Stanford | Precourt Institute for Energy

OCTOBER 2017

# An Integrated Control Tower: Unlocking Long-Term Investment Capital for Clean Energy Innovation

*By Soh Young In,[*] Ashby Monk,[Δ] and Raymond Levitt[†]*

## *1. Introduction*

As recent history highlights, there are numerous challenges in bringing novel energy technologies from the lab all the way to the global energy marketplace. But one challenge in particular has proven particularly intractable recently; the lack of financing for clean energy entrepreneurs. This failure to connect clean energy entrepreneurs with aligned, long-term capital sources is often referred to as the "valley of death" (VoD), and it has two distinct manifestations: The first is the "technology valley of death", which refers to the inability to fund new technologies to the point of becoming viable businesses; and the second is the "commercialization valley of death", which refers to the inability to fund businesses to the point of full commercialization of the technology. The two valleys are, however, related. Because the commercialization VoD demands such a high quantum of capital, it limits the amount of capital willing to flow into the earlier stage companies, thereby exacerbating the technology VoD.

Part of the challenge in resolving both VoDs stems from inconsistent flows of investment capital into the clean energy industry, which has been aggravated by the recent failure of venture capital to deliver big winners in the Cleantech 1.0 boom and bust. Previous studies have shown that the VC funds' investments were unable to meet the capital demands for clean energy companies and projects, as their size and the duration of their capital could not prove a technology's commercial viability, and they could not manage the risk of illiquidity extending beyond the lifecycle of the fund (see, for example, Gaddy, et al., 2017; Ghosh and Nanda, 2010). From a structural point of view, there were insufficient exit options for early-stage investors, and there was also a lack of established investors to whom VC-backed companies could look for follow-on capital to help them overcome the VoDs (Mazzucato and Semieniuk, 2016; Monk, et al., 2015; Nanda, et al., 2013).

In this solution paper, we suggest that new capital inflows can and will increase if we can better allocate the risks (and thus returns) of clean energy investments

*Soh Young In - Corresponding author. Stanford University, Jerry Yang & Akiko Yamazaki Environment & Energy Building, 473 Via Ortega, Suite 242, Stanford, CA 94305, United States. Email: si2131@stanford.edu

ΔAshby Monk. Stanford Global Projects Center, Jerry Yang & Akiko Yamazaki Environment & Energy Building, 473 Via Ortega, Stanford, CA 94305, United States. Email: amonk@stanford.edu

†Raymond Levitt. Stanford Global Projects Center, Jerry Yang & Akiko Yamazaki Environment & Energy Building, 473 Via Ortega, Stanford, CA 94305, United States. Email: rel@stanford.edu

to the parties that can shoulder them. While this may sound like a simple fix, such as pushing illiquidity risks onto long-term investors, the complexity of actually allocating these risks correctly is high and requires new investment vehicles and structures. Indeed, based on our review of the marketplace, there are no (or very few) investment vehicles today that address the two key problems preventing the assignment of risks to the appropriate investors, namely the fragmented nature of investor networks and the large information asymmetries among different investor categories and companies. In the current clean energy capital market, there is severe discontinuity between pre- and post-commercialization investors, and, worse, their investment strategies are often misaligned. By this we mean that the two sets of investors' strategies do not actually overlap, thereby leaving a "valley" of corporate development uncovered by private investors. In addition, information asymmetries among investors mean that the risks of specific projects and companies and are not properly assessed and thus not compensated with commensurate returns.

As an attempt at a "solution", we develop a blueprint of a new investment intermediary that could achieve high investment returns through a multi-strategy vehicle that better aligns risks with investors. This vehicle will work as an integrated control tower, offering a tailored path to clean energy companies / projects for various types of large, long-term investors. We refer to this process as a "re-intermediation" of clean energy finance, as it is our belief that unlocking sufficient capital for the clean energy industry to thrive demands new financial intermediaries.

Specifically, this new investment vehicle will look to simultaneously deliver three core functions: (1) act as an anchoring institution that provides small amounts of priming capital and perhaps even take a first-loss position; (2) act as a trusted financial intermediary for long-term institutional investors (LTIs) looking to provide equity and debt capital for longer duration projects; and (3) serve as an information platform that provides reliable and objective information about clean energy companies or projects in a highly transparent and trustworthy manner. Such an investment vehicle will, we believe, lower barriers to clean energy funding and optimize access to available financial resource by directing "investor traffic" towards the most efficient and aligned investments products and opportunities.

Please note that this solutions paper is just an initial sketch of our ideas. The identified clean energy investment barriers, and the new investment vehicle designed to overcome them, will be further developed and supported by a follow-up academic study that will (1) demonstrate how the new investment vehicle can de-risk clean energy investments; (2) develop a framework to test the viability and scalability of the new investment vehicle using network analysis and organizational design; and (3) incorporate potential user feedback from a range of investors and entrepreneurs.

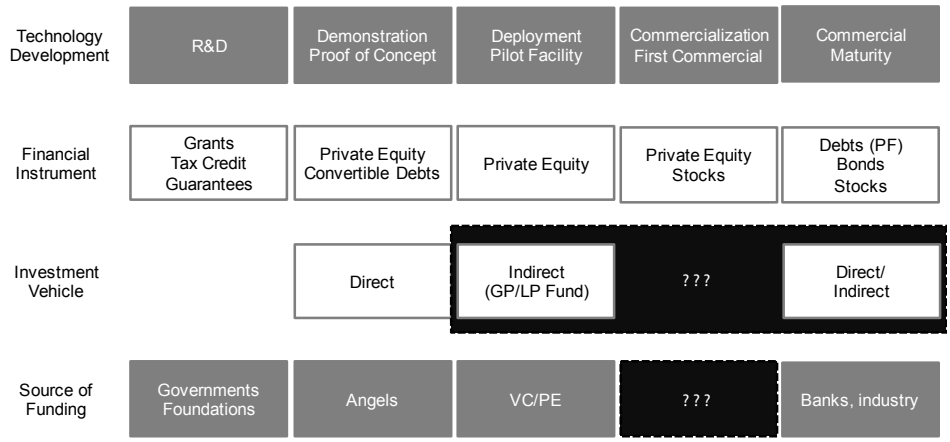
## 2. CLEAN ENERGY VALLEY OF DEATH

### 2.1 Technology Development and Investment

As innovative technology runs from a lab-scale idea to commercialized facilities, it is exposed to different types and magnitudes of risk. At each phase, different sources of investment capital are available through different investment instruments and vehicles (see Figure 1). This section analyzes current investment practice, such as key funding sources, how companies, investors and co-investment clusters interact throughout a company's development cycle and align risk and return through an investment vehicle in the specific context of clean energy innovations.

Our discussion sheds new light on the VoDs and shows them to be a continuous problem—not a discrete phenomenon. The VoD is located where either

**FIGURE 1: Stages of Technology Development and Sources of Finance**




investment capital does not exist to meet a specific capital demand and/or there are no overlaps between / among investment vehicles pre- and post-segment below. While most previous literature focuses on addressing either one of the two challenges, we claim that they are ultimately inseparable and should be addressed together.

**Research and Development (R&D):** Startups develop, test and redefine their new ideas at a lab scale. Since this phase requires relatively small amounts of capital, but has extremely high failure rates, public agencies are often required to support these lab-scale ideas before private investors come into play. There are research funds and government grants and subsidies directly available for universities and national labs to foster earlier technology development.

**Demonstration and Proof of Concept:** Startups validate and demonstrate their technologies and seek to show their scalability and profit potential via a proof of concept (PoC). A typical clean energy startup requires about $2M-$5M of seed funding to fully execute a PoC. Generally, entrepreneurs invest their own money (including family and friends' funds) or raise angel funding to get started. As many ideas require extremely high-risk technology development, startups often lack sufficient funding to escape the technology VoD. There are additional funding sources, such as seed funds, startup accelerators, seed-stage VC funds, and crowdfunding. However, in the wake of the clean energy bubble bursting, these have been fewer in numbers. That being said, some philanthropic investors, such as the Gates Foundation and the Breakthrough Energy Coalition, signaled they will direct significant resources to this sector to bridge the technology VoD. And PRIME has helped to re-intermediate philanthropic capital into demonstration and proof of concept breakthroughs. However, challenging educational, operational, and perceived regulatory barriers have prevented much philanthropic to flow into these opportunities.

**Pilot Scale and Deployment:** Startups need to validate their developed technologies at a pilot scale before deploying their product on a commercial scale. This is when VC funds actively participate and often seek a syndicate of like-minded co-investors. This phase usually takes about $20M+ and 2-5 years. As the startup still has no marketable product, and even sometimes no obvious market for future product, VCs tend to focus on the entrepreneur's vision and the realm of possible applications for the new technology. VC funds invest in exchange for equity, or an ownership stake, in the startups they invest in. VCs work closely with startups in order to reduce their investment risks and maximize future cash flow. Again, recently, many VCs have limited their participation because of the capital intensity of the asset class, reminding us of the important role the commercialization VoD can play in earlier stage investment activity.

**First Commercialization:** Startups next roll-out to large scale and first commercial plant construction to prove that a product has mass-market commercial viability. This phase requires high-scale and long-term capital investment, while its technology risks are still high. Late-stage VC funds (or "growth VC funds"), which raise and manage relatively larger pools of capital, will sometimes come in at this phase. Once commercial viability is proven, investors look for exit opportunities through public market transactions, including corporate merger and acquisition (M&A), PE buyouts, asset transaction and/or an initial public offering (IPO). On average, it requires several hundred million dollars and 5-10 years for investors coming in at even this later stage to exit. While technology risks are lower at this phase, the financing risks truly become enormous. A company may require in excess of a $1 billion to prove their technology works at a large scale. This is the start of commercialization VoD.

**Commercialization:** Once the company proves its commercial viability and has a successful operating track record with its first commercial facility, various financing options can become available through public market transactions (e.g. project finance, debt financing, asset refinancing, other asset transactions).

### 2.2 Investment Risks

As is implied above, there is a different mix of risks involved in clean energy ventures at each of the phases of development. Thus, investors must assess the market, the technology, the team and the financial risks of the project, and gauge the likelihood the entrepreneur will be able to overcome these risks. To be more specific, the following is a representative list of the key risks considered by clean energy investors:

**Market risk:** Investors assess the size of the addressable market and its competitive landscape, including whether there is a market that exists and is accessible, whether it is too early or too late to enter into the market, and whether the market is big enough to provide desirable returns, assuming certain levels of penetration.

**Technology risk:** Investors need to precisely understand and estimate technology risk; such as the progress of the technology development and its stability. If the technology is new to the investor group, they may need to hire experts or partner with someone who has relevant knowledge and experience.

**Team and Management risk:** It can be challenging to find scientific founders with the relevant management experience required to build and scale a startup. As such, one of the key risks is the management team itself. To reduce management risk – or at least convince themselves they are reducing management risk – VCs often play a mentoring or monitoring role to the firm. They often sit on the board of directors, or have the right to appoint or fire managers. Compensation for these contributions could result in a higher measured financial return. VCs also request and maintain private information of the company.

**Financial risk:** Financial risk is whether the company is able to have sufficient runway and to raise required capital. Sufficient runway, or a diverse exit strategy, is a vitally important consideration when early-stage investors are making an investment. Raising capital is often very difficult and time consuming, and the more reserves a company has, the longer they have to find product-market fit, or whatever it is they need to discover to become financially viable.

## 3. INVESTMENT BARRIERS

### 3.1 Discontinued Investor Network

As the company evolves along its development cycle, the distance between the company and the original source of finance becomes wider and their network connection eventually disconnects. Most early-stage companies are funded by risk capital, such as via PE or

VC funds looking for high-risk and high-return projects and allocating risks and opportunities in value creating ways. However, these later stage investments don't perfectly align with these investors.

Some recent literature raises the question as to whether VC funds could be expanded to bridge the clean energy VoD, as commercializing clean energy ventures takes large-scale and long-term capital investment. However, most VCs seek to manage high levels of technology risk, which means their distribution of returns in portfolio is highly skewed and thus demands a high number of small investments. Indeed, VCs increase their chance of winning by investing in a large number of companies and projects, not a few capital-intensive projects (Gaddy et al., 2017; Ghosh and Nanda, 2010).

From investor interviews, we find current VCs in clean energy particularly struggle with mitigating the financial risk due to lack of exit strategies and a lack of confidence that investors will join to take their investments forward. Firstly, while the expected loss rate may not change if the investment duration gets longer, investors still need to be compensated for the illiquidity of their committed capital. VCs often look for earlier exit opportunities to reduce the duration of illiquid investments. However, there is a discrepancy between VC/PE funds average investment period (7-8years) and the average time to IPO (12-13 years or longer).

Secondly, there aren't enough investors participating in the market with sufficient scale and duration to whom VCs can hand over their early-stage investments. The LPs of VC funds are divesting out of capital-intensive projects, and/or the phases and sectors where earlier exit is not feasible. The history of capital-intensive industries such as biotechnology, communications networking and semiconductors suggests that early-stage investment capital can become increasingly available as the corporates start buying startups. For instance, in the biotech sector, large pharmaceutical companies IPO at pre-commercial stage. Thus far, however, energy producing firms and utilities that supply electricity to customers have been far from active in acquiring promising clean energy startups. Large banks can also finance expensive projects, but they wait until a project's technology is proven – there is a saying that, "banks will always be in first in line to finance your second project." Consequently, the investor network throughout the innovation landscape is not continuous between pre- and post-commercialization phases.

### 3.2 Information Asymmetry

This disconnected network loses important information about companies, as early investors often capture the info and do not share it in an objective manner (they hoard the info and use what's useful to them with follow-on investors). This information could include the level of a company's technology, the market and management readiness and how much more follow-on capital a given company may need to reach an exit. There is no requirement for GPs to make their data available, and they often do the opposite – they keep it highly secret. Of course, they provide some data to their current and potential investors (the LPs), but even here it is normally under confidentiality agreements that allow GPs to cherry-pick they information they want to provide to their LPs. Lastly, even if one obtains comprehensive data, measuring returns to illiquid private equity is a complicated task (Harris, et al., 2016). This in turn creates a negative feedback loop whereby the opportunity set shrinks due to a lack of capital, and makes it even more difficult for willing investors to enter this market.

Benston and Smith (1976) demonstrate the financial intermediaries exist to help overcome these sorts of information asymmetries, but the idea is for them to facilitate investments rather than use that information to maintain an advantage. Brown et al., (2017) empirically illustrate that the GPs with poor performance are likely

to inflate their investment performance reports through questionable selection of benchmarks and data. Over time, this behavior leads to a breakdown in trust among late-stage and early-stage investors.

Information asymmetry tends to be more acute in clean energy ventures because current investment strategies of early- and later-stage investor groups are based on exploiting each other's benefit. Investment during pre-commercialization mostly is irreversible, while post-commercialization phase investors have the option to either delay or deploy their investment. The extraordinary capital requirements expose VC's investments to a possible high sunk cost environment and increase uncertainty around exit strategies. Although post-commercialization investors, such as banks and corporates, can meet the size of capital requirement, they only invest when they have a certain level of confidence in commercial viability of the technology.

As shown by the seminal work of Akerlof (1970) and by the subsequent contribution of Rothschild and Stiglitz (1976), the information asymmetry highlighted above results in an allocation of risk that is suboptimal, with sub-standard returns on investment. In clean energy, post-commercialization investors, who are unable to evaluate the expected return (or the value of clean energy ventures) with incomplete information, tend to offer a price that corresponds to the average in the market. Pre-commercialization investors, who hold private information about the company, will aim to sell it at above-average price. This "lemons" problem (see Akerlof, 1970) plagues the clean energy venture market and further decreases expected return on early-stage investment. Furthermore, Leland and Pyle (1977) emphasize even the VC market (or financial intermediaries generally) may fail to meet their objectives when the information gap is substantial. When information is not adequately transferred, the market may poorly perform leaving companies and projects that are viable underfunded.

# 4. NEW INVESTMENT VEHICLE

## 4.1 Re-intermediation

We claim that aggregated capital flows can increase depending on how to balance risk and return. In this sector, people make the mistake of thinking about early investors and late investors as separate and distinct. In clean energy, however, early investors need to be cognizant of the players that could facilitate future exits right at the outset. The late stage company scenarios have to be explicitly considered at the outset, right when the entrepreneurs are choosing which kinds of investors they'd like to work with. In this respect, the success of an investment strategy – and thus investment vehicle – in the clean energy sector demands overcoming fragmented investor networks and information asymmetries.

Traditional financial intermediaries exist because they enjoy economies of scale and/or comparative advantages in the production of information about companies and projects (see, for example, Diamond, 1984; Diamond, 1991; Ramakrishnan and Thakor, 1984;Boyd and Prescott, 1986). Thus, they ought to produce and analyze information about entrepreneurs and to set financial contract terms to improve entrepreneurs' incentives (Berger and Udell, 1995). This financial intermediation is particularly important in financing early-stage ventures because the information is mostly not publicly available or incomplete. In order to compile and assess this information, today's investment management process involves many parties and agents, such as asset managers, placement agents, and consultants. In theory, the multiple layers of intermediation can help bring expertise and knowledge to the sector. But it can also create agency conflicts, misalignment of objectives and fragmentation. Indeed, the high cost of intermediation and the distorted incentives have raised debates as to whether asset owners should simply work to dis-intermediate and invest directly (Monk et al., 2017). Indeed, it was only

when Australian, Canadian and Dutch pension funds began investing directly in the infrastructure market that the asset class matured. As it pertains to this industry, however, we do not believe disintermediation is the right path, as the skills needed to assess and manage these assets are very hard to boil down into a single organization. As such, our "solution" in this paper is focused on re-intermediation and the launch of new asset management firms that can play the role of a control tower.

A successful investment vehicle must align the interests of a diverse group of investors along with those of the entrepreneur. This demands that both early- and late-stage investors understand what the realistic set of possible outcomes are for a given company, recognizing that some companies may align with venture capital funding, while others will be on a more humble glide path. The early investors have to invest in ways that offer sufficient flexibility to accommodate for different outcomes, which means bringing in more types of capital partners earlier in the process. In particular, the earlier that large, long-term investors can be brought into the capitalization structure, the better. Most VCs did not see their job as cultivating deep relationships with the long-term investor community (i.e., pension funds), which was part of the problem in the first clean energy innovation cycle of investment.

### 4.2 New Investment Vehicle Design

Any successful energy innovation investment vehicle should, in our experience, comprise three functions, including acting as (1) an anchoring institution; (2) a back-bone capital intermediary; and (3) an information platform. We describe each function below independently, but we believe that a truly enlightened investment vehicle could have all three in its design. As readers will note, however, each function may require stand-alone subsidiaries operating under a broad umbrella rather than a single entity trying to achieve all of these objectives at once.

#### *Function 1*: An anchoring institution that can provide priming capital

The new vehicle should include small amounts of priming capital, which can: (1) take the first-loss risk; (2) gather, assess and provide critical information about the risks of opportunities to syndicate partners; and (3) align early and late-stage investors from the outset. One relevant vehicle design, which is being designed by Cyclotron Road to function as an anchoring institution but is currently under its development process, is called the "First Look Fund (FLF)". FLF will make priming capital investments at standardized terms in select companies participating in early-stage technology development programs, partnering with the awardee on achieving pre-set milestones. Investment managers of FLF will ideally work with prominent capital partners across government, academia, traditional VC, strategic corporate VC groups to investigate the feasibility of such a fund to generate attractive financial returns. Investors in the FLF will benefit from rights to information on the companies' development and an opportunity to get a "first look" into the companies' next financing rounds before their official fundraising begins. The companies would use these unrestricted funds to accelerate their technology and business de-risking process.

#### *Function 2:* A Back-bone capital provider that meets unique capital requirements of clean energy ventures

Once the anchoring institution reduces the investment uncertainty by providing private information of the early-stage companies, patient (though still relatively early-stage) investment capital should support companies' growth and financial sustainability over a long development cycle. The backbone capital provider should (1) provide capital with longer maturity; (2) increase probability for the company to reach an exit; and (3) further accumulate private information that can level the playing field among pre- and post-commercialization investors.

The new investment vehicle should be as expert in building a syndicate of early and late investors as it is in the underlying companies it's investing in. There should be a partner whose domain of expertise is the community of LTIs, specifically, such as pensions, endowments, sovereign funds, family offices, and foundations. These LTIs should, in theory, be willing partners in these deals, as they are often designed to manage investment risks over a long horizon. However, LTIs have not been a leading source of capital for clean energy investments, outside of serving as LPs in the GP fueled clean energy bubble. For instance, pension funds and insurance companies currently manage $51 trillion but only account for $22 billion of clean energy assets globally (Kaminker and Stewart, 2012). LTIs find it increasingly difficult to access clean energy investment opportunities in cost-effective ways that align with their own long-term objectives. Part of this is due to the short-term, opportunistic behavior of current investment managers. In part, it is also due to a lack of understanding of LTIs' unique decision making. The suggested investment vehicle design aims to provide a tailored access point to LTIs' unique investment criteria, including aligned fee structures, and a new class of intermediary that can better align with their own goals and needs of clean energy investment.

A relevant example of re-intermediating LTIs into a transitioning phase of clean energy startups is the PRIME Coalition ("PRIME"). PRIME is a nonprofit intermediary that supports collaboration among philanthropic and early-stage investors to aggregate funds at a sufficient scale for demonstration and PoCs of still relatively new clean energy technologies. Collaboration at this level is particularly challenging due to philanthropists' unique charity goals, a misalignment with the structure of traditional VC/PE funds, and the uncertain potential for market adoption of commercial products. PRIME works closely with university and national labs and their incubator programs, such as Cyclotron Road, and filters investment pipelines that satisfy both soundness of technology and desired impact. It provides legal and financial expertise and relevant information so that a new class of investors can support private ventures that are too risky for traditional sources of capital. This, in turn, crowds in other sources of capital, including other LTI groups or even commercial investors, into clean energy ventures.

### ***Function 3:*** **An information platform that provides reliable and objective information on clean energy investments**

A new information platform is needed that can source and triage investment opportunities, conduct research, serve as an information clearing house, and coordinate investor alliances in a highly transparent manner. It would ideally be seen as independent and have a goal of aligning a range of investors around companies and projects it selects as worthy. The information platform could reduce information asymmetries and transaction costs for all levels of investors that are interested in investing in the clean energy innovation landscape.

The idea for a new information platform was derived from the creation of "Aligned Intermediary (AI)", an investment advisory group that is specialized in helping LTIs deploy their long-term, direct investment capital in clean energy infrastructure projects. With AI's deep network and domain expertise, it has helped LTIs access investment opportunities across the risk spectrum that fits their unique risk tolerance, geographic and technology preferences. AI works as an origination team that also deeply understands its LTI members. It can then coordinate among multiple LTIs, some of whom might wish to proceed on an investment, and share investment information with non-member, like-minded investors. AI itself does not provide financing to companies or projects. Instead, it serves as a credible and well-resourced information platform that: (1) entrepreneurs and project sponsors can count on to access the community of LTIs; and (2) LTIs can count on to be incredibly well-networked

within the clean energy ecosystem and aligned to their return objectives. This bridge between the biggest pools of capital and the entrepreneurs was designed specifically to help overcome the commercialization VoD.

In sum, we have seen many attempts to bridge VoDs in clean energy. From our experience, however, the innovation pipeline will not increase its throughput until risk and return are reframed and a new generation of hybrid – early and late stage – investors can be recruited to the sector through high risk-adjusted investment returns. In this regard, the new financial intermediary we are proposing should function almost as a control tower that integrates and enhances the efficiency of scattered investor communities and investment vehicles in clean energy. It will allocate risks correctly as well as reduce information asymmetries. Thus, it is critical that all three suggested functions should be simultaneously and interactively performed.

## 5. CONCLUSION AND FUTURE STUDIES

Overcoming the VoDs requires an entire re-conceptualization of what a "clean energy deal" should look like. We emphasize the importance of overcoming a fragmented investor network and information asymmetries. We suggest that a new investment vehicle could be successful if it could simultaneously perform three key roles: (1) an anchoring institution that provides priming capital and can take first-loss; (2) a financial intermediary that can align small and large LTIs over a long development cycle; and (3) an information platform that can provide reliable and objective information about a company in a highly transparent manner. With these three criteria, we believe this new investment mechanism could adequately balance risk and return and catalyze a wide range of investors, LTIs in particular.

The suggested new investment vehicle will thus increase new capital inflows in clean energy by re-allocating risks (and thus returns) to the appropriate investors. This vehicle will have three key functions and operate as an integrated control tower that provides a tailored path to clean energy companies / projects for various types of large and long-term investors. Specifically, it will facilitate collaboration among a variety of investor-types. This is important, as the valley of death, whose capital requirements are longer and larger than several investors can provide, requires just such a collaborative approach (for the collaborative model, see Monk et al., 2017). This in turn will increase the "success rate" of clean energy startups and further mobilize private capital investment, attracted to clean energy finance by desirable risk-adjusted returns.

The purpose of this paper was simply to present some of our initial hypotheses (albeit based on nearly a decade of work in the area). We thus propose a follow-up academic study to define all relevant actors (investors, startups, and various institutions behind it) and to evaluate their network patterns within the clean energy ecosystem using network analysis and organization design. Previous studies have primarily focused on evaluating investment performance of PE funds within their limited partnership boundaries. Yet, they do not consider how co-investment clusters, or different types of investor networks, can greatly affect decision making and even the valuation of startups they invest in. Clean energy investment is dynamically interactive, and we should take a holistic approach to understand the entire investment process, from sourcing investments, as part of the due diligence, throughout the portfolio monitoring process, or even the exiting of investments. The proposed study will help to develop a systemized and optimized investor network across all relevant sources that have a potential impact on asset owners' portfolios, and demonstrate the viability and scalability of the kind of new investment vehicle framed in this solution paper.

## REFERENCE:


Akerlof, G. A. (1970). The Market for "Lemons": *Quality Uncertainty and the Market Mechanism. The Quarterly Journal of Economics, 84*(3), 488.

Benston, G. J., & Smith, C. W. J. (1976). A Transactions Cost Approach to the Theory of Financial Intermediation. *The Journal of Finance, 31*(2), 215.

Berger, A. N., & Udell, G. F. (1995). Relationship Lending and Lines of Credit in Small Firm Finance. *Journal of Business, 68*(3), 351–381.

Boyd, J. H., & Prescott, E. C. (1986). Financial Intermediary-Coalitions. Journal of Economic Theory, 38(2), 211–232.

Brown, G. W., Gredil, O. R., & Kaplan, S. N. (2017). Do Private Equity Funds Manipulate Reported Returns? *Journal of Financial Economics,(forthcoming)*.

Diamond, D. (1984). Financial Intermediation and Delegated Monitoring. *Review of Economic Studies, 51*(3), 393–414.

Diamond, D. W. (1991). Monitoring and Reputation : The Choice between Bank Loans and Directly Placed Debt. *Journal of Political Economy, 99*(4), 689–721.

Gaddy, B. E., Sivaram, V., Jones, T. B., & Wayman, L. (2017). Venture Capital and Cleantech: The wrong model for energy innovation. *Energy Policy, 102* (July), 385–395.

Ghosh, S., & Nanda, R. (2010). Venture Capital Investment in the Clean Energy Sector. *Harvard Business School Working Paper, 11–20*.

Harris, R. S., Jenkinson, T., & Kaplan, S. N. (2016). How Do Private Equity Investments Perform Compared to Public Equity? *Journal of Investment Management, 14*(3), 14–37.

Kaminker, C., & Stewart, F. (2012). The Role of Institutional Investors in Financing Clean Energy. OECD *Working Papers on Finance, Insurance and Private Pensions,* (23), 1–54.

Leland, H. E., & Pyle, D. H. (1977). Informational Asymmetries, Financial Structure, and Financial Intermediation. *Journal of Finance, 32*(2), 371.

Mazzucato, M., & Semieniuk, G. (2016). Financing Renewable Energy: Who is Financing What and Why It Matters. *Technological Forecasting and Social Change, 12*.

Monk, A., Kearney, S. W., Seiger, A., & Donnelley, E. (2015). Energizing the US Resource Innovation Ecosystem. *Stanford Global Projects Center & Stanford Steyer-Taylor Center for Energy Policy and Finance,* (June).

Monk, A., Sharma, R., & Sinclair, D. (2017). *Reframing Finance New Models of Long-Term Investment Management*. Stanford: Stanford University Press.

Nanda, R., Younge, K., & Fleming, L. (2013). Innovation and Entrepreneurship in Renewable Energy. In *The Changing Frontier: Rethinking Science and Innovation Policy*, ed. A Jaffe, B Jones, pp. 199–232. Chicago, IL: University of Chicago Press.

Ramakrishnan, R. T. S., & Thakor, A. V. (1984). Information Reliability and a Theory of Financial Intermediation. *Review of Economic Studies, 51*(3), 415–432.

Rothschild, M., & Stiglitz, J. (1976). Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information. *The Quarterly Journal of Economics, 90*(4), 629–649.


Stanford | Precourt Institute for Energy

energy.stanford.edu/clean-energy-finance