like national laboratory in the region. This would inherently create a substantive clean-tech footprint in whichever area it is placed.
- Small steps like increasing the number of state sponsored research internships and fellowships at California research institutions is also recommended. This will help enrich the quality of the skilled workforce, provide new opportunities for advancement, and pull in qualified applicants from out of state helping to bolster the overall cleantech research effort.

Local Government

Reevaluate and Streamline Regulations

- Local governments should reevaluate city and county-level environmental regulations to make them less burdensome for clean-tech developments. This effort should focus primarily on regional and county-wide zoning regulations, and require municipalities to comply with county-wide ordinances to help in easing the establishment of businesses, the entry of utility services into the companies promptly, and help expand the available re-purposed lands to address the increased price and lack of supply issues that the state currently encounters.

Generate the Local Workforce

- Local community colleges will need to become a wellspring for a future clean-tech workforce. Communities should build, advertise, and openly recruit students for vital technician development programs at community colleges and likewise work with new clean-tech businesses to create placement programs to help get trainees into permanent jobs. Partnership programs along with skill-based education that incorporates agility would ensure that the current workforce is also receiving necessary training across all counties to keep up with the advancing nature of the industry.

Improve Image–Attract Business

- Businesses are composed of individuals. To ensure the attraction and retention of clean-tech companies to the cluster, local communities should also focus on quality of living improvements and encourage the development of attractions and amenities to attract skilled labor.
• Branding the local community as a hub and desirable destination for clean-tech businesses and employees will also help attract and retain important stakeholders. Public relations efforts should be chaired by local government offices, and advertising budgets should include line items for promotional content.

• Like the state government, local governments should offer subsidies on items like property tax, that would actively incentivize businesses and which would help keep industry local.

Higher Learning and Research Institutions

Build On and Bolster Existing Programs

• The best way to build an advanced clean-tech economy is through sophisticated research and higher education programs. The UC and CSU systems and private California universities should expand student enrollment and educational programming capacity for educating scientists, engineers, and technicians in clean-tech fields. The focus on STEM fields is critical and scholarship funding can help remedy the high costs of education.

• We recommend focusing on skill-driven education, focusing on technical and soft skills, as current employers regard the educational system as different from their needs. MOUs between employers and universities can allow companies to review and advise on the school curricula to make sure they meet the needs of the job market.

• To bolster clean-tech advancement, it is vital to encourage the expansion of clean-tech research programs and hire more faculty whose specialties align with clean-technologies and climate research.

Link Efforts Between Campuses and Across Departments

• Inconnections drive innovation. The UC and CSU systems should create new initiatives that link research efforts between the UC and CSU systems, link campuses within the systems, and promote additional collaboration with other private research universities within the state.

• Attempts to connect research efforts within each campus are also needed to encourage the creation of on-campus initiatives to link research projects in different faculty departments to collaborate on clean-tech goals. Active promotion and advertisement of collaborative efforts should become a priority for each university.
• Both of the above endeavors can be aided by the creation of more consortia to help bridge connections between researchers and organizations. By bringing researchers together weekly and monthly to present research in a formal setting, new ideas can be borne out of discussion, helping to drive innovation. Creating more academic conferences can help generate connections between academic researchers, and provide openings for industry representatives to stay in tune with new R&D breakthroughs.

Help Researchers Connect to Market

• Research institutions should deemphasize time and publication requirements imposed on research faculty and encourage R&D on spin-off products using university laboratories.

• Most research institutions claim a large share of the intellectual property pie when products are spun out of their laboratories. Research institutions can stipulate smaller shares of overhead collection for spin-off intellectual property.

• Increased advising capacity on intellectual property law for researchers can also encourage them to create companies based on their work.

Venture Capital

Help VC’s Better Understand the Market

• Outreach efforts should target VCs to help them understand that clean-tech returns take place over a longer time horizon and adjust their funds accordingly. At this early stage of the cluster formation, we do not see the emergence of VC taking place rapidly, given the current hurdles and presence of VCs in the state's northern region. Thus, focused VC recruitment and connecting them directly with businesses should be a priority.

Inter-Organizational Efforts

Create New Connections

• Much of the work in building an innovation hub comes from the interconnection of industry, government, research institutions. There are several ways to encourage and promote greater cohesion and cooperation across sectoral boundaries. It is thus recommended that California work to build coworking spaces and startup incubators, encourage corporate investment into research institutions and small businesses, and conduct active and targeted industry outreach by
creating new events and facilities dedicated toward interconnectivity within the larger clean-tech community.

**Build Local Ties to Retain Business**

- Create industry advisory boards which mandate that participation be contingent on local interest and resident status so that industry advice is geared towards benefitting the cluster. This means actively choosing industry partners who live and work locally to advise the government, so that the government is more likely to adopt policies that help retain existing businesses. It should be noted that this carries a risk that advisory boards will avoid an influx of new competitors, which has to be mitigated.

**Create Greater Demand**

- There is no better way to incentivize industry than to create greater demand for clean-tech. Aggressive decarbonization policies across all sectors will help fuel the need for rapid clean-tech industry growth. So, expand cleantech and decarbonization goals, expand incentives for clean-tech customers, and ensure that state and local governments become bigger consumers of clean-tech.

**Promote Competition**

- Competition breeds innovation. Across all sectors, companies, governments, and research institutions can help kick start cutting edge research and clean-tech entrepreneurship through creative ideas like innovation prizes for researchers and small businesses that make outsize impact in the clean-tech field.

**Maintain Cluster Stability**

- All sectors need to maintain stable policies on clean-tech. In such a rapidly shifting industry environment, proper transparency and proper transition between policy regimes is vital for market and cluster stability.
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Appendix A: Organizations Providing Resources for Clean-tech Companies in Southern California

1. California Energy Commission: The California Energy Commission is the state's primary agency for energy policy and planning. They provide funding, research, and technical support for clean energy projects and programs throughout the state.

2. California Clean Energy Fund: The California Clean Energy Fund (CalCEF) is a nonprofit organization that invests in and supports clean energy startups and projects. They offer funding, mentorship, and networking opportunities to help entrepreneurs bring their ideas to market.

3. Clean Energy California: Clean Energy California is a program run by the California Public Utilities Commission that provides resources and information on clean energy programs and incentives for businesses and consumers in the state.

4. California Climate Investments: California Climate Investments is a program that invests in clean energy and climate-related projects throughout the state. The program is funded by the state's cap-and-trade program and provides funding for a variety of clean-tech projects, including renewable energy, energy efficiency, and transportation.

5. California Green Business Network: The California Green Business Network is a nonprofit organization that helps businesses adopt sustainable practices and reduce their environmental impact. They offer certification and recognition programs, as well as resources and training for businesses looking to go green.

6. California Association of Clean Energy Consultants: The California Association of Clean Energy Consultants is a professional organization that connects clean energy consultants and experts with businesses and organizations looking to implement clean energy solutions.

7. California Solar Energy Industries Association: The California Solar Energy Industries Association (CALSEIA) is a trade organization that represents the solar industry in the state. They offer resources, advocacy, and networking opportunities for solar professionals and businesses.

8. Energy Upgrade California: Energy Upgrade California is a program that provides resources and incentives for homeowners and businesses looking to make energy-efficient upgrades to their homes and buildings.
9. Caltrans Sustainable Transportation Planning: Caltrans Sustainable Transportation Planning provides resources and guidance for transportation planners looking to incorporate sustainable practices and technologies into their projects.

10. California Sustainable Communities Network: The California Sustainable Communities Network is a collaborative network of local government agencies, nonprofits, and businesses working to promote sustainable communities and clean-tech solutions throughout the state. They offer resources, training, and networking opportunities for members.
Appendix B: Expert Interviews and Discussions

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<th>Interviewee</th>
<th>Organization Represented</th>
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<tr>
<td>Trelynd Bradley</td>
<td>California Governor Office of Business and Economic Development</td>
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<tr>
<td>Tina Andolina</td>
<td>California State Senate Environmental Quality Committee</td>
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<tr>
<td>Governor Deval Patrick</td>
<td>Harvard Center for Public Leadership</td>
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<td>Kristopher Sanchez</td>
<td>Nevada Governor Office for Economic Development</td>
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<td>Nigel Jacob</td>
<td>City of Boston’s Office of New Urban Mechanics</td>
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<tr>
<td>Pam Edinger</td>
<td>President of Bunker Hill Community College</td>
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<tr>
<td>Fadi Chehade</td>
<td>Former CEO of ICANN - Personal Capacity</td>
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Appendix C: Importance of Incubators and other Collaborative Organizations in Cluster Formation

Currently, climate tech incubators and accelerators receive funding from various sources such as governments, corporations, and universities. These programs offer a range of support services including business advising, marketing and design assistance, public relations support, introductions to investors, office space, and laboratory facilities.

Some funding institutions may also invest their own capital, either dilutive or non-dilutive, to provide a startup with the initial boost it needs. For both university spin-offs and independent entrepreneurs, incubators and accelerators often serve as the first step towards success. By enabling innovators to progress from the lowest technology readiness levels (TRL) through the “valley of death” between research and development, these programs help startups reach the manufacturing stage.

In cases where an innovation is not yet developed enough to require a manufacturing site, entrepreneurs can apply to use the scale-up facilities available at national labs. Besides serving as testing facilities for startups, national laboratories, incubators, and universities may also function as research and consulting centers for corporate and financial investors.

There are 4 key reasons why the presence of clean-tech incubators and very important in developing a clean-tech cluster:

1. **Access to Resources**: Incubators provide clean-tech startups access to a variety of resources, including office space, mentorship, networking opportunities, and funding.

2. **Support and Guidance**: Incubators can also provide clean-tech startups with support and guidance from experienced mentors and advisors who can help them navigate the complex world of clean-tech entrepreneurship and develop effective business strategies.

3. **Validation and Credibility**: Incubators can help validate and give credibility to clean-tech startups, which is especially important for those seeking funding from investors. Being associated with a reputable incubator can demonstrate that the startup has gone through a rigorous selection process and has potential for success.

4. **Collaboration and Innovation**: Incubators often bring together a diverse group of entrepreneurs, investors, and industry experts, which can lead to collaboration and innovation. This can help clean-tech startups access new ideas, technologies, and business models that can help them grow and succeed.
Appendix D: Examples of 5 promising startups in Southern California

Eve Energy Ventures Inc (Xeal)
Eve Energy Ventures is an early-stage electric vehicle charging company. What sets Xeal apart from other charging tech is that their chargers do not require Wi-Fi connectivity between the vehicle and the charger. Instead, the company relies on blockchain and cryptographic tokens, without the need for Wi-Fi.  

Enervee
Enervee is a company that rates appliances and products based on their energy efficiency. Retailers can then sell products in Enervee’s store where scores appear next to products to try to help consumers make more efficient purchases.

EVgo
Another EV charging company, EVgo made headlines over and over this year for building strategic partnerships with giants like General Motors, Uber, Tesla, and BMW. The company also won grants and funding from various state governments, including California, to expand their charging station offerings. EVgo's charging stations are strategically located along major highways, in cities, and at other high-traffic locations, making it convenient for EV drivers to charge their vehicles on-the-go. Their charging stations are equipped with fast-charging technology, which can charge an electric vehicle in as little as 30 minutes.

Heliogen
Heliogen Inc. makes a concentrated solar energy system that uses a series of mirrors to concentrate sunlight into a small area and produce steam. It is involved in producing green hydrogen energy. By producing high-temperature heat without any carbon emissions, the company believes it can help reduce the carbon footprint of a range of industries, from cement and steel production to oil refining and chemical manufacturing.

Connect Homes
Connect Homes specializes in prefabricated home building. Their homes are built in a factory and then shipped to the site where they are assembled. Unlike traditional construction practices, prefabs offer easier installation and drastically reduce the carbon needed to complete a build.

85 CB Insights, n.d.
86 Enervee, n.d.
87 Heliogen, n.d.
88 Connect Homes, n.d.
Appendix E: Life-cycle of a Clean-tech Startup

Clean-tech startups face three “Valleys of Death”. For a startup to be successful, they have to successfully navigate these three hurdles:

1. Valley 1: Research to Development
2. Valley 2: Development to Demonstration
3. Valley 3: Demonstration to Deployment

Government entities and research institutions play an important role in the Research and Development phases. VC firms and the private sector play an increasingly important role in Demonstration and Deployment phases.

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Fig: Valleys of death for clean-technologies and sources of help at each stage.\(^{89}\)

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\(^{89}\) Breakthrough Energy Institute, 2019