Perspectives from the IN^2 Network: State of the Cleantech Landscape

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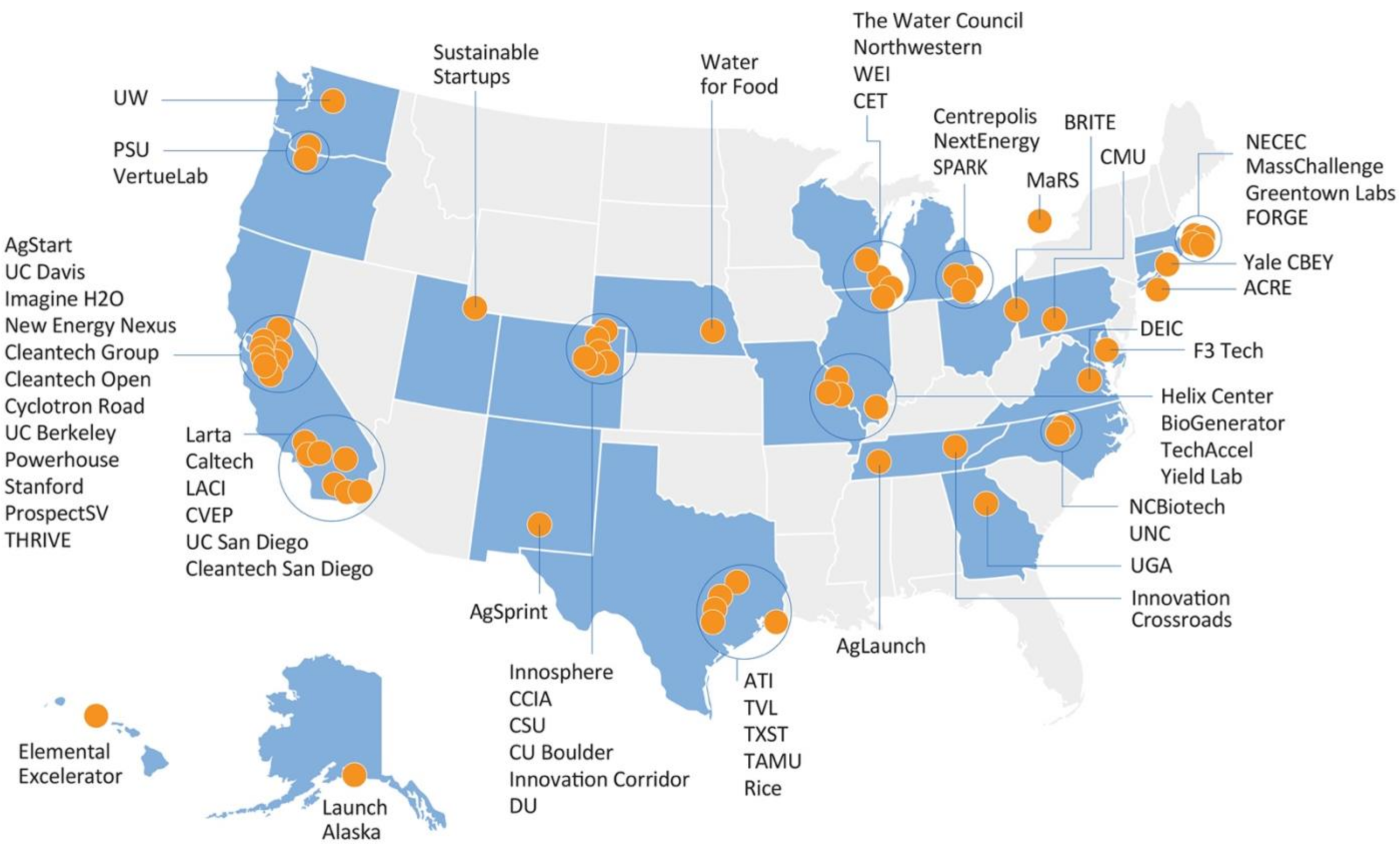
Acknowledgements

We would like to thank all the Channel Partners who contributed their valuable time to provide data, participate in phone interviews, and reach out to their portfolio companies for data. Without you, this paper would have not been possible. We also want to extend a special thank you to the eight leads that collected data and interviews with partners in their regions: Cleantech Open, Innosphere, Larta Institute, Launch Alaska, New Energy Nexus, Northeast Clean Energy Council (NECEC), Wilton E. Scott Institute for Energy Innovation at Carnegie Mellon University, and Jon Brumley Texas Ventures Lab at the University of Texas Austin. In addition, we want to thank the partners who participated in in-depth interviews: Wilton E. Scott Institute for Energy Innovation at Carnegie Mellon University, Caltech Rocketfund, Elemental Excelerator, The Yield Lab, AeroShield, CoverCress, UbiQD, and Yotta Energy. Lastly, we'd like to thank Cleantech Group for their efforts in creating and distributing a diversity survey to the network. These efforts will enable a benchmark against which this network will measure future success.

Partners:



- ACRE | New York, NY
- AgLaunch | Memphis, TN
- AgSprint | Las Cruces, NM
- AgStart | Woodland, CA
- Ann Arbor SPARK | Ann Arbor, MI
- BioGenerator | St. Louis, MO
- BRITE Energy Innovators | Warren, OH
- Caltech, FLOW Program | Pasadena, CA
- Carnegie Mellon University | Pittsburgh, PA
- Centrepolis Accelerator | Southfield, MI
- Clean Energy Trust (CET) | Chicago, IL
- Cleantech Group | San Francisco, CA
- Cleantech Open | Los Angeles, CA
- Coachella Valley Economic Partnership | Palm Springs, CA
- Colorado Cleantech Industries Association (CCIA) | Golden, CO
- Colorado State University Energy Institute, Powerhouse | Fort Collins, CO
- Cyclotron Road | Berkeley, CA
- Daugherty Water for Food Global Institute at the University of Nebraska | Lincoln, NE
- Dominion Energy Innovation Center | Ashland, VA
- Elemental Excelerator | Honolulu, HI
- F3 Tech Accelerator | Easton, MD
- FORGE | Somerville, MA
- Greentown Labs | Sommerville, MA
- Helix Center | St. Louis, MO
- Imagine H2O, Inc. | San Francisco, CA
- Innosphere | Fort Collins, CO
- Innovation Corridor Foundation | Denver, CO
- Innovation Crossroads | Oak Ridge, TN
- Larta Institute | Los Angeles, CA
- Launch Alaska | Anchorage, AK
- Los Angeles Cleantech Incubator | Los Angeles, CA
- MaRS Discovery District | Toronto, CA
- Mass Challenge | Boston, MA
- MIT Energy Club | Boston, MA
- New Energy Nexus | San Francisco, CA
- NextEnergy Center | Detroit, MI
- North Carolina Biotechnology Center (NCBiotech) | RTP, NC
- Northeast Clean Energy Council (NECEC) Institute | Boston, MA
- Northwestern University | Evanston, IL
- Portland State University Business Accelerator | Portland, OR
- Powerhouse | Oakland, CA
- Prospect SV | San Jose, CA
- Rice University | Houston, TX
- Stanford, TomKat Center for Sustainable Energy | Stanford, CA
- Sustainable Startups | Salt Lake City, UT
- TechAccel | St. Louis, MO
- THRIVE | Los Gatos, CA
- Texas A&M Engineering Experiment Station Clean Energy Incubator (TAMCEI) | College Station, TX
- Texas State University | San Marcos, TX
- The Water Council | Milwaukee, WI
- The Yield Lab | St. Louis, MO
- University of California, Berkeley | Berkeley, CA
- University of California, Davis Energy and Efficiency Institute (EEI) | Davis, CA
- University of California, San Diego | San Diego, CA
- University of Colorado Boulder | Boulder, CO
- University of Denver | Denver, CO
- University of Georgia, Innovation Gateway | Athens, GA
- University of North Carolina, Institute for the Environment | Chapel Hill, NC
- University of Texas at Austin, Austin Technology Incubator (ATI) | Austin, TX
- University of Texas at Austin, Texas Venture Labs | Austin, TX
- University of Washington | Seattle, WA
- University of Wisconsin-Madison, Wisconsin Energy Institute | Madison, WI
- VertueLab | Portland, OR
- Yale Center for Business and the Environment | New Haven, CT

Table of Contents

Research Motivation

The need for high impact cleantech innovations is more pressing than ever. In order to support the transition to a low-carbon economy, the cleantech ecosystem needs to accelerate and de-risk new technologies. Where are the companies[1] launching these new technologies located, what resources are available to enable this transition, and who will fund them?

The Wells Fargo Innovation Incubator (IN^2) is a technology incubator funded by the Wells Fargo Foundation and administered by the National Renewable Energy Laboratory (NREL). IN^2 involves and fosters a network of more than 60 cleantech accelerators, incubators, funds, and university programs across the United States, referred to as channel partners in the program.[2] These partners provide support to more than 6,000 cleantech startups ranging in stage from bench scale to commercially ready (descriptions of these terms are in the Appendix, Table 1).

The NREL and Wells Fargo Innovation Incubator (IN^2) partners provide a range of support services to more than 6,000 cleantech companies across the United States.

The term 'cleantech' is used here as an umbrella concept that includes any company or organization advancing the clean energy economy by aiding the transition to a low-carbon future. NREL's cleantech network includes companies ranging from solar power to agricultural solutions (a full list of technology focus areas can be found in the Appendix, Table 2). Startups require various types of services and support to enable their transitions to profitable and sustainable companies, and as such, partners offer services including, but not limited to, business and/or technology incubation, funding (dilutive and non-dilutive), and exposure through mechanisms like pitch competitions.

The goal of this white paper is to establish an understanding of the current cleantech landscape through the lens of this network by assessing who the network is supporting, geographic trends across the United States within cleantech, and the influence of universities and national labs on entrepreneurship. A gap analysis follows, which highlights needs in the ecosystem. Key findings and recommendations related to ecosystem function are also presented based on robust data analysis and in-depth interviews.

Background & Methods

In 2019, IN^2 convened its network partners to share knowledge and best practices. During a breakout session focused on the pipeline of cleantech innovation, two major themes emerged:

- There is a perceived focus on startup maturations and scaling. Some network partners reported not seeing many early-stage startups.
- Because of this perceived focus on maturation, there was a concern that there might not be a healthy pipeline of companies accessing incubator or accelerator programs, depending on location.

[1] Company and startup are used interchangeably throughout this paper. Startup is defined as "a temporary organization designed to look for a business model that is repeatable and scalable." (Areito 2018)

[2] One Channel Partner, MaRS Discovery District, is located in Toronto, Ontario, in Canada.

To further explore these ideas, IN[2] appointed eight leads from within the network: Cleantech Open, Innosphere, Larta Institute, Launch Alaska, New Energy Nexus, Northeast Clean Energy Council (NECEC), Wilton E. Scott Institute for Energy Innovation at Carnegie Mellon University, and Jon Brumley Texas Ventures Lab at the University of Texas Austin, to interview the other partners in their regions and collect data on their portfolio companies. Each partner was asked to provide the information shown in Table 1 about their cleantech portfolio companies. (Only data for U.S.-based companies prior to January 1, 2020 were requested.) Partners were asked to report up to 100 companies or two years of participant company data – whichever came first. Forty-nine partners provided data for this paper, resulting in data about 1,363 unique cleantech companies spanning 45 states. [3]

Table 1: Cleantech portfolio company data requested of network partners.

Data Collected on Each Company	Optional Data Reported	Additional Data Sourced from Pitchbook
Company name	Website	Amount and type(s) of funding raised
Technology focus area*	Amount and type(s) of funding raised	Revenue
Stage of technology*	Revenue	Number of employees
Year entered and exited program	Number of employees	Year founded
Company name (if changed)	Customer(s) (name or type)	
Location while in program and current location		
Company origination *(university, national lab, independently generated, or other)*		
Licensed IP		
Company status *(active, closed, unknown)*		
Company exit		

*Definitions of stages and technology focus are located in the Appendix.

[3] Data provided by partners do not represent the entirety of the companies they support. Partners support not only cleantech companies, but also other verticals within the U.S. and across the globe, totaling more than 6,000 companies.

In addition to providing data about their cohorts of companies, participating partners were interviewed by leads via phone or email to determine their organizational type, technology area of focus and whether those area(s) have changed, services offered and whether those service(s) have changed, number of companies supported, and number and types of opportunities provided to portfolio companies.

Once interviews and data were collected from each partner, leads provided the data to IN^2. The data was reviewed for consistency and completeness, then aggregated. Company names and locations were then used to pull additional data from Pitchbook, which was combined with the master data spreadsheet for a comprehensive analysis. While not all cleantech programs nor startups are represented with these data, these data provide a fairly recent snapshot[4] into the cleantech ecosystem.

Data analysis was conducted in the following four main areas:

- Landscape of the network (size, stage, technology focus, etc.)
- Geographic trends
- Influence of universities and national labs
- Demographics and diversity.

In addition to these data collected, IN^2 conducted in-depth interviews with network partners and startups. These interviews served to augment the data and help inform a more robust understanding of the cleantech landscape. To form a baseline of understanding on diversity and inclusion in cleantech, IN^2 partnered with the Cleantech Group to conduct interviews and a survey. Surveys were sent to cleantech startups and network partners.

Existing Research on the Cleantech Ecosystem

Many reports have analyzed the cleantech ecosystem, focusing on the amount of public and private capital found in the sector over time, and how cleantech companies perform in comparison to other startup types such as biotech and software. Reports focusing on capital have assessed the amount of public versus private capital infused over time, internal rate of return to private investors, and the number of deals across various financing stages.

Cleantech company performance has been captured by the number of exits (mergers, acquisitions, and initial public offerings (IPO)), by revenue, and occasionally, by number of employees and company age. There are a number of conflating factors that make it difficult to analyze cleantech companies relative to other startup sectors from a historical perspective. During 2008-2013, the cleantech sector was flooded with capital from both public and private sources (commonly referred to the Cleantech 1.0 era). Due to a multitude of factors, private investors lost over half of their $25 billion investment (Gaddy et al. 2016). After this collapse, the cleantech sector generally became synonymous with risky or undesirable investments due to much longer commercialization cycles, amount of capital required, and the challenges associated with commercializing hardware.

Additionally, this era was a unique mix of *(i)* misaligned expectations from investors on return size and time to return, *(ii)* an economic transition during the United States' second largest economic recovery,

[4] The startup data collected are companies that were competitive or mature enough to participate in an accelerator or incubator program in the network and therefore are only a subset of the entire ecosystem.

and *(iii)* a globalizing energy marketplace. For example, Surana, Doblinger and Anadon (2020) evaluated more than 600 cleantech startups over a period from 2008 to 2012, looking at factors such as startup company lifetime, patenting activity, and partnering with universities, agencies, and other national labs. The authors assert that startup companies survive longer and produce more patents when the startup partners with a government agency or laboratory rather than a university. However, the survival lifetime of startups can largely depend on the amount of available capital, both public and private, to support and sustain companies. Gaddy et al. (2016) reported that from 2006 to 2011, venture capital (VC) firms spent $25 billion funding cleantech startups, reaching peak investment around 2008 followed by a sharp fall-off. The bust period resulted in numerous cleantech companies closing, filing for bankruptcy, or falling prey to unfavorable acquisitions. Therefore, it is a difficult task to truly assess the survival rate and performance of cleantech companies during this time as it can be conflated with the amount of available capital influencing startup performance metrics and survival rates.

A broad approach was taken by Surana, Williams, Krawczyk (2020) surveying more than 6,000 cleantech companies within the United States. Notably, this study determined that particular states specialize in one technology category across the development pipeline, including research and development (R&D), company formation, and deployment. The authors found that cleantech companies are healthier if they partner with the state by accessing state-supported incubators or accelerators and state R&D funding. However, little is known regarding the extent to which companies move across the United States to other states to access a variety of innovation support resources. In this work, the dynamic between access of nationwide innovation support programs by companies in our dataset was investigated.

In addition to studies analyzing the success or failures in the cleantech ecosystem, a fair amount of work has assessed the demographics of its entrepreneurial and investment labor pool. A number of studies since 2015 have observed that cleantech VC and startups predominantly employ white men. A study (Schultz 2015) conducted on diversity in VC firms (representing 552 senior VCs across sectors) found that 92 percent of senior leadership positions at top-tier VC firms were male and 78 percent were white; 1.3 percent were Hispanic and less than 1 percent were Black. Similarly, a study (Gompers 2017) found that from 1990 to 2016, women represented less than 10 percent of startup entrepreneur and VC labor, Hispanics represented about 2 percent, and African Americans represented less than 1 percent. This was despite the fact that all three of these groups have strong representation in educational programs that lead to careers in this sector and in other highly compensated professions. Research comparing firm diversity to firm financial performance has established that more diverse firms, on both a gender and ethnicity basis, are more likely to achieve above-industry-average returns than non-diverse firms (Hunt 2015). In fact, the least-diverse firms were statistically more likely to achieve below-industry-average returns.

This work builds on these previous ecosystem-wide studies and demographic analyses, shedding additional light on the state of the current cleantech landscape and the people building it. The particular focus of this paper is on the geographic, demographic, and other characteristics of the ecosystem, and the influences of key players such as universities and national laboratories on company and ecosystem health.

Landscape Analysis: Partners and the Companies they Serve

IN² Network Partners: A Range of Services Provided

As stated above, the IN² program supports more than 60 network partners in 24 states across the United States. Partners were classified into one of four types: university, accelerator/incubator, fund, and economic development organization. Each organization also provided details on types of support services it offered: business incubation, technology incubation, fund, or pitch event. There was a good variation of partner types, as seen in Figure 1, with 40 percent classified as accelerators/incubators, 38 percent as universities, 12 percent as funds, and 10 percent as economic development organizations.

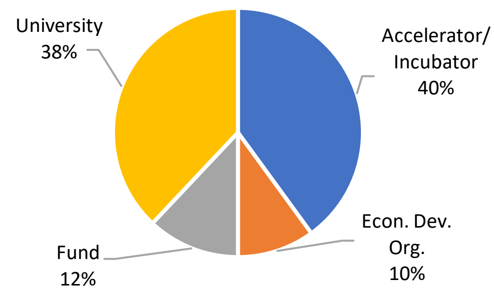


Figure 1: Network partner organization classification.

Services offered by partners primarily fell into business or technology incubation services, at 64 percent and 22 percent, respectively. Other services provided by partners include investment funds (8 percent) and pitch events (6 percent). While these partners are diverse in the services they provide and their locations, they do not represent the entire cleantech ecosystem. For the purpose of this paper, the term "ecosystem" will refer to the network partners and the companies they support. Figure 2 shows the distribution of partners across the United States (above) and the companies they provided data for (below).

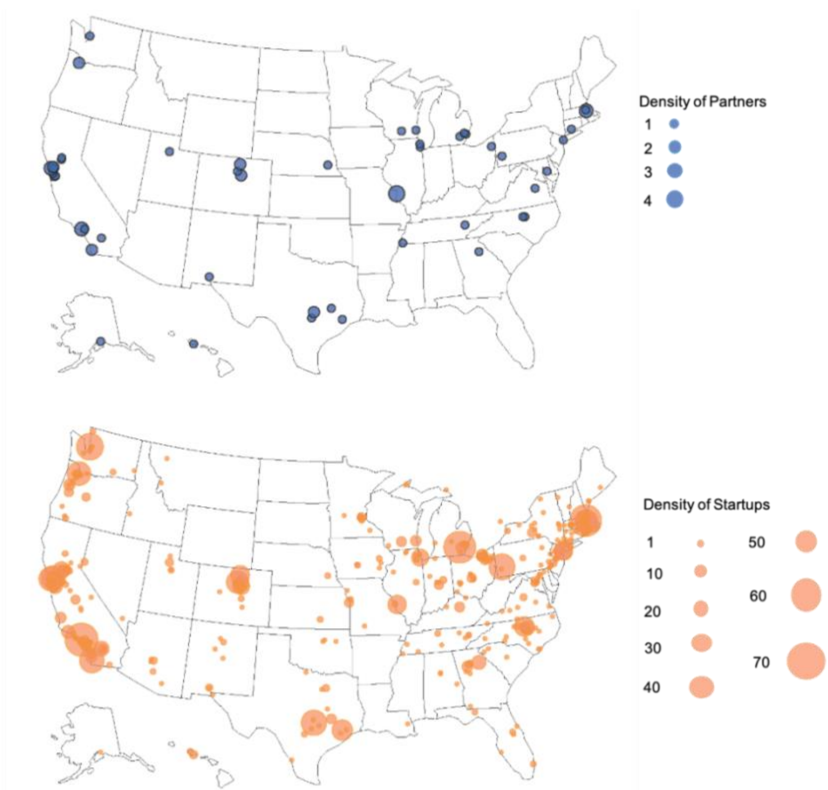


Figure 2: Maps of IN² Channel Partner organizations (top) and the 1,363 cleantech startup companies represented in this report (bottom). Not all Channel Partners provided portfolio data for this report.

The Startup Companies: Local Hubs, but Many Cross-Country Connections

A large number of the 1,363 portfolio companies in the dataset are located in states where there are at least four or more network partner organizations, and/or states with large population densities, creating entrepreneurial hubs such as those found in California and Massachusetts. This finding is consistent with Surana, Williams, Krawczyk which shows that state R&D spending, clean energy policies and programs lead to economic development and a robust energy industry within the state. As the IN^2 network includes sustainable agriculture companies, there is also a heavy influence of startups and partners in the Midwest.

Companies were plotted on a map, and a line was drawn to their network partner to indicate connections between companies and the organizations where they received support (Figure 3). Companies that received support in their own city are represented by concentration. Concentration is shown by different colors as indicated on the scale. This figure shows the concentration and geographic distribution of connections in the network.

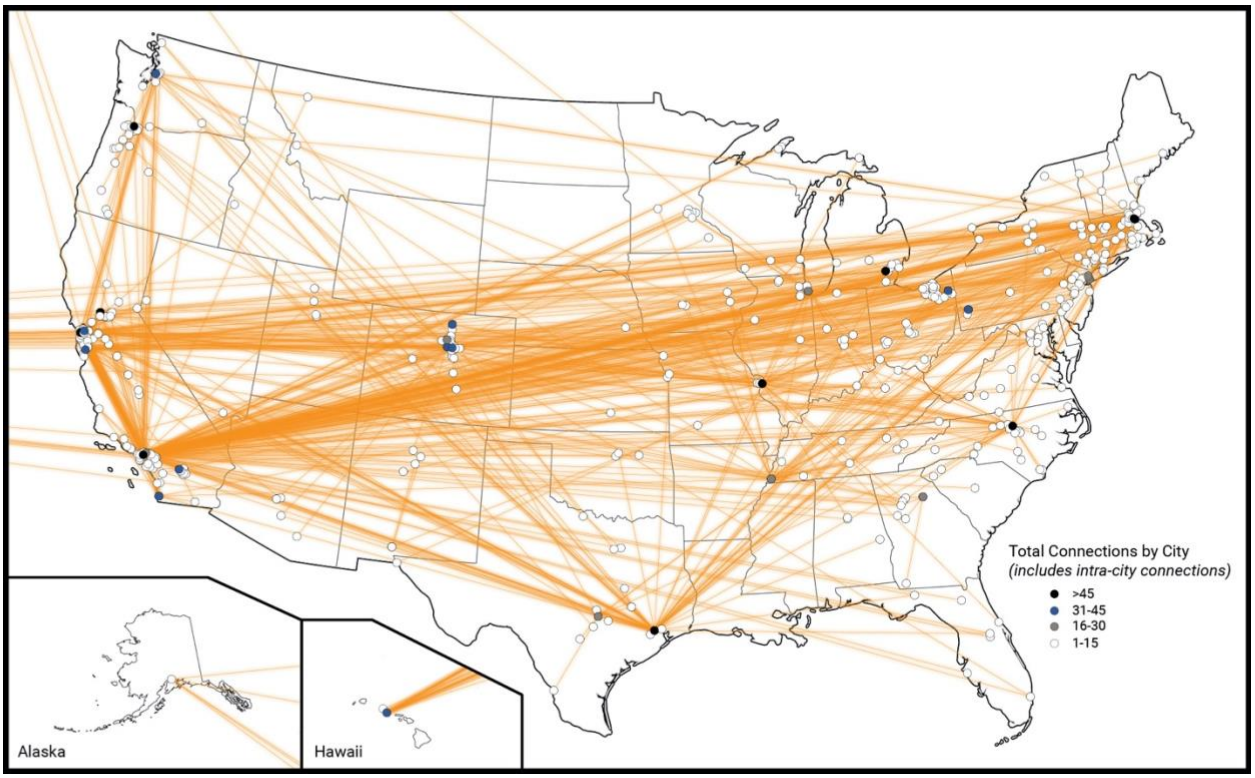


Figure 3: Map showing connections between companies and the network partner organizations supporting them.

Startups Utilizing More of the Network

Many companies received support from multiple partners in this network and other organizations outside of this network. Naturally, companies at different stages and in different technology focus areas need different kinds of support along their paths. Within the dataset of companies, 155 companies participated in multiple partner programs, totaling 350 instances of support. While not a comprehensive assessment of company-leverage of partner services and programs, this provides a snapshot into this aspect of the network. Connecting with multiple programs showed benefits. Companies that had completed multiple programs were more likely to be in business than those who completed one program.

The majority (63.5 percent) of companies in the dataset were served by programs in the same state where they are located, which is in alignment with the findings reported by Surana, Williams, Krawczyk (2020). This overall trend varies widely state-to-state, however. Startups in states such as Arizona or Kentucky where there is no network partner were served by a program out of state. In Michigan, 87 percent of companies were receiving services from programs in-state; in California and Texas, the percentages were 83 and 69 percent, respectively, while in Illinois only 38 percent of companies were obtaining services from Illinois network partners. Companies located in the Northeast often receive support from outside their states, but within the Northeast region.

From a partner perspective, the picture varies widely. Network partners in states such as Hawaii and Alaska serve largely out-of-state companies, which could be explained by their remote locations, while the partner in Tennessee also has a low percentage of companies served in-state, but for less clear reasons. Several university programs serve exclusively in-state companies, while programs like IN^2, by design, cast a geographically wide net and serve only a small percentage of in-state companies.

The Startup Landscape: Location, Stage, & Technology

Location May Not Matter Anymore

There has been a perception that startups were required to move to a specific 'entrepreneurial hub' such as Silicon Valley in order to succeed. But location may not have as much of a significant impact on company success as once perceived. This dataset did not provide an ample perspective over time, but a small percentage of companies in the dataset did show a change in location. Several companies interviewed reported that they had not moved their operations and felt that the COVID-19 pandemic had lessened that pressure. This research shows that few companies moved their headquarters, suggesting that they were able to be successful without changing location.

The Pipeline is Not Drying Up

A key motivation for this study was to explore current company stages (Figure 4), to determine if there is a shortage of early-stage companies that might be a negative indicator of overall ecosystem health. This analysis found that there is a good balance of company stage overall, as well as within technology sectors and by state, although some states have a higher concentration of early- or late-stage companies. There is a healthy distribution of companies by stage, with 376 or about 30 percent at bench scale, 369 or about 30 percent prototype, and 500 or about 40 percent commercially ready. In this dataset, Colorado, New York, and Texas have a greater abundance of later stage companies, whereas California and Massachusetts have a more even distribution across stage.

There is a robust balance of company stage and technology focus area across the U.S.

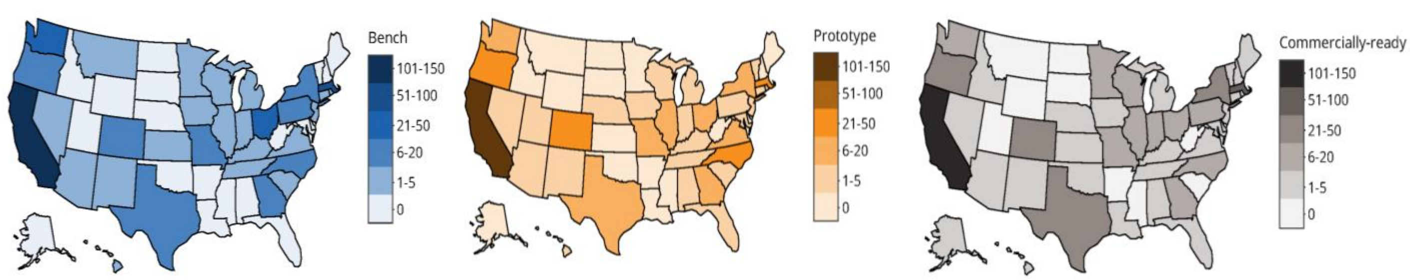


Figure 4: Distribution by stage for U.S. cleantech companies. The colored scale bar has been normalized across all three maps.

Twenty Years of Innovation

Figure 5 shows the companies founded over the past 20 years, broken down by current company stage, or shown in yellow if their status was closed or unknown. Of the companies for which these data were available, 80 percent were definitively active (still in business), while 20 percent were either closed or unknown.

A healthy number of startups launched in recent years. Many companies have progressed beyond bench scale.

Categorizing the companies by year(s) in operation, a few trends were observed: *(i)* a healthy number of startups have launched in recent years, and *(ii)* many companies have progressed beyond bench scale to prototype and commercially ready. It's important to note that data were collected in 2020; therefore, the smaller number of companies founded in recent years is not indicative of poor ecosystem health, but instead the prematurity for those companies to funnel into network partner programs. Additionally, companies founded before 2011 are not as abundant in the dataset because network partners reported recent program participants only (companies founded before 2000 were not included in the figure). It is clear that a higher proportion of older companies are later stage, indicating that they are progressing along a path to maturity. Despite anecdotal assertions that the vast majority of cleantech startups fail, there was not a large proportion of closed companies or companies whose status was unknown.

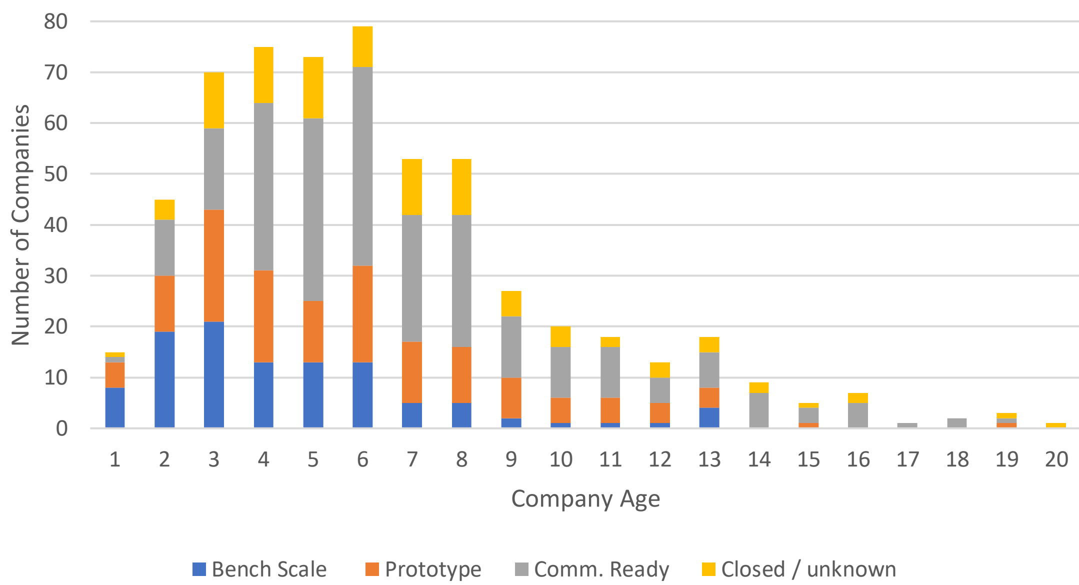


Figure 5: Concentration of companies by year founded and distinguished by current stage. Companies are still active unless denoted by closed/unknown. Note: companies one year of age were founded in 2019.

Additionally, of the companies in the dataset that were identified as no longer active, a much higher proportion (44 percent compared to 29 percent for still-active companies) were identified as being at an early stage (Figure 6). The charts on the left and right of Figure 6 represent 988 and 183 companies, respectively.

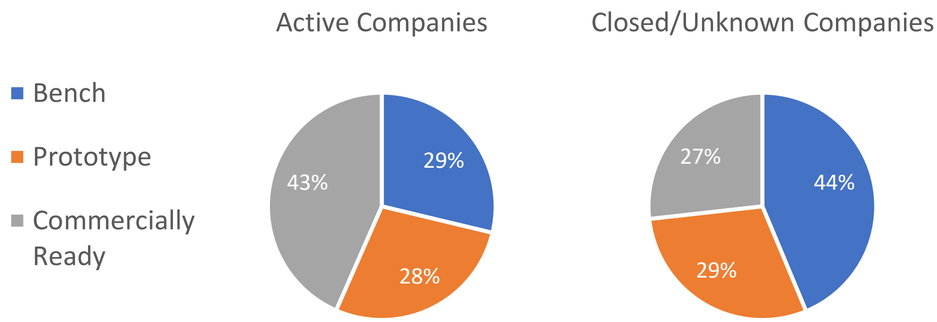


Figure 6: A comparison of the companies in the dataset that are (a) still active (988 companies) and (b) no longer active (183 companies) and the relative proportion of company stage in these two pools.

Tech Focus and Stage Around the Country

Figure 7 shows the concentration of companies by technology focus area and the distribution of companies within each focus by stage. Companies were assigned a technology focus area by their incubator/accelerator partner. The high concentration of environmental services and agriculture solutions can be attributed to the agtech companies in the ecosystem.

Nearly all of the technology focus areas have representation across each stage. Among the top six tech types, energy storage has the highest proportion of early-stage companies, followed by advanced materials. Energy efficiency has the highest proportion of late-stage companies, followed by waste and recycling.

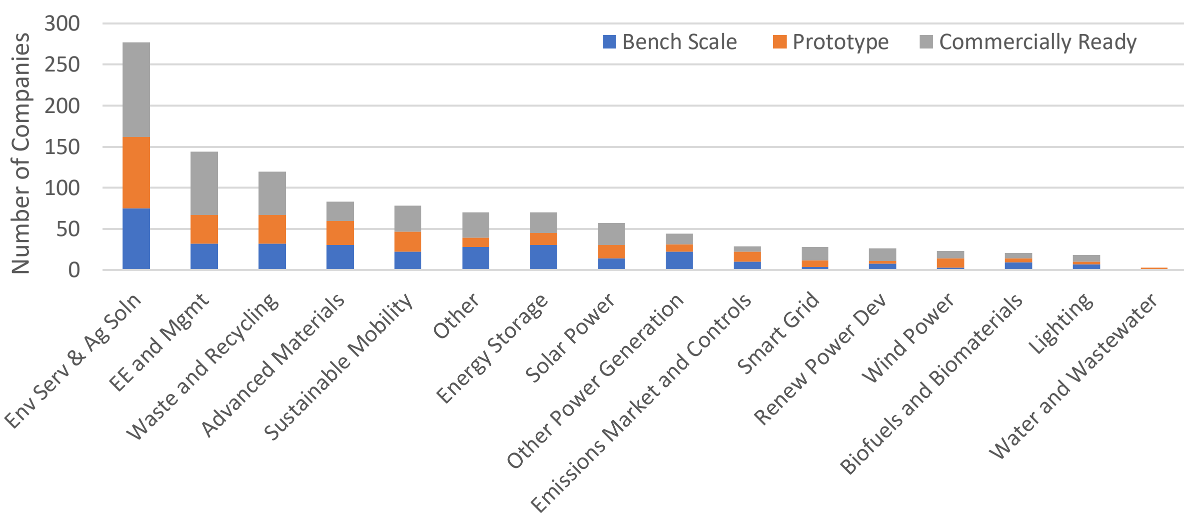


Figure 7: The companies' reported technology focus areas, broken down by stage (1,276 companies provided both stage and tech focus). For definitions of technology focus areas, see the Appendix, Table 2.

Patterns of technology focus were explored in the states with the highest number of companies in the network and displayed in Figure 8. Texas, California, and Colorado had more companies specializing in one technology focus area (waste & recycling, environmental services & agriculture solutions, and advanced materials respectively) while Michigan and Massachusetts had a more even distribution of companies across a larger diversity of company technology types.

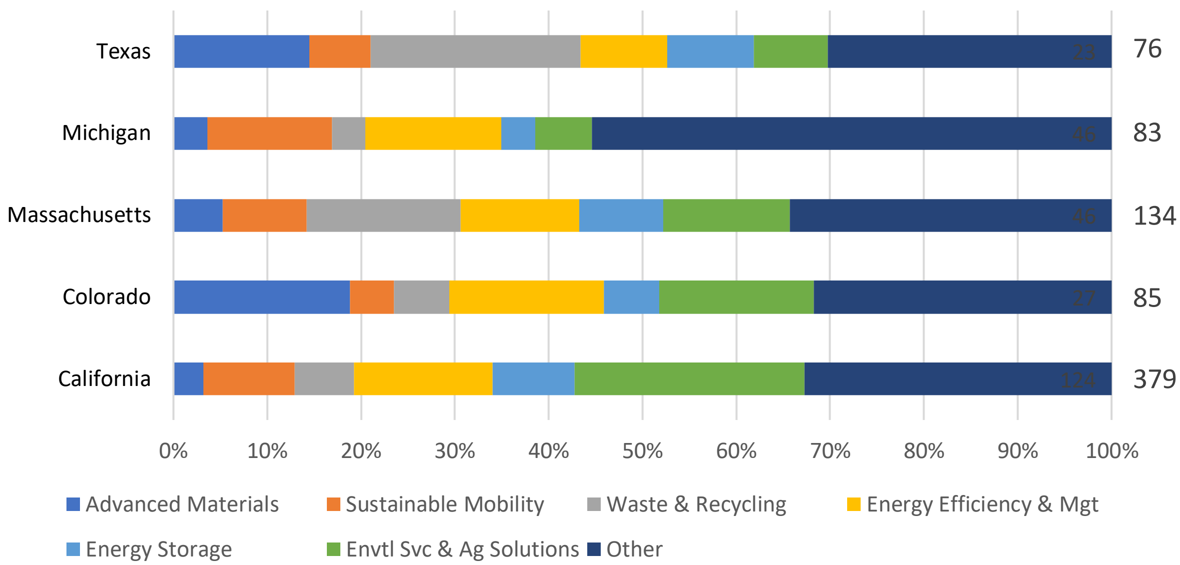


Figure 8: Startup technology focus in the top five states concentrated with most startups.

Demographics

Employee numbers for 813 of the companies in the dataset are shown in Figure 9. A very small percentage (3.4) of companies had one employee; 40 percent had 2-5 employees, and another 40 percent had 6-25 employees. In total, more than 80 percent of startups in the dataset had 25 or fewer employees, while only 5 percent had more than 100 employees. Unsurprisingly, companies that are earlier stage (bench scale) have fewer employees, while companies with more than 25 employees tended to be farther along in development (prototype to commercially ready).

80% of startups in the dataset had 2-25 employees.

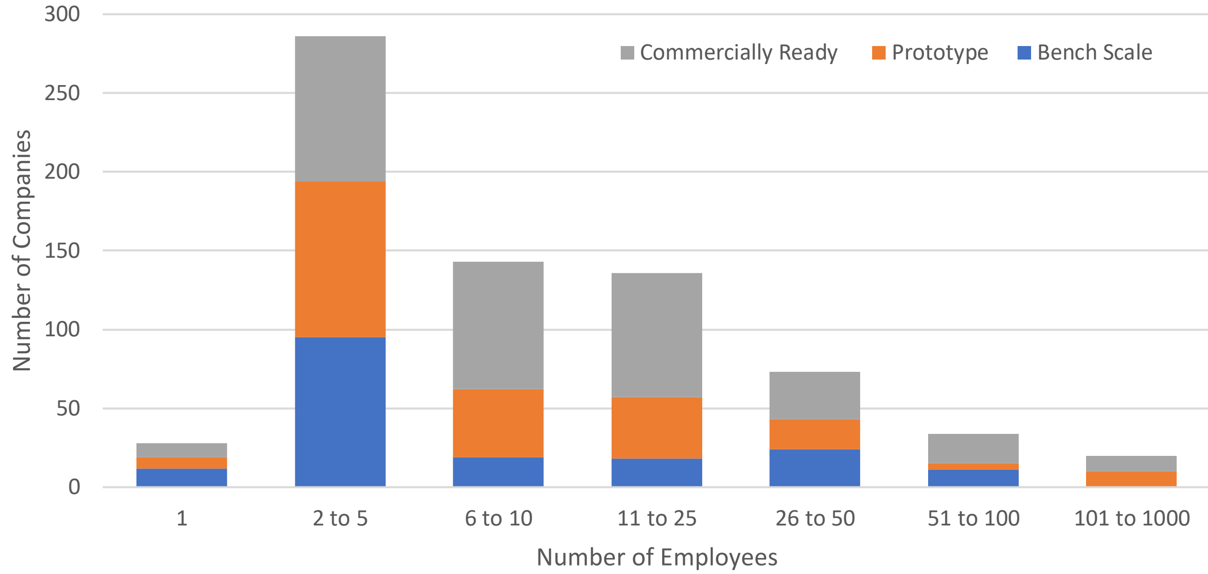


Figure 9: The frequency of companies reporting number of employees and across company stage.

IN^2 partnered with the Cleantech Group to assess diversity in the cleantech sector across the United States, surveying the network partners' portfolios. For the purpose of this research, diversity was defined as the presence of team members who are female, people of color, differently abled, or veterans of military service. The survey was completed by 140 companies; data was provided in sufficient detail to summarize ethnic diversity for 133 of those companies, and gender diversity for 134. Findings from this survey indicated that 78 percent of companies have predominantly white employees, while 93 percent had a majority of male employees.

Survey respondents were also asked to rate their companies' commitment to diversity; a majority agreed that their organization's culture, not just its policies, reflected a commitment to diversity. As in other industries, there is much room for improvement in diversity and inclusion in cleantech.

Different Roles for Universities and National Laboratories

> Universities play a strong role in the creation and support of cleantech innovations and companies.

The Role of Universities: Origination and IP

Universities play a strong role in the creation and support of cleantech innovations and companies. As many of these universities have well-developed research programs, many companies are formed there, or external companies license university-developed intellectual property (IP).

Almost half of the companies in the dataset that originated at a university had licensed IP (49 percent), while 26 percent of companies that originated elsewhere had licensed IP. Universities also sponsor network partner organizations; about 40 percent of the network partners are located at universities across the United States.

Partners interviewed indicated the importance of being connected with a university's technology transfer office (TTO), saying that partnering with the technology transfer office at their university was a "two-way street," as recommendations are sent from the TTO to the program and vice versa.

The Role of National Labs: Partnership to Advance Innovations

"Being accepted into the IN^2 program was a game changer for us; it gave us credibility."– *Elise Strobach, CEO & Co-founder AeroShield*

This dataset includes very few companies originating from a national laboratory. Rather, national laboratories (including NREL) support startup companies in other aspects such as technology development or third-party validation through various research partnership agreements.

The five states with the highest number of companies that NREL supported from 2017 to 2019 (226 total across all of NREL's programs, including but not limited to IN^2 companies) were California, Colorado, Massachusetts, New York, and Virginia. Top services provided included technical systems analysis, hardware research and validation, modeling and simulation, and chemical R&D. The top fields of application included renewable power distribution, transportation, advanced materials, and energy efficiency.

These figures are consistent with Surana, Doblinger and Anadon's findings that partnering with national laboratories or government agencies affords various benefits to startup companies such as access to world-class facilities and internationally recognized expertise. National laboratories that have lab-embedded entrepreneurship programs (LEEPs) provide entrepreneurial training and lab facility access to incubate startup companies. LEEPs currently reside at Lawrence Berkeley National Laboratory with Cyclotron Road, Oak Ridge National Laboratory with Innovation Crossroads, and Argonne National Laboratory with Chain Reaction Innovations (Garfield, Moore, Adams 2019). NREL's technology incubator programs including Shell Gamechanger Accelerator™ Powered by NREL (GCxN) and the Wells Fargo Innovation Incubator (IN^2) provide startups funding and dedicated NREL expertise to validate their innovations and accelerate the path to market.

In addition to serving outside startups, Energy I-Corps, a U.S. Department of Energy (DOE) program, provides entrepreneurial training to national laboratory researchers developing new technologies. The DOE also supports other programs that fuel new ventures into the marketplace, LEEPs, American-Made Challenges (Prizes), and others. Through these programs, entrepreneurs gain access to world-class facilities, researcher expertise, funding, and entrepreneurial training.

"Analysis at NREL was a big validation point for the company. It opened a lot of doors, created press opportunities, and provided valuable connections to funding, speaking opportunities, commercial partners, and pilots." – *Sean Walters, Global BD Manager, Yotta Energy*

The Importance of Reputational Vetting

Universities and national laboratories support startups in unique and distinct ways that go beyond technology origination or IP. Companies and partners interviewed for this white paper reported that partnership with the national laboratory provided a 'reputational vetting' in addition to the concrete technical vetting that may have taken place through a research partnership. Third-party laboratory technical validation helped companies in securing other support for their companies, including raising funds.

Gaps Analysis

The current state of cleantech was also assessed by conducting in-depth interviews with four cleantech companies across different development stages, locations, and technology focus areas, and four network partners from universities, accelerator/incubators, and funds. From these interviews it was clear that there is great enthusiasm around the new era of cleantech, and that using what was learned from the Cleantech 1.0 era, there is little concern about another bust. As climate impacts increase globally, small businesses, large corporations, and investors are leaning into the development and implementation of sustainability action plans. With the infusion of capital, resources, and knowledge the outlook for cleantech is filled with promise.

While the outlook is promising, interviewees indicated that there are still gaps in the ecosystem. One such gap is the lack of the *right* kind of capital. While there is a large influx of venture capital, this may not be the right type of investment for cleantech given the longer timeframe on the return of investment, and the return's smaller size.

Another gap is the challenge startups face in gaining access to pilots and demonstrations. Typically, the partners needed for pilots and demonstrations include utilities and large corporations, but there are high barriers preventing startups from conducting pilots and demonstrations. In interviews, some companies and partners explained that utilities and corporates often prefer the technology to be third-party validated and de-risked beforehand and startups often lack access to these resources.

A lack of entrepreneurial training and business acumen also presents a significant barrier for startups. Many startups are created by scientists or engineers, who may struggle with the dynamics of running a successful company, including understanding the market or customer, building a team, writing a business plan, and more. This largely impacts companies as they seek funding and could be addressed by increasing entrepreneurs' awareness of incubator/accelerator services.

Lastly, the innate risk associated with cleantech, moreover hardware technologies, is met with the heightened need for credibility and know-how, which companies and partners agreed could be gained through participation in network partner and national laboratory programs. Additional perspectives are summarized below in Tables 2 and 3. Table 2 suggests strategies specific to the network of accelerators, incubators, and other support programs, while Table 3 suggests strategies for a variety of ecosystem stakeholders.

> "I'm very optimistic about the future. Cleantech is smarter, balance sheets have improved, and the industry's direction is based on scientific fact and not simply speculation." – *Anna J Siefken, The Wilton E. Scott Institute for Energy Innovation at Carnegie Mellon University*

Table 2: Perspectives and strategies based on interviews of select network partners.

Gap Analysis: Network Partner Perspective	Suggested Strategies for Network Partners
There is a healthy pipeline of companies, but there appears to be less capital than current demand.	• Deploy patient capital
Programs are largely funded by foundations, grants, corporate and government entities.	• Continue to coordinate among a variety of funding sources to support a more robust ecosystem and meet the range of startup needs
There is a lack of industry interest in pilots and demonstrations. Industry may need companies de-risked before initiating a technology pilot.	• Support companies in collecting data to show credibility • Develop sites and industry partnerships for smaller-scale demonstration projects • Support work with technology incubation or national laboratory programs to obtain third-party validation
Inventors often lack the business savvy or entrepreneurial training to run a successful business or may not be interested in being entrepreneurs.	• Offer more training on the topics of building a team; building a sales force; developing financial statements; identifying the market(s); customer discovery; fundraising • Scale technology transfer programs to provide more early-stage licensing and training opportunities
There is limited funding available for early prototyping and R&D stages.	• Deploy non-dilutive funding • Provide access to lab space • Enable greater access to technical expertise
Connections/introductions to industry, investors, and customers are necessary for success.	• Provide/offer personalized introductions
A majority of startups originate inside universities or research organizations, but these may not be coordinated with the network of accelerators and incubators to provide the services needed by a specific startup.	• Non-university organizations partner more closely with universities and research organizations • Provide training and resources to help early-stage tech • Provide resources to support entrepreneurship for faculty and researchers • Establish regional connections with universities for a pipeline of companies
Awareness of organizations that assist specific technology types and stages is lacking.	• Directly market the services of the network partner, targeting industry organizations, geographies, etc. in order to maximize the value of the investment by technology or stage • Serve as information hubs to direct startups to the correct resources and programs at the right phase
Regulations developed in prior eras may hinder deployment of new technologies.	• Develop regulatory strategies and priorities and coordinate with regional actors to deploy them • Educate regulators on technology innovations and the barriers that regulations create to deployment

Table 3: Perspectives and strategies based on interviews of select startups in the dataset.

Gap Analysis: Company Perspective	Suggested Strategies
Company location impacted ability to fundraise to some extent. Less capital access in states outside of CA.	• Startups consider remote headquarters in locations with large concentrations of investors • Investors consider diversifying portfolios with respect to geography. Investment firms consider HQ locations across the country, perhaps close to a university or a national laboratory
Success was enabled by accessing varied types of support from incubators/accelerators or universities including networking, programming, cohort learnings, mentorship, exposure, and credibility. **There are a lot of resources and programs available for startups, but understanding the correct ones at the correct point in time is crucial.**	• Startups identify and access the right resource at the right time, largely determined by stage and technology • Startups perform a cost/benefit analysis prior to accepting resource support
Access to lab and office space can be cost-prohibitive to a company's success.	• Startups may want to explore incubator or accelerator programs and other resources such as contract manufacturing or prototype development that can reduce cost of lab space
There is a lack of awareness for startup-specific business services, such as human resources, public relations, etc.	• Vendors that provide assistance to startups (human resources, marketing, hiring, etc.) may partner with local accelerators, incubators, universities, or funds to enhance their accessibility to startups
Environmental impact is difficult to measure and inconsistent across startups.	• Ecosystem stakeholders may creatively explore ways to measure and validate environmental and climate impacts of startups
Certain grants are structured in ways that prohibit funds to be used on equipment or lab space or time. Some startups need understanding of how to write successful proposals with appropriate cost allocation.	• Accelerator or incubator organizations may benefit from creating educational programs around public funding and restrictions on hardware and equipment acquisition, and from creating programing to solve this problem with shared lab space and/or equipment
Taking extra risk with a hardware startup is tough.	• Investors may want to target companies that are in programs (or have accessed multiple partner services) aimed at de-risking hardware technologies through technology incubation or other services

Factors Driving Success

A number of interviewees of this white paper commented on the difficulty of measuring startup progress along the path to maturity or "success" in a meaningful way, as well as for the sector as a whole.

From the data analysis and the in-depth interviews performed, it is possible to make some observations about the path to success. Some of these are intuitive:

- With respect to company size: all of the companies in the dataset with more than 100 employees were beyond bench scale. While some companies stay small forever, a larger number of employees is an indicator of maturity and advancement in company stage.
- There was a positive relationship in the dataset between companies that had licensed intellectual property and those that were still active: only 8 percent of the companies that were known to be closed or whose status was unknown had licensed IP (24 out of 285), compared to 38 percent of still-active companies (484 out of 1,273).
- Finally, companies in interviews reported that it is easier to raise funds during later stages. This is supported through analysis of data from the IN^2 data collection and from PitchBook reporting deal count and size; the proportion of deals is higher at commercial stage than at prototype, which is higher than bench scale. The average number of deals per company was also highest at commercial stage and lowest at bench scale.

While these data-based observations confirm expectations about a startup's maturity, the project's in-depth interviews yielded other more nuanced observations about measuring success and the milestones that companies target at different stages of development. Success is defined in many different ways, and the end goal of different cleantech actors, from investors to startups, varies widely. As mentioned above, at the later stages, company performance is often measured through different types of 'exits,' (IPO, demonstrated profit, mergers and acquisitions, and capture of market share); distinct, earlier-stage milestones also exist. The project identified indicators of success that might be applied throughout a startup's trajectory, summarized in Table 4.

Table 4: Indicators of company maturity by stage as drawn from data analysis and interviews.

Stage of company	Measures of maturity and path to success
Bench Scale	• non-dilutive and early-stage funding • ability to raise private funding • participation in business or technology incubation programs • IP development (or licensing of other IP)
Prototype	• types and volumes of funds raised • third-party-validated proof of concept • partnerships with universities or national laboratories • partnerships with industry or utilities
Commercially Ready	• number of employees • types and amount of funds raised • licensing of IP or product deployment • merger or acquisition • volume of revenue (profitability) • completed demonstration/pilots

These factors might be used to develop useful measures of progress or success, whether for individual startups, technology sectors, or the ecosystem as a whole. Further work, either as a follow-up to this study, or performed more broadly across the ecosystem, can help inform this assessment and allow for a better understanding of how to accelerate the transition to a low-carbon economy that is at the heart of the cleantech sector.

To build upon this research, it would be ideal to interview and collect metrics on cleantech startups to determine one or more unitless success metrics that could be applied to different company stages or types. These data could help identify what resources are needed at different points in the path to success. These data could also serve as a baseline to compare against periodically by collecting and analyzing the cleantech landscape. In addition to this work, studying cleantech across the globe could provide additional insights into the health of the ecosystem. In order to more accurately apply broader lessons learned in accelerating cleantech, conducting a similar analysis on a different industry may provide further insights into how cleantech differs from or is like other industries.

Key Findings & Recommendations

Based on the key findings from the data analysis for this paper, the broader research, and the in-depth interviews performed, a number of recommendations can be made, summarized in Table 5.

Table 5: Key findings and recommendations on perspectives of the cleantech landscape in the U.S. based on data and interviews.

Key Findings	Recommendations
There's a healthy mixture of startups across all technology stages and types.	Cleantech incubators, accelerators, and university programs are encouraged to continue supporting companies across all stages and technology types. These programs could consider expanding into other support services for various stages of companies, opening new types of technology support, or utilizing tech support available at national laboratories or universities.
A significant proportion of companies in the dataset originated from universities. National laboratories were the source of very little company origination in this dataset but provide a variety of other support services to startups such as entrepreneurial training, incubation programs, and other partnership agreements.	Startups may consider forging or strengthening relationships with universities or national laboratories in their regions, specifically with these institutions' incubator programs or technology transfer offices.
Cleantech incubators and accelerator organizations primarily provide business incubation services as opposed to technology incubation or others.	Incubator/accelerator and other support organizations may want to creatively explore services beyond business incubation. Additionally, the broader cleantech ecosystem could improve awareness of organizations specializing in various service types.

Key Findings continued	Recommendations continued
Startup companies access network support across the country (more than one-third of innovation support was accessed from out-of-state programs). Different programs offer services that are appropriate at different points in a company's trajectory.	Startups need to understand when and how to access these services in order to make best use of what's being offered. Incubator, accelerator, and university programs can help startups identify whether accessing services out of state will aid in speeding their path to market. Further study can help identify metrics for success at different stages and identify gaps in available resources.
There is a predominance of white and male employees in the cleantech sector.	Strong STEM education and entrepreneurship training programs for diverse groups, and specialized support for diversity in the earliest-stage companies, could have a large impact on integrating diverse individuals into cleantech.

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Appendix: Supplementary Information

Table A-1: Portfolio company stage definitions.

Stage	Technology Development
Bench Scale	▪ Technology Readiness Level (TRL) 1-5 ▪ Conceptual stage with physical proof that the concept may work ▪ Development plans for prototyping and testing ▪ 3-5 years to market
Prototype	▪ TRL 6-7 ▪ Prototype available for testing and validation ▪ Plans available for development to final product ▪ Less than 2 years to market
Commercially Ready	▪ TRL 8-9+ ▪ Production models available in limited quantity ▪ Less than 18 months to market

Table A-2: Technology focus area with definitions based on Cambridge Associates (Source: Cambridge Associates).

Group	Subsector	Definition
Renewable Power	**Solar Power**	Technologies and processes that directly convert solar radiation into electricity or hot water
	Wind Power	Technologies and processes that convert kinetic energy from the wind into electricity
	Other Power Generation	Technologies and processes that generate electricity from other renewable inputs, fuel cells, or waste capture
	Biofuels and Biomaterials	Technologies and processes that produce fuels and materials from non-fossil fuel, biomass-based sources
Renewable Power Development	**Renewable Power Development**	Processes that allow for the financing, installation, management, operation, or ownership of renewable power generation projects
Energy Optimization	**Energy Efficiency and Management**	Technologies and processes that allow for more control over energy use and reduce energy consumption
	Lighting	Technologies and processes that reduce energy use through more efficient lights and lighting systems
	Smart Grid	Technologies and processes that work to optimize electricity transmission and distribution from the point of origin to the end consumer
	Sustainable Mobility	Technologies that contribute to the increased efficiency and electrification of transport
	Energy Storage	Technologies and processes that increase the efficiency of or reduce the cost, weight or environmental problems associated with devices that store energy for use at a later time
Resource Solutions	**Waste and Recycling**	Technologies and processes that repurpose old materials into new products and reduce or eliminate the quantity and impact of undesired materials
	Water and Wastewater	Technologies and processes that lead to the more efficient purification, recycling, and management of water and wastewater
	Advanced Materials	Technologies and processes that use biochemicals and substances to improve resource efficiency or serve as substitutes for more polluting materials
	Environmental Services and Agricultural Solutions	Technologies and processes that protect and allow for the restoration of natural ecosystems or contribute to more sustainable agriculture practices and techniques
	Emissions Markets and Controls	Technologies and processes that reduce, measure, or control the release of greenhouse gases into the atmosphere