From Solutions to Scale

Considerations & Insights for Investing in Nascent Climate Technologies

Yale Center for Business and the Environment

Yale Center for Business and the Environment

About The Yale Center for Business and the Environment

The Yale Center for Business and the Environment provides a platform for generating, incubating and launching innovative action at the intersection of business and the environment. The Center joins the strengths of two world-renowned graduate schools—the Yale School of Management and the Yale School of Forestry & Environmental Studies—together with an extensive network of internal and external thought leaders at the business-environment interface. Driven by student interest, we develop partnerships with a wide range of actors across Yale (students, faculty, staff) and in the professional world (alums, companies, NGOs, governments). Our work covers finance, entrepreneurship, marketing, operations, and strategy on issues involving energy, water, carbon, food, natural areas and society.

www.cbey.yale.edu

Cover, left: US Department of Energy. A researcher works on fuel cell testing at the National Renewable Energy Laboratory (NREL) campus in Golden, Colorado, where both the public and private sector conduct research to scale up promising clean energy technologies.
https://www.flickr.com/photos/departmentofenergy/9094959460/in/album-72157634233150172/

Cover, right: Opus 12. A scientist examines a cell in the laboratory at Opus 12, a startup in Berkeley, California. The company is developing technology to convert carbon dioxide into useful products, like plastics and fuels. Courtesy of Heidi Lim and the Opus 12 team.

TABLE OF CONTENTS

FOREWORD

Richard Kauffman
Chairman of the Board at New York State Energy Research and Development Authority (NYSERDA)
Chair of Generate Capital
Adjunct Senior Research Scholar at Columbia Center on Global Energy Policy

The costly and time-consuming journey from technological breakthrough to commercial-scale implementation has long frustrated policy-makers, entrepreneurs, and early stage investors. The capital required to survive this journey—often in the tens or hundreds of millions of dollars—has prevented needed climate solutions from achieving scale in deployment. While software and IT can improve efficiency, they are not sufficient. The path to climate change solutions will need to go through technologies that are much more capital intensive. These solutions could include the creation of renewably produced hydrocarbons from air capture of CO2 and hydrogen from water; next-generation small-module nuclear reactors; a replacement of steel and concrete with carbon neutral or negative products; as well as the continued development of battery, solar, and storage technologies. These are all solutions that will require considerable capital and time to develop. Getting them to scale is a critical problem.

As an investor and policy-maker, I've witnessed firsthand the hazards of trying to get solutions across the so-called "Valley of Death" prior to widescale deployment. As CEO of Good Energies, an early investor in solar manufacturing technology, I saw more than one of our investments help turn the much-vaunted German "Solar Valley" into "Solar Death Valley." At the US Department of Energy, I had the opportunity to oversee the Loan Program immediately after the solar panel manufacturer Solyndra filed for bankruptcy and to try to rescue battery maker A123, which had received grants to build its manufacturing plant.

The failures of Solyndra and A123 turned government financial support of innovative cleantech manufacturing into a partisan fight, invoking claims of "crony capitalism" and the risk of the "government picking winners and losers." It killed the proposed federal "Clean Energy Deployment Agency" bill in Congress; this agency would have provided low cost loans precisely to help companies get to scale. The failures of Solyndra and A123 were only two of many such failures. As a consequence, most venture firms pulled back from making investments in capital-intensive start-ups out of fear that there would be no subsequent financing to build out commercial manufacturing. These failures also reawakened a long-standing debate about how much investment should be put into early stage "innovation" versus later stage "deployment." Simply put, some argued that the solution to climate change should come from investments in over-the-horizon technology, while others argued that we should accelerate deployment of solutions already commercially available today.

In the last several years, we have seen developments supporting both of these arguments. Most prominently, in support of advancing the argument for greater investments in innovation, Bill Gates and colleagues have founded (and funded) both Breakthrough Energy Coalition and Breakthrough Energy Ventures: the former advocating for greater government and private investment in research and development, the latter a venture firm that seeks to make investments in capital intensive clean energy solutions. And in regard to deployment, while the Federal government has backed away from large-scale support of innovative manufacturing of clean technologies, many states have increased their efforts at market development, including expansions of their Renewable Portfolio Standards. Very few states, however, have been willing to invest public dollars in support of the Valley of Death by providing direct support to manufacturers. As an example, as New York State's "Energy Czar," I helped establish the New York Green Bank. However, informed from the political fallout from Solyndra, the Green Bank's strategy is to finance project deployment—not manufacturing—using technology that has been commercially accepted by the market.

Of course, the debate between the primacy of investing in innovation or deployment is a false choice: while more innovation is necessary to achieve climate change targets, it is also essential to deploy existing clean energy technology today. Indeed, there is a positive, self-reinforcing relationship between deployment and innovation. The bigger the end markets, the greater the economic prize that draws in more capital and innovation that reduces costs which further drives end market opportunity. A good example of this feedback loop is in the semiconductor industry, where continued reductions in costs and improvements in performance have increased demand for processors that have further driven additional innovation that have reduced cost and improved performance. This long-term trend—referred to as "Moore's Law"—isn't a law of physics. It's a law of the connection between markets and innovation.

Therefore, lack of investment in nascent technologies needs to be seen as a missing link in a long chain of activities from an idea to mass deployment. And indeed, this problem is more symptomatic of multiple missing links in the chain that inhibit climate change solutions from achieving scale, rather than being the problem itself.

I am grateful for the report "From Solutions to Scale: Considerations for investing in nascent climate technologies," since it provides a detailed look at the missing links surrounding a critical challenge and offers some specific remedies. Only through a comprehensive understanding of the chain of activities—and the need to repair or to add links to this chain—will we be able to marshal the ideas and capital needed to address climate change. The report gives us a tug in the right direction.

Richard Kauffman is the Chair of Generate Capital, a leading financier and owner of clean economy infrastructure. He is also Chair of the New York State Energy Research and Development Authority (NYSERDA) and a Adjunct Senior Research Scholar at Columbia University's Center On Global Energy Policy. Prior to these positions, he was in the office of New York Gov. Andrew Cuomo as the state's first Chairman of Energy and Finance for New York, or 'energy czar,' in January 2013. On behalf of Governor Cuomo, Mr. Kauffman led New York State's comprehensive energy policy effort, known as Reforming the Energy Vision.

Mr. Kauffman oversaw and managed the state's complete portfolio of energy agencies and authorities, comprised of the Department of Public Service (DPS), the New York Power Authority (NYPA), the Long Island Power Authority (LIPA), and the New York State Energy Research and Development Authority (NYSERDA). He was appointed chair of NYSERDA's board in June 2013.

As the state's most senior energy official, Mr. Kauffman was New York's lead delegate in Paris at the 2015 United Nations Climate Change Conference, or COP21. In 2014, Mr. Kauffman was named by Fortune Magazine as one of the World's Top 25 Eco-Innovators.

EXECUTIVE SUMMARY

New technologies can play a critical role in solving the climate crisis during the 21st century. When researchers map out scenarios of policies and actions that could avert the worst impacts of climate change, the success of these models often depends on the development of advanced technologies in areas such as renewable resources, energy efficiency and storage, and carbon removal. This report refers to such solutions as "nascent climate technologies." Without innovation in these areas, addressing climate change will be far more difficult, if not impossible. The public and private sectors play a crucial role in developing nascent climate technologies by deploying capital to bring promising solutions to scale.

Traditional investing structures typically work best either early or late in the innovation process. Grants and public sector funding tend to support early-stage solutions through research and development, while venture capital and private equity tend to support commercialization and deployment. The messy middle in-between these two periods—which typically includes demonstration and pre-commercialization—is often called the "valley of death," because many new technologies struggle to stay funded through this phase. In practice, new technologies tend to face multiple valleys of death during this period, with potential shortfalls happening whenever they require a capital influx to move from one stage of innovation to another.[1]

Gaps in funding often occur due to a combination of perceived outsized risk, large capital requirements, long development timelines, and other factors that are off-putting to market-rate risk investors. More risk-tolerant, patient investors—such as philanthropists, family foundations, high-net-worth individuals, and corporate venture capital—are stepping up to address these funding gaps, but some may lack the tools, resources, and relationships to deploy their capital in the most effective way. In particular, supporting nascent climate technologies requires high levels of coordination between actors across the technology development pathway, as well as an ability to navigate a diversity of financial, as well as non-financial, risks and uncertainties.

Distilling insights from over 20 interviews with professionals in the field, this report reviews key barriers to investing in nascent climate technologies and identifies useful considerations and insights when seeking to advance critical climate solutions. The interviewees for the report included investors, entrepreneurs, government agency representatives, philanthropists, foundations, incubators, accelerators, and universities. Based on these conversations and additional research, this report highlights five key areas for investors to consider when supporting nascent climate technologies:

1. **Improving collaboration and coordination among investors** across multiple stages of technology development and investment types
2. **Strengthening the ecosystem** of climate innovation across the investment landscape
3. **Building investor capacity** to effectively evaluate, select, and fund nascent climate technologies
4. **Better aligning risk and return metrics** with investor capabilities and start-up needs
5. **Enhancing non-financial support,** such as expertise, partnerships, connections, equipment, and political advocacy

1 Advancing the Landscape of Clean Energy Innovation—Breakthrough Energy Ventures, 2019.

INTRODUCTION

In 2018, the Intergovernmental Panel on Climate Change (IPCC), an international group of scientists and experts, found that average global warming would need to stay below 1.5°C relative to pre-industrial times in order to minimize the most destabilizing impacts of climate change. Staying within this limit (or even the more generous limit of 2°C that was set by the Paris Climate Agreement) requires substantial reductions in greenhouse gas emissions starting now and continuing through 2030. To remain below 1.5°C, approximately half of all global emissions would need to be reduced—decreasing from the current level of approximately 52 gigatons of CO2eq per year down to 25-30 gigatons of CO2eq per year. According to the Global Carbon Project, only approximately 9% of the earth's carbon budget remains.[2] In a 2018 special report, the IPCC highlighted four pathways for limiting warming to 1.5°C. All four of these pathways rely to some extent on new technologies.[3] Achieving these deep emission reductions would align with the goals set by countries under the Paris Agreement in 2015 and provide numerous co-benefits for public health, biodiversity, and equity, among others. Yet, the availability and scale of the technologies that can reduce greenhouse gas emissions lag behind what is needed.

This report uses the term "nascent climate technologies" to refer to hardware technologies (not purely software-based) that have high potential to mitigate climate change. These early-stage solutions have already undergone research and development (R&D) to establish basic technological efficacy, but they require further prototyping, development, and commercialization to reach the scale that is necessary to have a major impact.

---

2 Global Carbon Budget—Global Carbon Project, Rob Jackson. 2019.

3 IPCC, 2018: Summary for Policymakers. In: *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming.* Masson-Delmotte, V., P. Zhai, et al. *World Meteorological Organization, Geneva, Switzerland, 32 pp.*

Box 1. Examples of nascent climate technologies:[4]

- **Engineered carbon dioxide removal—** Technologies and systems that capture carbon dioxide from the air and either store it in a reservoir—such as a mineral deposit or in an underground reservoir in supercritical liquid form—or use the captured carbon as a feedstock for other industrial uses. By removing carbon dioxide directly from the atmosphere, these solutions help to cancel out emissions from other sources, but they are unlikely to lead to net zero emissions in the absence of substantial reductions elsewhere.[5]
- **Battery and storage—** Technologies that help balance the supply and demand for power by storing energy cheaply, at scales ranging from a single household to a large generation facility. Improved battery storage technology could be used to address many challenges facing the power sector today, including integrating variable fuel sources into the grid, deferring capital investment in infrastructure, and improving economic dispatch, efficiency, and power quality.[6]
- **Electrical grid modernization (also known as the Smart Grid)—** Technologies that modernize and improve the existing electrical grid system. Updates to the grid will help deliver electricity more efficiently, allow for the further implementation of distributed energy resources, and improve the reliability of electrical delivery.[7]
- **Hydrogen fuel—** Technologies that produce energy by breaking down hydrogen, with only water as a byproduct. Hydrogen technology has broad potential applications in the transportation, manufacturing, and electrical generation industries. For transportation applications, efficient hydrogen fuel cells using natural gas can emit roughly 50% less carbon dioxide emissions than a comparable internal combustion engine. Hydrogen fuel cells could also be used to generate electricity and store energy to mitigate the intermittency of renewable energy.[8]

4 Advancing the Landscape of Clean Energy Innovation—Breakthrough Energy Ventures, 2019.
5 Pulling CO2 out of the air and using it could be a trillion-dollar business—Vox, David Roberts, 2019.
6 Advancing the Landscape of Clean Energy Innovation—Breakthrough Energy Ventures. 2019.
7 Advancing the Landscape of Clean Energy Innovation—Breakthrough Energy Ventures. 2019.
8 Ibid.

In any sector, new technologies tend to receive funding from different sources of capital at different stages of innovation. At the research and development stage, when solutions remain largely unexplored, projects are often funded by philanthropy, government grants, and angel investors. At the pre-commercial or commercial stage, when solutions are commercially viable (or close to it), projects are often funded through venture capital, corporate venture capital, or private equity. This report will focus on solutions in the long period between the initial breakthrough and commercial readiness. A 2018 report in the Stanford Social Innovation Review ("The Investment Gap that Threatens the Planet") categorizes these solutions as "nascent."

Figure 1. Sources of capital for climate solution stages

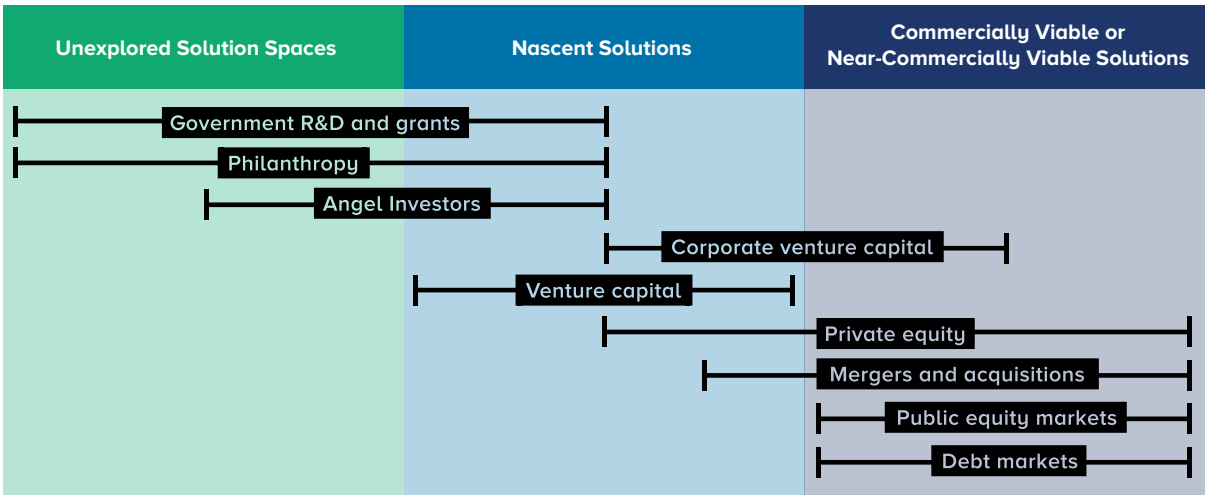


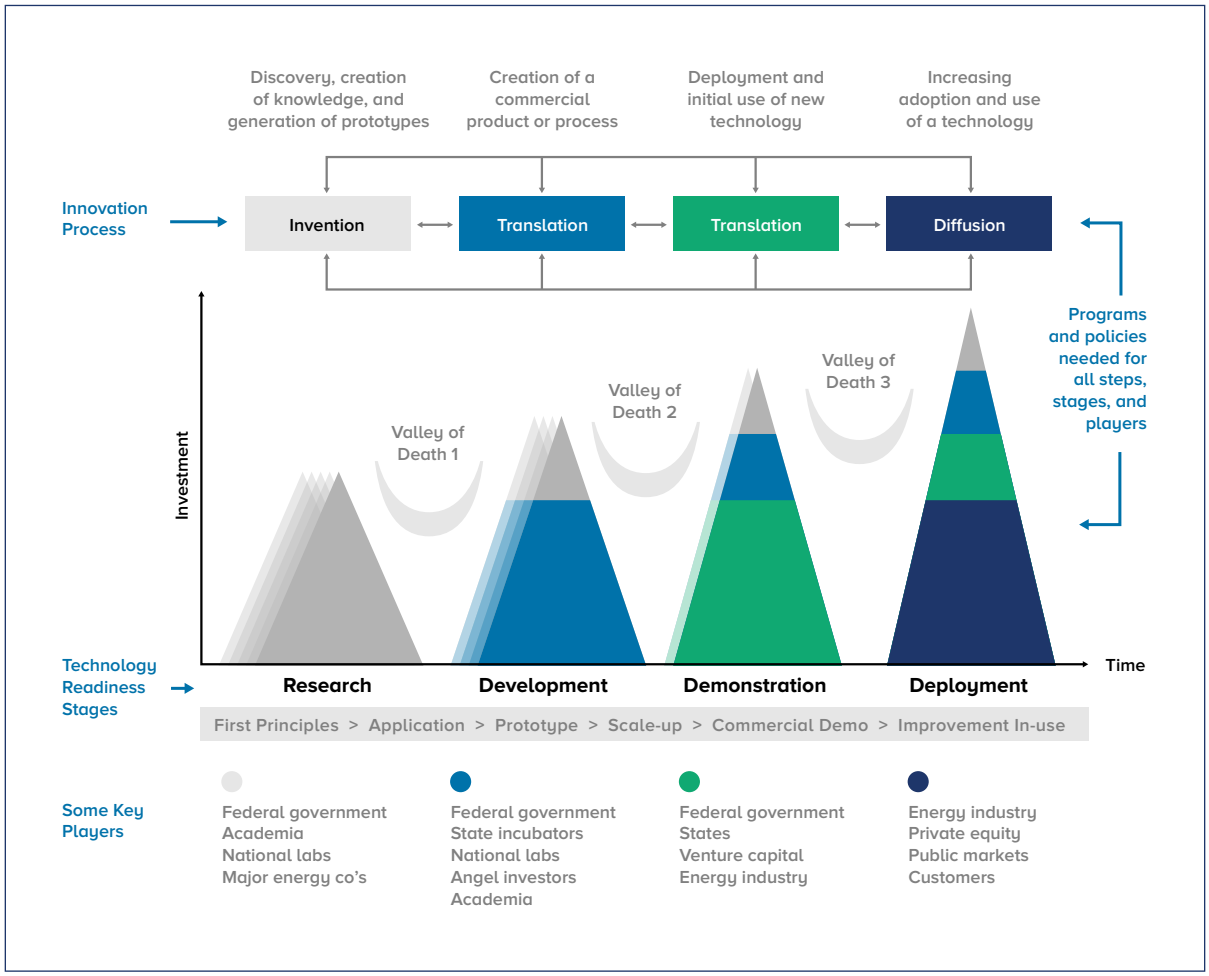
Image source: The Investment Gap that Threatens the Planet—Stanford Social Innovation Review
https://primecoalition.org/wp-content/uploads/2017/12/Winter_2018_the_investment_gap_that_threatens_the_planet.pdf?x48191

For nascent solutions, there are often funding gaps where technologies have outgrown early funding sources but are not developed enough for later funding sources. This is the so-called "Valley of Death" where innovations often fail to move forward not due to technological shortcomings but due to lack of funding.[9] In practice, there can be multiple "valleys of death" on the road to commercial deployment, because funding gaps exist across multiple stages of technology development.[10]

9 A Valley of Death in the Innovation Sequence: an Economic Investigation—Research Evaluation, T.R. Beard et al., 2009.

10 Ibid.

Figure 2. Multiple valleys of death across multiple stages of innovation



Source: Advancing the Landscape of Clean Energy Innovation—Breakthrough Energy
https://www.b-t.energy/reports/advancing-the-landscape/

"Innovation challenges grow with each successive stage along the innovation pathway. While clean energy innovation at the research stage is supported by a diverse, world-class set of U.S. research institutions, the support system weakens as inventions move toward commercialization...The clean energy incubators that have emerged in recent years have tended so far to support primarily software solutions."[11]

—Advancing the Landscape of Clean Energy Innovation—Breakthrough Energy Ventures. 2019.

11 Ibid.

Innovation funding gaps feel are particularly acute for nascent climate technologies. That is because these urgently-needed technologies require a high degree of capital to reach scale, and because even with capital, they face many market and regulatory uncertainties.[12] This report will explore the barriers faced in funding nascent climate technologies as well as key insights for overcoming those barriers.

REPORT GOAL

Specifically, this report seeks to address the following questions:

- **What are the key barriers to investing in nascent climate technologies?**
- **What current best practices or future changes in the investing landscape can accelerate the flow of financial capital toward nascent climate technologies?**
- **How can emerging, risk-tolerant, patient capital and traditional yet impact-seeking investors better coordinate, communicate, and align with another?**
- **Which non-financial factors can be catalytic but are potentially lacking for innovators developing nascent climate technologies?**

The primary investment types that fall within the scope of this analysis are outlined below. For the sake of this report, grants are considered investments, as they provide capital with the aim of creating additional value, but the value takes the form of impact, rather than financial returns. These financial tools are not intended to be exhaustive, but representative of capital types which have come up in research and interviews, and have been deployed to support the development of nascent climate technologies. Each of these capital types is also included in our Definitions Section.

- **Unrestricted Grant—** A grant intended to support the general purpose of an organization, rather than a specific project. The grant is unrestricted because there are no stipulations on how the money should be used.
- **Recoverable Grant—** An investment tool with elements of both a loan and a grant, in which the recipient of capital repays the investor the principal amount and possibly an interest rate, based on financial performance. Like a loan, this structure allows the investor to recoup the capital if the recipient performs well, and like a grant, it is forgivable if the recipient does not perform well. Recoverable grants are becoming more widespread as a form of patient, affordable, and flexible capital in the United States.[13]

12 Advancing the Landscape of Clean Energy Innovation—Breakthrough Energy Ventures, 2019.

13 France's 'Soft Loan' Model Paves Way for Recoverable Grants - Stanford Social Innovation Review, Alexandra Chamberlin, 2019, https://ssir.org/articles/entry/frances_soft_loan_model_paves_way_for_recoverable_grants_in_us

- **Program Related Investment (PRI)—** A mission-driven investment that must meet a legally defined charitable standard. Specifically, the IRS states that a PRI must meet the following criteria to qualify: 1) The primary purpose is to accomplish one or more of the foundation's exempt purposes; 2) Production of income or appreciation of property is not a significant purpose, and; 3) Influencing legislation or taking part in political campaigns on behalf of candidates is not a purpose.[14]
- **Mission Related Investment (MRI)—** A commercial investment that is intended to support an organization's social mission. In contrast to Program-Related Investments (PRIs), MRIs do not have to meet charitable standards and do not have any legal standards or requirements to qualify as such. However, as commercial investments, investors often expect them to meet the same prudent standards as other investments.
- **Convertible Note—** A type of loan, or debt, that grants the holder the right to convert into shares, or equity, upon certain conditions, such as a predetermined conversion price or upon closing a round of funding. Some of the advantages of convertible notes for early-stage companies are that they allow founders and investors to delay fixing valuation until more information is available; they offer an easier, less complex, and more flexible mode of financing than many other options; and they often allow founders to retain control rights.
- **Simple Agreement for Future Equity (SAFE)—** An investment tool created as a simple replacement for convertible notes. A SAFE enables a startup and an investor to accomplish the same general goal as a convertible note (granting the investor equity at a later date), though a SAFE is not a debt instrument with a maturity date. The investor invests money and receives the right to purchase stock in a future equity round (when one occurs) subject to certain parameters set in advance in the SAFE.

The following pages synthesize our key findings and detail some practical considerations on how to support nascent climate technologies, which require risk-tolerant, patient capital and tailored support to reach commercialization.

The primary audience for this report is capital providers who currently invest, or intend to invest, in nascent climate technologies, particularly those who use or plan to use the financial structures outlined above. The secondary audience is individuals or institutions that may wish to play a supportive role in strengthening the climate investment ecosystem, or entrepreneurs who are looking for insight into the investor perspective.

Note that the research and interviews for this report are primarily US-focused, but many insights are likely to apply to other geographic regions as well.

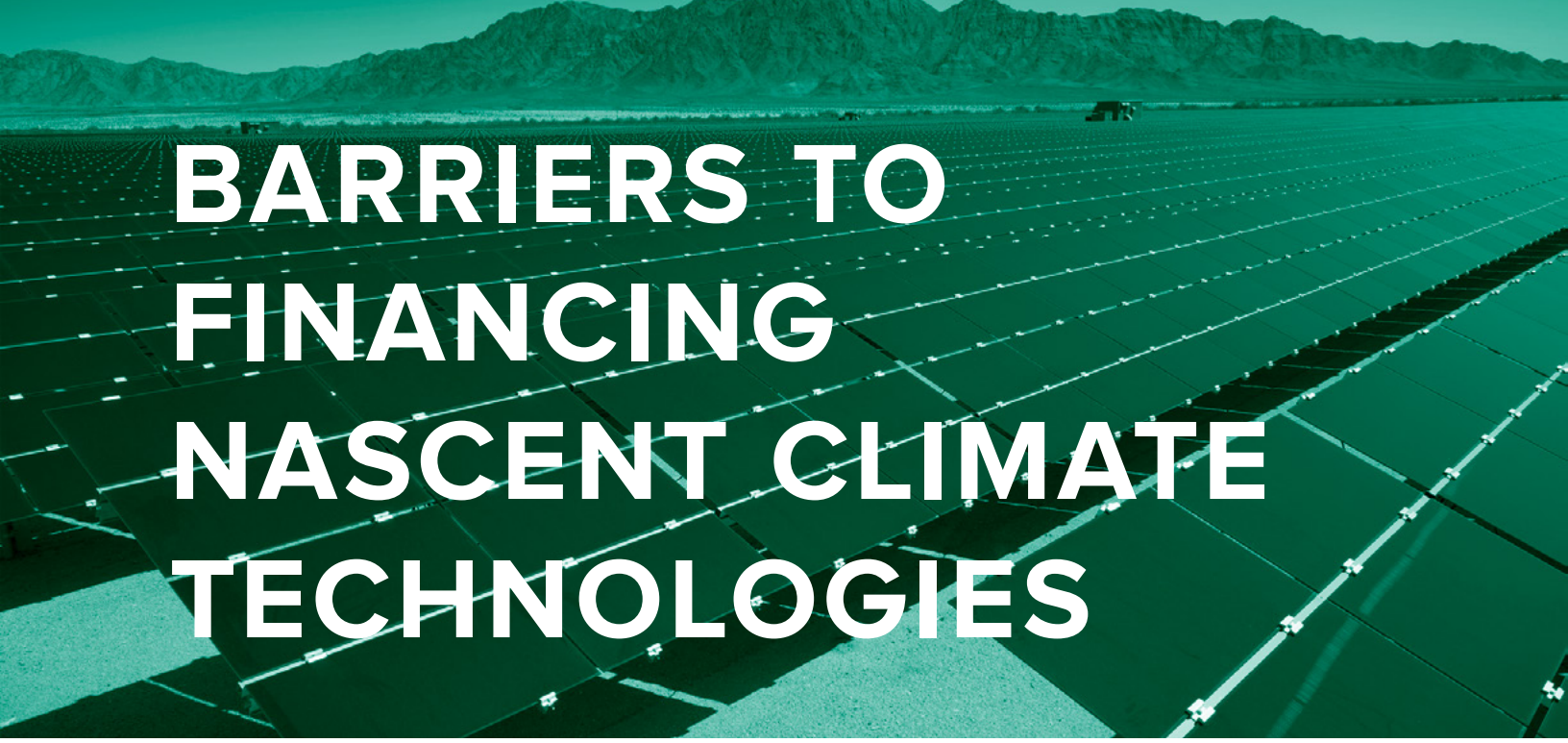
14 IRS: Program-Related Investments. https://www.irs.gov/charities-non-profits/private-foundations/program-related-investments

METHODOLOGY

This report is the culmination of interviews with 20+ investors and entrepreneurs as well as representatives from government agencies, philanthropies, incubators, and accelerators, in addition to a review of relevant current literature.

The following individuals and entities who contributed to our report, include but are not limited to:

Yale University
Columbia Business School
United Nations Development Program
Elemental Excelerator
Prime Coalition
Echoing Green
Surdna Foundation
NY Energy Research & Development Authority
New Energy Nexus
Techstars Sustainability Accelerator
Autodesk Foundation
The Rockefeller Foundation
CREO Syndicate
Climate Finance Advisors
Global Impact Investing Network
Activate (Cyclotron Road & Activate Boston)
DBL Partners
Opus 12



BARRIERS TO FINANCING NASCENT CLIMATE TECHNOLOGIES

Nascent climate technologies face numerous barriers to investment on the long road to commercial deployment. Some of those investment barriers are unique to climate technologies, tied to past trends and the uncertainty of a transition to a low-carbon future. Other barriers apply across multiple capital-intensive technologies (e.g. biotech). This section is split into two parts. The first part explains the historical context that has left investors wary of climate technologies. The second part outlines a list of present-day factors that lead to misalignment between nascent climate technologies and traditional funding structures.

Note, this section uses two different terms to refer to a similar set of technologies. “Cleantech” refers to technologies that reduce negative environmental impacts, particularly in the energy and power industry. “Climate technologies” refers more specifically to technologies that can potentially mitigate climate change by reducing or removing greenhouse gas emissions. The reason we have chosen to use two different terms is to accommodate a term that was commonly used at a specific point in time (the cleantech boom of the late 2000s) while also maintaining the focus of this report on technologies with potential climate benefits.

Past losses from investing in cleantech have led to present trepidation towards climate technologies

In part, the current early climate technology funding gap can be explained by investors’ past experiences, specifically the mistakes and losses that came with the wave of energy technology investing in the late 2000s. During that period, investors harbored high hopes for clean energy innovations (often called “cleantech”), akin to the expectations they held for digital and internet technology companies. These companies tended to have rapid timeframes for scaling and achieving high-valuation exits. By 2010, cleantech investments had reached their peak, representing 16% of total dollars invested.[15] This was enough to establish cleantech as the third largest venture capital investing category behind biotechnology and software.[16]

15 Ibid.

16 Developing your Cleantech 2.0 Investment Strategy—The Climate Solutions Collaborative, Rob Day, 2017.

Unfortunately, investments in cleantech did not live up to the high return expectations. In fact, cleantech venture capital investments over the past decade-plus have achieved only 4.1% gross IRR (before fees).[17] Net of fees, these investments are barely returning capital at all. Such returns can be attributed to a combination of several macro-economic and situational factors, including low oil prices and competition from low-cost Chinese companies.[18] This drop was further solidified by the 2016 U.S. Presidential election and a signaling from the incoming administration that their focus would be on developing oil and "clean coal" technologies. This posture cast doubt on tax incentives for emerging cleantech solutions.[19] Further disappointing for VC investors was a lack of high exit valuations for cleantech companies. Those high expectations did not translate to cleantech due to the hard assets and longer time horizons necessary for commercializing new nascent climate technologies.[20] By 2015, cleantech investment had fallen to its lowest level since 2005, at just 2% of venture capital investment.[21]

Cleantech investing has only just begun to recover over the last few years, partially due to economic, sub-national policy, and technological developments. For example, the average price for a solar panel has dropped below $1 per Watt generated, and cleantech innovations such as electric vehicles and LED lighting have gained considerable market share since 2010. However, both private and public investment in early-stage cleantech remain underwhelming, while the need for these solutions continues to grow.

17 Developing your Cleantech 2.0 Investment Strategy—The Climate Solutions Collaborative, Rob Day, 2017.
18 Why the Clean Tech Boom Went Bust—Wired, Juliet Eilperin, 2012.
19 https://www.brookings.edu/research/cleantech-venture-capital-continued-declines-and-narrow-geography-limit-prospects/
20 Ibid.
21 The Investment Gap that Threatens the Planet—Stanford Social Innovation Review, Scott P. Burger, et al., 2018.

Nascent climate technologies are often misaligned with traditional funding structures

In addition to historical challenges, the funding gap for nascent climate technologies can be partially explained by the differences between traditional funding structures and the risk-tolerant, patient investments needed for the development and commercialization of climate technology breakthroughs.

These solutions often face unique challenges in the form of comparatively higher risk from regulatory, technology, and market factors, larger upfront capital expenditures, and uncertain timelines for financial returns.

Based on a literature review as well as conversations with investors, below are some of the most prevalent challenges we have identified that climate technologies face in aligning with traditional investment structures:

- **Investor preference for capital-light technologies,** which can produce large returns with a low upfront investment[22]
- **Mismatch between investor timelines and long routes to market** for climate technology[23, 24, 25]
- **Perceived high risk and/or low short-term returns** from climate innovations[26]
- **Increased perceived and real risk** when funding the transition from carbon-intensive business models
- **Perceived lack of liquidity and profitability** into low-carbon investments
- **Lack of communication and coordination among funders** from one stage of technology development to another
- **Lack of deal flow** due to limited public and philanthropic investments in incubators and accelerators[27]
- **Lack of tools and incentives** to align portfolios with a low-carbon future

Currently, there's a short supply of funders willing to provide the risk-tolerant, patient capital that can help bridge the gap when conventional financing is not available.[28] The following section outlines five areas of consideration that can aid investors looking to step forward and fill this gap, helping startups to overcome the barriers listed above.

22 Pole-to-Pole Innovation: Funding Socially Impactful Physical Products—Impact Engineered, Bruce Usher, 2019.
23 Advancing the Landscape of Clean Energy Innovation—Breakthrough Energy Ventures, 2019.
24 Fostering Energy Innovation for a Sustainable Twenty-First Century—40 Big Ideas for a Sustainable Future, Ken Gillingham, 2019.
25 Advancing the Landscape of Clean Energy Innovation—Breakthrough Energy Ventures, 2019.
26 Ibid.
27 Ibid.
28 Ibid.

KEY CONSIDERATIONS AND INSIGHTS

Every startup is different, and every investor is different, so it's not possible to develop a step-by-step playbook for investing in nascent climate technologies. However, based on our conversations with investors and startups across the climate technology landscape, we have identified five broad insights or areas of consideration that may help investors to address barriers and unlock new opportunities. The subsequent "Case Studies" section delves into specific examples where some of these insights have been successfully put into practice.

1 IMPROVING COLLABORATION AND COORDINATION among investors across multiple stages of technology development and investment types

Investors tend to work in silos. They often focus on specific stages of innovation, and they often have distinct objectives for returns and impact, as well as distinct constraints. To some extent, specialization is valuable. It is important for investors to be able to deploy specific investments that are targeted and require a degree of focus and expertise. However, if investors deploy capital in silos without understanding the priorities of other investors, they risk limiting the development—and subsequently the financial returns and impact—of nascent climate technologies. When investors understand the expectations and constraints of other investors—particularly across the stages of technology development and investment types—they can better understand and improve on their own unique value-add.

For instance, if an investor deploys capital with complex terms, it may impede the startup that is receiving the investment, as the company will need to explain and justify these terms to other investors when seeking future rounds. Nicholas Flanders, Co-Founder of carbon conversion startup Opus 12, said in an interview, "In general, I like to keep it simple. It's hard enough to raise money. If you create a new structure with all kinds of payback clauses—'if' and 'when'—then you have to go out and explain it to investors. It's not a one-time thing. You'll have to be explaining to them for the life of the company."

Investors at different stages have distinct roles to play in helping nascent climate technologies achieve the next steps towards commercial success. Investors are most effective when they understand their roles, including where they can be most valuable to start-ups.

For instance, unrestricted grant capital can be essential when the viability of the technology remains uncertain, regardless of start-up stage. Flanders said, "It's really hard to raise investor funding for technology risk, so grants are a way of reducing the technology risk and reducing funding risk." This non-dilutive capital can help cover high capital expenditures for early-stage technology development, costs that private capital will not likely fund.

Additionally, grants and other early sources of capital can reduce risk and open the door for future investment because later-stage investors benefit from the knowledge of how the money was spent. Often, investors assess potential investments independently. This can duplicate due diligence efforts, even if investors are willing to share information, because investors seek distinct sets of information related to their particular investment priorities. By better understanding the investments startups have previously received, investors can accelerate their own diligence processes and reduce the perceived and actual risk of their investments. For instance, a venture capital investor may learn from a grantmaker how efficiently a team learned or how extensively they were able to de-risk a technology.

2 STRENGTHENING THE ECOSYSTEM of climate innovation across the investment landscape

The climate technology ecosystem is rapidly maturing, but it still has room to grow towards becoming a fully established marketplace, where startups and investors can efficiently and effectively find one another.

For early-stage companies, there are two broad mechanisms that generate investment deal flow:

- **Demand-pull—** investors actively targeting startups
- **Demand-push—** start-ups actively targeting investments

Because the ecosystem of nascent climate technology startups and investors is in development, many startups and investors may not be aware of each other. Investors interested in addressing climate change may not have knowledge of startups developing promising technologies, and startups may struggle to find the investors who are potentially interested in backing them. This challenge applies to multiple types of investors, from philanthropists to venture capital firms. In addition to limiting the benefits of collaboration discussed in the previous section, this market information failure restricts the ease and volume of investment deal flow.

Currently, many investors need to do a disproportionate amount of legwork to identify suitable climate start-ups, relative to other potential investments. This can be time-consuming, and it can increase the duration and transaction associated with investing in nascent climate technologies, as well as increase bias towards what is familiar or more accessible. When interviewed for this report, Professor Todd Cort of Yale University

speculated that cleantech may face many of the same risks as any early-stage technology, but he emphasized that the industry faces particularly high "search costs," as investors have to assess both financial and environmental risks and returns.

Some stakeholders are working to address the ecosystem gap for investments in nascent climate technologies. They are developing solutions—like platforms, databases, membership communities, and tools—to help investors better deploy capital towards nascent climate technologies, and to help startups find investors.

Figure 3. Challenges and solutions for ecosystem gaps in financing climate technologies

	Start-ups / Investments	Investors
Demand-pull (Investors seeking startups)	**Challenge:** Start-ups with duplicative technologies in the same investment pool **Solution:** Communities and networks of climate mitigation technology startups (e.g. Activate, Carbon XPrize)	**Challenge:** Investors making investment decisions on incomplete information with high search costs **Solution:** Database platforms that aggregate deal flow data for investors and start-ups to use (e.g. Global Innovation Exchange, CRANE)
Demand-push (Startups seeking investors)	**Challenge:** Start-ups not knowing which investors they can approach for investment **Solution:** Incubator programs with established funding connections to recommend (e.g. Echoing Green, Elemental Excelerator)	**Challenge:** Investors not having the knowledge to collaborative and learn from one another **Solution:** Membership organizations convening different investors (e.g. Global Impact Investing Network, Aspen Network of Development Entrepreneurs)
Other coordination gaps	**Challenge:** Start-ups experiencing multiple valley of death investment gaps, or getting delayed at different phases of technology development **Solution:** Firms or funds providing industry connections for pilots (e.g. Shell Foundation, Closed Loop Partners)	**Challenge:** Investors not having sufficient upstream or downstream pipeline for investment and follow-on funding **Solution:** Partnerships among different investors across capital types (e.g. Echoing Green & TPG Rise, Techstars & The Nature Conservatory)

3 BUILDING INVESTOR CAPACITY to effectively evaluate, select, and fund nascent climate technologies

As nascent climate technologies receive more funding, some of that capital will come from investors who are well versed in the space, while other funding will inevitably come from investors with less experience. For instance, Draper Richards Kaplan Foundation, which traditionally provided grants to nonprofits, is now also making more traditional investments into for-profit startups.

Attracting a wider set of investors is a positive step forward, but in some cases, less experienced investors may lack the capacity to effectively understand the benefits and drawbacks of new technologies or to implement the flexible financial structures needed to fund them. This lack of expertise can cause delays, mistakes, and undue complexity—stumbling blocks that can both hinder technology development and lead to lower investment returns.

In interviews, entrepreneurs shared stories about investors who were inexperienced in deploying non-traditional investment tools. For instance, we heard about a foundation that claimed to offer philanthropic investments like program-related investments (PRIs), but after some due diligence, it was clear they had little experience actually deploying these investment instruments. This led to significant delays to investment as the foundation worked out deal terms.

Having an experienced team can be crucial when employing innovative financial strategies. Nascent climate technologies often depend on non-traditional investment structures, some of which combine elements of philanthropy with more return-oriented investments. While certain forms of expertise may still be transferable, traditional venture capital models may not always align with these structures. Deploying alternate investment tools requires a balanced combination of specialization and diversity of skills, as well as experience within teams. For instance, investors like Prime Coalition, Autodesk Foundation, and The Rockefeller Foundation have dedicated team members with experience across investment tools. Some organizations may find it difficult to hire and compensate team members with the necessary capacity for success in a field that is still relatively small, so other strategies may be necessary—for instance, specialized training for staff and collaboration with other investors.[29]

Along with financial expertise, investing in nascent climate technologies also requires a familiarity with climate and energy systems, especially as they relate to the emissions impact of a given technology. Given that nascent technologies are often intended to replace existing technologies and systems, the possible benefits can be complicated to quantify. To help build investor capacity, Prime Coalition recently launched a beta version of an open-source tool, CRANE, which provides a standard procedure for investors to assess the greenhouse gas reduction potential of new technology.[30] The first version was released in April 2020 and is available for free to many users.

29 Advancing the Landscape of Clean Energy Innovation—Breakthrough Energy Ventures, 2019.
30 CRANE Backstory—CRANE, 2020 (https://cranetool.org/about/)

In interviews, investors expressed a desire to learn from other investors' experiences and deal structures. This report contains a few case studies with informative examples of funding nascent climate technologies. Although examples like these can be a helpful reference point for investors, they are not a substitute for internal team capacity. Even when investors deploy capital with the help of external matching and advisory services, team experience is crucial, because these services are only as effective as the client's ability to subsequently guide the investments.

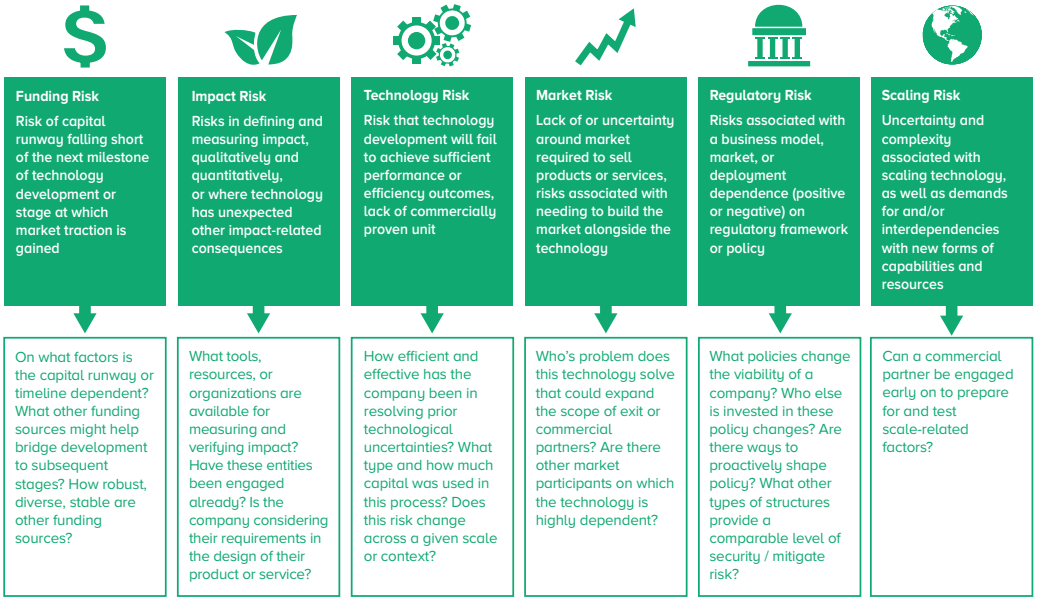
Team capacity allows investors to deploy their capital nimbly and strategically, which enables more efficient use of resources as well as better support for startups. For instance, Autodesk Foundation was able to use different funding structures at different stages of technology to flexibly support Amped Innovation—a startup developing solar-powered appliances for low-income customers. First, Autodesk provided a grant to execute initial R&D and early product development. Later, once Amped Innovation was able to show market demand for its product line, Autodesk Foundation made an equity investment as part of the startup's Series A funding round (See "Case Studies" for more information).

4 BETTER ALIGNING RISK AND RETURN METRICS with investor capabilities and start-up needs

A flexible understanding of risk and return is important for investing in nascent climate technologies. According to Shuaib Siddiqui, Director of Impact Investing at Surdna Foundation, "investors need to have clarity of the risk [they] are willing to take to determine the type of capital [they] are willing to bring to bear."

Figure 4 outlines some examples of different types of risk, along with some guiding questions that investors can ask themselves to understand and mitigate these risks. This list is not intended to be exhaustive but rather to serve as a helpful starting point for consideration.

Figure 4. Key risks and corresponding investor questions associated with nascent climate technology development



Investors have specialized risk and return profiles, which influence the types of investments they are willing to make. "Each foundation is different. Each bank has different risk assessments and different risk profiles. Foundations are no different," said Siddiqui in an interview. This applies to most types of investors, not just foundations, as investors often have some unique value proposition or investment thesis that differentiates them when raising funds or seeking investment opportunities.

Investors are constantly working to understand and manage the risk of their investments, but they are always likely to face higher levels of risk when investing in nascent climate technologies, compared to more proven technologies. Many of these inherent risks are not unique to climate technologies; they exist for any new technologies that face uncertainties on the pathway to commercialization.

Fortunately, collaboration among investors can reduce risk and increase overall investment. A 2019 report from the impact consulting firm Tideline found that risk-tolerant, patient capital can mitigate the risk faced by more cautious investors when different sources of funding are combined into blended capital structures.[31] Additionally, some capital types are built for risk. Siddiqui said, "from a Surdna Foundation point of view, the role of PRIs is that they are risk-seeking, trying to figure out where things do and don't work."

Some investors specialize in certain types of risk, so it is important to clearly identify the risks that a given startup is facing. Robert Ethier, Vice President of Investments at Activate, noted in an interview that grant capital can be particularly useful for reducing technology risk, whereas venture capital is more optimized for addressing market risk. Thus, if investors can clearly distinguish between technology and market risk, then they can strategically direct their funding and support. As discussed earlier in this report, funders can further accelerate technology development by collaborating across silos to explicitly identify and determine which type of capital is addressing which type of risk.

Even when risk and investment tools are aligned, it is important for investors to adapt their risk assessment and performance tracking to the natural development profile of the startup. The pathway to commercialization for nascent climate technologies can be non-linear, with slow and intermittent breakthroughs, yet many investors employ performance measures, reporting, and milestones that are linear, requiring periodic progress updates. These metrics are often a way for investors to measure and manage the risk of their investments. Performance metrics that accommodate non-linear progress—as well as those that reward learning and agility—can provide startups with the necessary latitude to experiment and take smart risks during critical phases of technology development.

Nicholas Flanders of Opus12 spoke in his interview about the long-term limitations of inflexible performance assessment:

"Artificially tight intermediate milestones during the technology development phase can create undue burdens. With frontier technology development, there may be no perceived performance improvement for several months, but during that interval, you have been trying many experiments, figuring out what doesn't work and then put those learnings together to achieve a 5 or 10X increase in performance; which means, if each month you have a goal that is following a linear trend upward, those update meetings are not going to go well. It is not the same as business performance tracking later in the development cycle."

31 Catalytic Capital: Unlocking More Investment and Impact—Tideline, Christina Leijonhufvud et al., 2019

5 ENHANCING NON-FINANCIAL SUPPORT, such as expertise, partnerships, connections, equipment, and political advocacy

Most, if not all, investors who fund nascent climate technologies engage in some form of non-financial support for those start-ups. This non-financial support can include tangible resources, such as office/lab space and legal or administrative services, as well as non-tangible support, such as mentorship, expertise, and partnership.

As an example of tangible resources, an entrepreneur mentioned having lab equipment and space at Lawrence Berkeley National Laboratory, which the startup was able to access through the Cyclotron Road program. This lab space was critical for the startup to test and develop its technology. Having access to those resources reduced the financial burdens of renting or purchasing equipment in the early stages of the development process.

Some entrepreneurs also mentioned the importance of non-tangible support. For instance, one interviewee mentioned that the community built through the Echoing Green fellowship provided essential psycho-emotional support when they were on the verge of giving up. This kind of support may not seem significant, but founders of climate technology startups face a difficult and discouraging path. Many founders start out with a high level of passion and drive, but progress can be slow, often hampered by a variety of frustrating roadblocks. It can make a critical difference when partners not only provide business and technical expertise but also give psycho-emotional support when founders inevitably meet setbacks.

Another key form of non-financial support is facilitating strategic relationships and connections. As noted earlier, the ecosystem of climate technologies often relies heavily on informal networks. In interviews, entrepreneurs noted that they valued having investors who could connect them to industry and commercial partners. Industrial partnerships with energy utilities, corporations, or government facilities can be critical for deploying pilots and enabling later-stage financing, especially for innovations with heightened commercial risk where a market is still in development — such as carbon removal. Pilot projects enable entrepreneurs to test, iterate, and prove the feasibility of their technology, as well as better understand commercial or non-commercial needs across the value chain.

Sometimes, commercial partners can also become valuable funders through corporate venture capital arms. In multiple interviews, we found that corporate VC funding can provide a unique form of risk-tolerant and patient capital. With these investments, financial and non-financial support tend to go hand in hand. Corporate funding is often more flexible than traditional VC in terms of returns and timelines, and corporate partners can provide strategic benefits, such as opportunities for learning and technology development, as well as connections to a ready customer pool.

However, the downside of commercial partnerships is the potential narrowness of a corporation's interest, which might constrain the trajectory of an innovation. Jake Harris of DBL Partners noted the parameters that should be in place with corporate venture capital (CVC):

"CVCs can be great investors and value-add partners for early-stage companies, but their financial and corporate objectives need to be aligned. Additionally, they need to be committed for the long-term. CVC's can't let changes in strategy change their long-term commitment, either to their portfolio companies or to the asset class more broadly. At the same time, start-ups are smart to have a syndicate of investors to hedge outsized influence from one single corporate investor in the case things do go wrong."

Finally, multiple investors pointed to the importance of policy mechanisms for accelerating climate innovations. Regardless of the technological readiness of a company, nothing can replace the need for policy incentives and other mechanisms that promote market adoption, given the difficulty of changing institutions and behaviors in an intrinsically high-carbon economy.

"What is notable about clean energy innovation is that public policy is engaged not simply to regulate or channel the dynamics of the market but also to create and amplify the market... [Public policy]... should be further strengthened and aligned to support both the supply and demand ends of the clean energy innovation ecosystem. The aim should be to create market forces strong enough to make rapid innovation profitable for innovators and investors and attractive to adopters, in the face of significant system inertia." [32]

– "Catalytic Capital: Unlocking More Investment and Impact," *Tideline*, 2019

Numerous investors cited the need for regulatory and policy support. DBL Partners takes an active role in trying to shape that support, through engagement with policymaking and regulation. The firm works with regulatory bodies at the federal, state, and local levels, advocating on behalf of portfolio companies on issues like compliance, permitting, and access to government resources. See Box 2 for specific examples.

Box 2. Promoting clean energy through public sector engagement (examples from DBL Partners)

- **Round table meetings:** This year, DBL plans to host a round table with several government agencies that regulate the energy industry, such as the California Energy Commission, the California Public Utilities Commission, and the California Independent System Operator (CAISO). DBL has a history of hosting cleantech investment round tables with state-level clean energy advisors, including meetings in 2016, 2017, and 2018. These round tables focus on clean energy policy in solar, energy storage, and other relevant industry sectors, helping to create a more favorable environment for innovation in these sectors.

32 Catalytic Capital: Unlocking More Investment and Impact—Tideline, Christina Leijonhufvud et al., 2019.

- **Legislative advocacy:** In 2019, DBL presented to the California State Assembly and Senate Hearing Committees in support of Assembly Bill 689, which would allow the Sacramento Municipal Utility District (SMUD) to take a financial stake in clean energy startups. Specifically, the bill gives SMUD the ability to acquire a non-stock security in a clean energy startup, and thus monetizing SMUD's intellectual value and time with companies to help develop clean energy products. California Governor Newsom signed the bill into law in September 2019. Now, SMUD is able to undertake a higher quantity and quality of collaborations with new clean energy entrants.
- **Regulator outreach:** In 2018 and 2019, DBL had a series of meetings and conversations with energy regulators to explain the business case for energy storage. Specifically, DBL representatives explained the value of the California Self Generation Incentive Program (SGIP), which provided financial incentives for storing electricity generated by residential and commer cial solar systems. In 2018, former California Governor Jerry Brown signed Senate Bill 700, which increased the pool of money in SGIP to over $1 billion. In meetings, DBL provided guidance as to how to implement the program in a way that would be workable for energy sector startup companies.

In some industries, political advocacy can be a form of protectionism that boosts companies at the expense of consumers. For nascent climate technologies, effective advocacy produces clear and widespread social benefits, in the form of reduced emissions. Investors can massively amplify their impact if they work not only to support individual start-ups within their portfolio, but also to create a thriving ecosystem in which many emissions-reducing start-ups can succeed. The Silicon Valley Leadership Group is one example of the types of coalitions that are forming to leverage the critical role of policy support. The association champions policy measures and initiatives that span the future innovation economy of the United States, including energy and the environment.

Box 3. Summary of non-financial support for nascent climate technologies

- Tangible assets, like lab/office space and equipment
- Non-tangible assets, from back-end services to mentorship and psycho-emotional support
- Access to commercial partners and co-investors
- Policy engagement on behalf of both portfolio companies and the entire climate innovation ecosystem

CONCLUSION

Early-stage innovations are critical to addressing the pressing challenge of climate change. Nascent climate technologies have the potential to offer new alternatives to carbon-intensive industries, as well as accelerate the deployment of existing solutions that have not yet reached the market at scale. Despite this imperative, early-stage climate innovations face funding gaps, both because of a challenging history and because they often pose a risk-return profile incompatible with traditional investment structures. At the same time, many investors can lack the skills, capacity, and mindset to deploy capital at the scale required to truly transform the economy.

Given these challenges, this report has explored how funders can help climate startups to reach wide-scale commercialization. Our findings suggest that risk-tolerant, patient capital is critical for advancing climate technologies, but the ecosystem that will provide this capital is still emerging. As the ecosystem continues to grow, there is room to improve on coordination, expertise, and frameworks for assessing risk and returns. Finally, the investors interviewed for the report have cited the need for non-financial support, such as policy engagement, but they have observed that the delivery of such support remains inconsistent. To these ends, the report includes the following insights and considerations:

1. **Improving collaboration and coordination among investors across multiple stages of technology development and investment types**
   Investments into nascent climate technologies are generally made in silos. Coordination among investors, including strategic use of varied investment types, can improve the efficiency and effectiveness of capital.

2. **Strengthening the ecosystem of climate innovation across the investment landscape**
   There is a growing ecosystem of startups and investors who are focused on nascent climate technology. Better tools, resources, and partnerships could improve this ecosystem and increase the flow of information and capital.

3. **Building investor capacity to effectively evaluate, select, and fund nascent climate technologies**
   Sometimes, investors are interested in investing in nascent climate technologies, but they lack the expertise to do so effectively, which can hinder the startups receiving investment. This necessary expertise includes a grasp on the complexities of nascent climate technology development, as well as an understanding of the nuances of the investment types being used.

4. **Better aligning risk and return metrics with investor capabilities and start-up needs**
   Traditional metrics for risk and return are often too limited to accurately evaluate investments in nascent climate technology. Investors interested in these technologies can benefit from employing adaptive and flexible evaluations. This approach can help investors strategically match their investments to different types of risk.

5. **Enhancing non-financial support, such as expertise, partnerships, connections, equipment, and political advocacy**
   Non-financial support can be under-used as an effective post-investment approach to improving the success of nascent climate technologies. This support can take many forms, such as commercial partnerships, legal expertise, research and development facilities, and political advocacy.

These considerations are presented with intentionally broad applicability, and they can inform a variety of creative solutions. They reflect themes from conversations with active players in this emerging area and, hopefully, provide inspiration for more conversation and action to come.

CASE STUDIES

CASE STUDY: AUTODESK FOUNDATION AND AMPED INNOVATION

Investor:	Autodesk Foundation
Startup:	Amped Innovation
Financial Structures Used:	Grant, preferred equity through a donor-advised fund (DAF)
Deal Size:	$75,000 (grant); $250,000 (preferred equity, out of $3 million total round)
Deal Stage:	Pre-seed round for grant, pre-revenue
Timing of investment:	Late 2016 (grant), September 2019 (preferred equity)

The Autodesk Foundation is the separate and distinct philanthropic arm of American software giant Autodesk. Autodesk makes software services for the architecture, engineering, construction, manufacturing, media, education, and entertainment industries. The company's vision is to help people imagine, design, and make a better world. The Foundation's mission is related and focuses on supporting the design and creation of innovative solutions to the world's greatest challenges including climate change and inequality.

Since 2016, the Autodesk Foundation has participated in both grant and equity financing deals with Amped Innovation, a solar appliance designer that focuses on energy efficiency and helping people in developing countries to monetize appliance usage. While Amped Innovation mainly focuses on energy access, the

technology can contribute to climate change mitigation by enabling climate-conscious economic growth. We have also chosen to highlight this case because it exemplifies the challenges and best practices highlighted elsewhere in this report.

The Autodesk Foundation felt that an investment in Amped Innovation would fit well with the foundation's ability to tolerate higher risk and longer investment timeframes. Amped Innovation's portfolio of solar collector systems designed for off-grid applications, especially in African emerging markets, also fit well with the foundation's interest in providing catalytic capital to companies focusing on impact through the development of hard technology. The $75,000 grant was followed by a $250,000 equity investment during Amped Innovation's growth phase financing.

The Autodesk Foundation was able to effectively utilize a donor-advised fund (DAF) to distribute these investments. DAFs work by creating or using a separate entity from the donor that receives charitable contributions. The tax benefit of the donation is realized by the charitable entity right away, but the money does not need to be deployed immediately. Funds can then be distributed from the DAF, with guidance from the philanthropist, in accordance with organizational goals. If Autodesk Foundation is able to recoup their investment the foundation will look to redeploy the funds to other investment opportunities that are in line with their mission.

To help carry out the investment, Autodesk worked with ImpactAssets, an impact investing facilitator that helps charitable companies find philanthropic opportunities in line with their mission. With the help of ImpactAssets, Autodesk was able to help fill Amped Innovation's $3 million preferred equity series-A round. Deploying this type of philanthropic capital at a critical growth junction was an example of providing the right type of capital at the right time. Initially, Autodesk Foundation deployed a grant to help grow Amped Innovation at an early stage, while later they were able to use flexible equity financing to continue to support Amped Innovation's growth. In this case, the equity financing also included an observer seat on the board which provided an opportunity for Autodesk Foundation to stay informed with Amped Innovation's strategic direction and best match post-investment support to what was needed.

In addition to funding, Autodesk Foundation also provided non-financial support to help Amped Innovation to generate net income, which is a step that often attracts new investors and opens new opportunities. The support offered to Autodesk Foundation portfolio organizations includes access to and training on Autodesk's product suite, talent acquisition support, marketing resources, and advice on how to structure contractual agreements.

Amped Innovation closed their series-A round in October of 2019. The $3.3 million raised as part of this investment round will help accelerate Amped Innovation's ability to bring high-quality, affordable solar-powered appliances to market, serving growing demands from energy distribution companies, utilities and mini- and micro-grid providers for better power solutions.[33] As Co-Founder and CEO Andi Kleissner put it: "The completion of our Series A funding marks the beginning of an exciting and critical new chapter for Amped Innovation."

33 https://www.ampedinnovation.com/post/amped-innovation-closes-series-a

CASE STUDY: ELEMENTAL EXCELERATOR AND GO ELECTRIC

ELEMENTAL EXCELERATOR

Investor:	Elemental Excelerator
Startup:	Go Electric
Financial Structures Used:	• Grants to Go Electric, and • Donations of warrants to Elemental Excelerator
Deal Size:	• $75,000 for the Go to Market track • "Up to $1M" for the Demonstration track (Elemental prefers not to disclose funding amounts for individual companies in the Demonstration track)
Deal Stage:	Seed and Series A
Timing of investment:	• 2015 (Go-to-Market Track) • 2017 (Demonstration Track)

Elemental Excelerator was founded in 2011, primarily as a grant-making entity. The team soon discovered that if they handed out money without providing additional structure or support, they were not going to achieve the outcomes they desired, no matter how enterprising the startup. The organization was uniquely placed to deploy a number of the strategies mentioned in this report, such as using innovative financing mechanisms, setting flexible return expectations, and providing non-financial support. Thus, in addition to providing funds, Elemental created two programs, dubbed "tracks," to support startups. Elemental's "Go to Market" track now provides support to start-ups in the pre-seed or seed stage that are still developing their technology. At a later stage, the "Demonstration" track, supports start-ups that are looking to scale or build out their business.

Startups admitted to the Go to Market track receive up to $200,000 in funding contingent on completion of certain milestones. These milestones are bespoke for each company and could include objectives such as completing coaching modules, or getting steel on the ground for the project. Elemental does not own the projects but instead makes a grant to an organization which in turn provides a warrant of 3% for Go to Market track start ups (whereas Demonstration track projects receive 1% warrants). Warrants are options to buy equity in the future. Entrepreneurs are then paired with a market intelligence coach and receive customized support for any area where they need support. This could include identifying buyers; developing channels to reach buyers; refining their value propositions; pitching to potential partners and investors; or scaling up their operations and manufacturing.

Startups admitted to the Demonstration track receive up to $1M. In addition to funding, Elemental supports the companies with guidance on project management, navigating complex permitting or regulatory processes, and connections to investors, customers, and other partners. Startups in the Demonstration track are typically seeking to develop transformational demonstration projects, attempting a geographic expansion, or improving a technology feature for an existing product.

Founded in 2011, Go Electric is a startup that builds turnkey microgrids. Microgrids enable electricity consumers to disconnect, or island, themselves from the main electrical grid. Islanding enables electrical consumer independence of the grid thereby increasing their resilience and ensuring continuous power for critical infrastructure even in times of grid disruption. Initially the startup provided microgrids for military bases, but now aims to scale their operations to serve industrial and commercial customers.[34] But to build out the company, Go Electric needed some support.

In 2015, Go Electric was accepted into Elemental's "Go to Market '' track and received $75,000 in seed funding from Elemental Excelerator. In return, Elemental Excelerator received warrants. Prior to joining the Go to Market program, Go Electric had raised $150,000, primarily from friends, family, and grant money. Go Electric subsequently raised a $4M series A in 2016. Then, in 2017 Go Electric was accepted into the Demonstration Track and received undisclosed funds of up to $1M. While Go Electric was in the Demonstration Track, Elemental also supported the startup by refining their utility business model and supporting intensive customer discovery. Go Electric's CEO, called the process "customer discovery on steroids." Other investors in Go Electric included: WindSail Capital Group (growth capital provider), ACRE (financial consultant), GP Investments ("alternative" investments firm), and Clean Energy Trust (patient capital, non-profit). Go Electric was also able to secure a contract with the Department of Defense to build a demonstration project at Camp Smith in Hawaii. Go Electric has made an impact through transitioning critical infrastructure between grid-mode and islandmode with reliability, transparency, and security. Beyond impact, Elemental's investment in Go Electric could provide a sizable return when the company exits.

Across Elemental's portfolio of 99 companies there have been a total of 10 exits. All exits have been by acquisition. These exits have not been "home runs," which is exactly what Elemental anticipated. Elemental's strategy has been to target more "middle of the road" companies with moderate risk and return profiles.

34 https://www.greentechmedia.com/articles/read/military-microgrid-startup-go-electric-wants-to-bring-energy-resilience-to

CASE STUDY: PRIME IMPACT FUND AND LILAC

Investor:	Prime Impact Fund
Startup:	Lilac Solutions
Financial Structures Used:	Equity
Deal Size:	$1.4M
Deal Stage:	Pre-A
Timing of investment:	November 2018

Prime Impact Fund is an early-stage venture capital fund comprising catalytic capital and built by Prime Coalition, a non-profit public charity whose mission is to mobilize philanthropic capital to help mitigate climate change.

Core to Prime Impact Fund's investment thesis is the belief that climate change is an urgent, existential threat. We must reduce greenhouse gas emissions by approximately 70 gigatons of CO2-equivalent by 2050, but existing technologies can only take us roughly halfway there; achieving the goal will require new solutions not yet deployed. A profound capital gap persists for companies developing these solutions at the earliest stages in sectors like energy, agriculture, water, and waste. Prime Impact Fund fills this gap with catalytic capital that has inherently higher tolerance for risk and long timeframes than conventional venture capital. By investing early and working closely with entrepreneurs as a hands-on partner, Prime Impact Fund de-risks these companies for follow-on, commercial investors, who can then scale them for impact as large, enduring, and self-sustaining enterprises.

Drawing on the success and relationships developed through Prime Coalition, Prime Impact Fund's investors include family foundations large and small; donor-advised funds; corporate giving programs and high net worth individuals and family offices. To date, Prime Impact Fund has co-invested with several organizations including Breakthrough Energy Ventures, The Engine, Clean Energy Trust, BioEconomy Capital, Safar Partners, and the Grantham Foundation.

One example of early traction can be observed through Prime Impact Fund's first investment – Lilac Solutions. In November 2018, Prime Impact Fund led a $1.4 million pre-A round in Lilac, a lithium extraction start-up whose technology enables the economic utilization of lithium from unconventional resources for the growing electric vehicle market. At scale, Lilac's cheaper and environmentally-friendly lithium production process has the potential to abate 280 million metric tons of carbon dioxide by 2050, equivalent to removing more than 605 million cars from the road for one year. The science behind the founders' idea was well tested, but traditional venture investors saw the opportunity as too high-risk at the time of Prime's initial investments. Since receiving Prime's support, Lilac developed its technology for market introduction and signed commercial pilot agreements with customers on three continents. The catalytic capital that Prime Impact Fund provided enabled Lilac to mature as a company and become more attractive to follow-on investors, which is helping to bring Lilac's solution to scale.

CASE STUDY: DBL PARTNERS AND ZOLA ELECTRIC

DBL PARTNERS
DOUBLE BOTTOM LINE VENTURE CAPITAL

Investor:	DBL Partners
Startup:	Zola Electric
Financial Structures Used:	• Equity– DBL Partners, SolarCity and Other Investors • Debt– Packard Foundation, Ceniarth, Calvert Foundation • Grant– USAID
Deal Size:	• $25M equity round led by DBL • $45M debt financing from Foundations
Deal Stage:	Series C
Timing of investment:	2015

Double Bottom Line Partners is a firm that uniquely sits at the intersection of venture capital and impact investing. DBL Partners was founded on the premise that a company's financial performance (The First Bottom Line) and positive social impact (The Second Bottom Line) not only complement but also enhance each other to drive performance and success. DBL has invested with this strategy for over fifteen years through multiple funds, which has resulted in DBL delivering top-tier first bottom line returns and investing in some of the biggest sustainability exits in the VC asset class, including the first IPO in the electric vehicle (EV) sector (Tesla), the first IPO in rooftop solar (SolarCity), and the first circular economy IPO (The RealReal).

In 2015, DBL led the Series C raise for Zola Electric (formerly Off Grid Electric), a full-service, vertically integrated pay-as-you-go solar energy company in Africa. At the time, the funding supported Zola Electric's scale up of its partnership with the Tanzanian government and entrance into its second African market, Rwanda.

This investment was an example of multiple groups coming together to support a company through the valley of death, with venture capital firms like DBL, corporate investors like SolarCity (and later EDF and Total), foundations, and government partners all investing together. DBL is expecting a venture-style financial return from Zola Electric, and the firm has already realized strong impact returns that are expected to continue to grow with the company over time as it brings power to the approximately one billion people who lack access to reliable, affordable power. Today, Zola powers 1 million people and offsets 120,000 tons of CO2 a year.

DBL has worked with Zola Electric on a number of “second bottom line” strategies and activities, aimed to further the company’s impact and create an enhanced competitive advantage, which then goes back to the first bottom line. One particularly impactful contribution on this front was through cleantech policy and thought leadership. In June 2018, DBL released the white paper, “Think Outside the Grid: Africa’s Trillion Dollar Energy Opportunity,” which examined how sub-Saharan Africa was emerging from a history of limited energy access. The region has an opportunity to unleash over $1 trillion of GDP simply by investing in off-grid solar in place of expensive and dangerous kerosene lamps, diesel generators, or unreliable connections to the electricity grid. The publication helped advance the clean energy agenda in Africa by educating the broader market on this emerging industry.

GLOSSARY OF TERMS

Capitalization table— A table that summarizes a company's ownership structure and value, including the percent ownership and equity value of each shareholder.

Catalytic capital— Debt, equity, and other investments that accept disproportionate risk and/or lower returns relative to a conventional investment in order to generate positive impact and enable third-party investment that otherwise would not be possible.

Cleantech— Technologies that reduce negative environmental impacts, particularly in the energy and power industry. Within the investment community, refers to technologies that are expected to be profitable, in part through their sustainability advantage. In this report, we more frequently use the term "climate technologies" in order to convey a focus on technologies that can potentially mitigate climate change.

Commercialization— The introduction of a product or service to the marketplace. This is often the final stage of development and entails overcoming challenges of production, distribution, sales, and marketing. Within climate technologies, this stage often faces particular acute challenges around regulatory uncertainty, which impacts margins and profitability, as well as less developed end-user markets.

Convertible note— A type of loan, or debt, that grants the holder the right to convert into shares, or equity, upon certain conditions, such as a predetermined conversion price or upon closing a round of funding. Some of the advantages of convertible notes for early-stage companies are that they allow founders and investors to delay fixing valuation until more information is available; they offer an easier, less complex, and more flexible mode of financing than many other options; and they often allow founders to retain control rights.

Debt— The provision of financial capital, with the expectation of repayment of the principal amount, often plus interest. Unlike equity, debt investments do not result in ownership of a company. However, they can be more secure than equity, as they are repaid before equity holders.

Donor Advised Fund (DAF)— A unique philanthropic tool that allows donors (e.g. individuals, families, or companies) to establish and fund a charitable account with a "sponsoring organization" that will (eventually) be used to support charitable activities. Donors receive an immediate tax deduction and maintain advisory privileges over the fund's ultimate distribution for charitable purposes (and in many cases over the investment options for the account). DAFs advantageously allow donors to decouple the timing of their charitable giving from any of the associated tax benefits (i.e. the tax deduction).[35]

Funders OR Investors— Entities who provide capital for startups and projects, with the expectation of a financial or non-financial return. This report reflects the trend towards more mixed financing vehicles, where the terms funders and investors are increasingly being used interchangeably.

35 Donor-Advised Funds: an underutilized philanthropic vehicle to support innovation in science and engineering—Massachusetts Institute of Technology, Ryan Macpherson et al. 2017

Investment thesis— The strategy that an investor uses to determine criteria and evaluate potential investments, usually based on research and analysis, as well as beliefs and assumptions about the state of the world.

Investment tools— Financial investment structures used to provide capital to startups in varied ways, depending on the needs of the investor and/or startup (e.g. unrestricted grants, recoverable grants, convertible notes, SAFEs, PRIs, MRIs).

Mission Related Investment (MRI)— A commercial investment that is intended to support an organization's social mission. In contrast to Program-Related Investments (PRIs), MRIs do not have to meet charitable standards and do not have any legal standards or requirements to qualify as such. However, as commercial investments, investors often expect them to meet the same prudent standards as other investments.

Nascent climate technologies— Early-stage hard technologies (not based in software) that have high potential to mitigate climate change. "Nascent" refers to the stage where they have already undergone research and development to establish basic technological efficacy, but they require further prototyping, development, and commercialization to reach the scale that is necessary to have a major impact.

Program Related Investment (PRI)— A mission-driven investment that must meet a legally defined charitable standard. Specifically, the IRS states that a PRI must meet the following criteria to qualify: 1) The primary purpose is to accomplish one or more of the foundation's exempt purposes; 2) Production of income or appreciation of property is not a significant purpose, and; 3) Influencing legislation or taking part in political campaigns on behalf of candidates is not a purpose.[36]

Recoverable grant— An investment tool with elements of both a loan and a grant, in which the recipient of capital repays the investor the principal amount and possibly an interest rate, based on financial performance. Like a loan, this structure allows the investor to recoup the capital if the recipient performs well, and like a grant, it is forgivable if the recipient does not perform well. Recoverable grants are becoming more widespread as a form of patient, affordable, and flexible capital in the United States.[37]

Simple Agreement for Future Equity (SAFE)— An investment tool created as a simple replacement for convertible notes. A SAFE enables a startup and an investor to accomplish the same general goal as a convertible note (granting the investor equity at a later date), though a SAFE is not a debt instrument]with a maturity date. The investor invests money and receives the right to purchase stock in a future equity round (when one occurs) subject to certain parameters set in advance in the SAFE.

36 IRS: Program-Related Investments. https://www.irs.gov/charities-non-profits/private-foundations/program-related-investments

37 France's 'Soft Loan' Model Paves Way for Recoverable Grants - Stanford Social Innovation Review, Alexandra Chamberlin, 2019, https://ssir.org/articles/entry/frances_soft_loan_model_paves_way_for_recoverable_grants_in_us

Unrestricted grant— A grant intended to support the general purpose of an organization, rather than a specific project. The grant is unrestricted because there are no stipulations on how the money should be used.

Valley of Death— The stage between breakthrough and commercialization where innovations often fail to move forward not due to technological shortcomings but due to lack of funding. In practice, new technologies tend to face multiple valleys of death, with potential shortfalls happening whenever they require a capital influx to move from one stage of innovation to another.

Warrant— A financial structure, issued by a company, that gives an investor the right to increase their ownership at a specified price until a specified expiration date. A warrant can be used as a type of incentive for attracting either equity or debt investors.

REFERENCES

A Valley of Death in the Innovation Sequence: an Economic Investigation—Research Evaluation, T.R. Beard et al., 2009.
https://academic.oup.com/rev/article-abstract/18/5/343/1519177

Advancing the Landscape of Clean Energy Innovation—Breakthrough Energy Ventures, 2019.
http://www.b-t.energy/wp-content/uploads/2019/02/Report_-Advancing-the-Landscape-of-Clean-Energy-Innovation_2019.pdf

Big Oils & Utilities Diverging Strategies for Energy Convergence—Goldman Sachs Equity Research, Michelle D. Vigna et al. 2019.
https://www.goldmansachs.com/insights/pages/gs-research/paths-to-power/report.pdf

Catalytic Capital: Unlocking More Investment and Impact—Tideline, Christina Leijonhufvud et al., 2019.
https://tideline.com/wp-content/uploads/Tideline_Catalytic-Capital_Unlocking-More-Investment-and-Impact_March-2019.pdf

Fostering Energy Innovation for a Sustainable Twenty-First Century—40 Big Ideas for a Sustainable Future, Ken Gillingham, 2019

Global Carbon Budget—Global Carbon Project, Rob Jackson. 2019.
https://www.globalcarbonproject.org/carbonbudget/19/visualisations.htm

Global Landscape of Climate Finance,—Climate Policy Initiative, Barbara Buchner et al. 2019.
https://climatepolicyinitiative.org/wp-content/uploads/2019/11/GLCF-2019.pdf

Innovative Finance for Energy Innovation—Deloitte, Jessica Kuntz, 2017.
https://www2.deloitte.com/content/dam/Deloitte/tr/Documents/energy-resources/innovative-finance-for-innovative-finance.pdf

IPCC, 2018: Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. World Meteorological Organization, Geneva, Switzerland, 32 pp.

Original commitment: see UNFCCC, "The Cancun Agreements," 2010. Extended commitment: see UNFCCC, "The Paris Agreement," 2015.

Pole-to-Pole Innovation: Funding Socially Impactful Physical Products—Impact Engineered, Bruce Usher, 2019.

Why the Clean Tech Boom Went Bust—Wired, Juliet Eilperin, 2012.

Start-up Blue Forest secures funding for first privately financed forest fire bond—Los Angeles Times, James R. Koren, 2018.
https://www.latimes.com/business/la-fi-fire-bond-20181101-story.html

The Investment Gap that Threatens the Planet - Stanford Social Innovation Review, Scott P. Burger, et al., 2018.
https://ssir.org/articles/entry/the_investment_gap_that_threatens_the_planet

Sustainable Finance Innovation Forum 2018 Key Takeaways—Goldman Sachs, 2018.
https://www.goldmansachs.com/insights/pages/sfi/key-takeaways-2018.pdf

Donor-Advised Funds: an underutilized philanthropic vehicle to support innovation in science and engineering—Massachusetts Institute of Technology, Ryan Macpherson et al. 2017.
https://innovation.mit.edu/assets/MIT-PRIME_DAF.pdf

Financing the Low Carbon Future—Climate Finance Leadership Initiative, 2019.
https://data.bloomberglp.com/company/sites/55/2019/09/Financing-the-Low-Carbon-Future_CFLI-Full-Report_September-2019.pdf

ACKNOWLEDGEMENTS

The authors would like to thank the following people for contributing their time and effort to the creation of this report:

Namrita Kapur (Yale University); Heather Fitzgerald (Yale University); Stuart DeCew (Yale University); Brendan Coffey (Steward); Peter Murphy (Global Impact Investing Network); Andrew Eil (Climate Finance Advisors); Logan Yonavjak (Consultant, formerly CREO Syndicate); Maureen Baehr (StartingUpGood); Dr. Graciela Chichilnisky (Global Thermostat); Sarah Kearney (PRIME Coalition); Nicholas Flanders (Opus 12); Thomas Belazis, (The Rockefeller Foundation); Ryan Macpherson (Autodesk Foundation); Ryan Kushner (New Energy Nexus); Hannah Davis (TechStars Sustainability Accelerator w/ TNC); Jake Harris (DBL Partners); Bruce Usher (Columbia Business School); Lauren Carter (Invest4Climate); Robert Ethier (Activate/Cyclotron Road); Christine Su (PastureMap); Richard Kauffman (NY Energy Research & Development Authority); Matt Logan (Elemental Excelerator); Todd Cort (Yale University); Steph Speirs (Solstice Initiative); Shuaib Siddiqui (Surdna Foundation).

The graphic design was created by Henk van Assen, Senior Critic at Yale University School of Art, together with Izzy Natale and Meghan Lynch, Designers at HvADesign.

ABOUT THE AUTHORS

Mikaela Bradbury
Mikaela Bradbury holds an MBA from the Yale School of Management and a Master of Environmental Management from the Yale School of Forestry & Environmental Studies. She is passionate about organizational and societal transformation and discovering innovative solutions to complex social and environmental problems. While at Yale, Mikaela served as a Research Fellow and Climate Change Innovation Coordinator with the Center for Business and the Environment and Research Assistant within the Department of Organizational Behavior. During her summer internships, she worked as an EDF Climate Corps Fellow, developing a climate change strategy for Williams Sonoma, Inc., and a Summer Associate in Goldman Sachs' Natural Resources Group, where she will be joining full-time in July 2020. Prior to Yale, Mikaela was an entrepreneur and brand strategy consultant. She graduated with a BA from Columbia University, Summa Cum Laude, Phi Beta Kappa. She has been a contributing writer for the Carnegie Council for Ethics in International Affairs and Greenbiz. Mikaela loves spending time in nature and practicing yoga.

Neil Yeoh
Neil Yeoh is the CEO & Founder of OnePointFive, a sustainability advisory and technology firm. During his time at Yale University, Neil served as a startup advisor for The Yale Center for Business and Environment. Prior to this, Neil was a Deputy Director at Echoing Green leading their startup post-investment support team and an $8.5mn climate portfolio. He has invested in and supported dozens of startups tackling climate change, helping them raise millions collectively to bring their solutions from lab to market. Neil writes for Forbes on next-generation climate solutions and startup investing. He has over five years of management consulting experience across four continents with Dalberg, Accenture and KPMG. Neil holds a Masters of Environmental Management from Yale University and an MBA from Oxford University. He also has degrees in Robotics Engineering, International Business, and Management from Adelaide and Hong Kong Universities.

Jake Billhorn
Jake Billhorn is a Joint MBA and Master of Environmental Management (MEM) Candidate at the Yale School of Forestry & Environmental Studies and the Yale School of Management. He is interested in developing strategies to actively encourage investment in ideas, technologies, and companies that are focused both on environmental and financial sustainability.

Prior to starting at Yale, Jake spent his career working as a commercial litigation consultant at the valuation firm Stout in Chicago. He has also worked on due diligence projects with Fenox Venture Capital and The Florida Aquarium. In addition, he served as a member of the Shedd Aquarium Auxiliary Board.

Originally from Chicago, Jake holds both a B.A. in Finance and a B.S. in Zoology from Michigan State University as well as the Sustainability Accounting Standards Board's F.S.A. credential.

Ben Linthicum
Ben Linthicum holds a Master of Environmental Management from the School of Forestry & Environmental Studies. While at Yale, he focused on sustainable finance, and he is broadly interested in how to mobilize capital to minimize the impacts of climate change. Before Yale, Ben worked for the Southern Appalachian Highlands Conservancy in Ashville, NC and the EPA in New York, NY. Most recently Ben worked for the City of Oakland's Sustainability Team where he revised the Oakland's climate action plan, wrote city council reports, and drafted the city's first electric vehicle action plan. Ben has a B.A. in Environment Studies from Warren Wilson College where he was a Udall Scholar and sat on the ESG Advisory Committee to the Board of Trustees. Originally from Missouri, Ben enjoys running, biking, and picking banjo.

ABOUT THE EDITORS

Ben Soltoff

Ben Soltoff is the Environmental Innovation Fellow at the Yale Center for Business and the Environment and the Tsai Center for Innovative Thinking at Yale. He works with students to explore how new ideas, technologies, and business models can address the world's most pressing environmental problems.

Ben holds a dual master's degree from the Yale School of Management and the Yale School of Forestry & Environmental Studies. As a student, he was dedicated to building Yale's ecosystem for environmental innovators, and he is continuing that effort as a full-time fellow.

Outside of Yale, he has worked for several environmentally relevant start-ups, ranging from a social enterprise in Mexico installing off-grid solar energy to a tech company in Silicon Valley building energy-efficient ovens that cook with light. He also has experience working on international climate policy at World Resources Institute as well as grassroots climate resilience initiatives in rural India.

Along with his Yale MBA-MEM degree, Ben holds a Bachelor of Science from Duke University.

Kathy Julik-Heine

Kathy Julik-Heine is focused on applying innovative policy and finance solutions to the renewable energy industry in the US and internationally. She received her MBA from the Yale School of Management, where in her first year she led initiatives in impact investing, student advocacy, and gender equality. Prior to business school, Kathy spent six years as a public sector management consultant with Deloitte Consulting, where she provided strategy and operations support to international development clients in the areas of local governance, women's economic empowerment, and energy sector development. In this capacity she lived in Brussels, Belgium, Hanoi, Vietnam and Washington, DC for 1, 2, and 3 years respectively. Kathy received her bachelor's degree in Economics from the University of Minnesota where she researched the efficacy of gender quotas and reservation policies in Northern India. Kathy's favorite brand to rep is her home state of Minnesota. She loves running, cycling, baking, live music, and discovering the secrets of new cities.

IMAGE CREDITS

Cover, left: U.S. Department of Energy, © 2013
https://www.flickr.com/photos/departmentofenergy/9094959460/in/album-72157634233150172/

Cover, right: Courtesy of Heidi Lim and the Opus 12 team

Page 5: Bureau of Land Management, © 2016
https://www.flickr.com/photos/mypubliclands/29812927675/in/album-72157670799277504/

Page 12: Bureau of Land Management, © 2016
https://www.flickr.com/photos/mypubliclands/29730317151/in/album-72157670799277504/

Page 13: Bureau of Land Management, © 2016
https://www.flickr.com/photos/mypubliclands/29730316311/in/album-72157670799277504/

Page 15: Bureau of Land Management, © 2016
https://www.flickr.com/photos/mypubliclands/29834173155/in/album-72157670799277504/

Page 24: Bureau of Land Management, © 2015
https://www.flickr.com/photos/mypubliclands/29206590404/in/album-72157670799277504/

Page 26: Bureau of Land Management, © 2013
https://www.flickr.com/photos/mypubliclands/29206586324/in/album-72157670799277504/