ResearchGate

See discussions, stats, and author profiles for this publication at: https://www.researchgate.net/publication/340104790

Financial Innovation for Energy Innovation

Preprint · March 2020

CITATIONS
0

READS
816

2 authors:

Ashby H. B. Monk
Stanford University
179 PUBLICATIONS **1,322** CITATIONS
SEE PROFILE

Soh Young In
Stanford University
45 PUBLICATIONS **115** CITATIONS
SEE PROFILE

Some of the authors of this publication are also working on these related projects:

Project Citizenship as Sovereign Wealth: Re-thinking Investor Immigration View project

Project Financing Energy Innovation View project

All content following this page was uploaded by Soh Young In on 27 August 2020.

The user has requested enhancement of the downloaded file.

Financial Innovation for Energy Innovation

Ashby Monk and Soh Young In

The move toward a global energy transition is underpinned by the collective need to limit the most severe impacts of climate change as well as to foster more sustainable economic growth. Floating photovoltaic power stations on Chinese lakes, integrated carbon capture technology on large-scale power plants in Canada, and decentralized urban wind turbines on Singaporean rooftops are just a few examples of how radical innovations in clean energy technology are fueling the global energy transition.[1] Bringing cutting-edge technology from the lab to the global energy market requires a supportive ecosystem. Innovation must be matched by market readiness to adopt disruptive technologies, local capacities to scale up new energy projects, energy policies with climate objectives, technological development, and sufficient and "aligned" investment capital.

Ashby Monk is Executive and Research Director of the Stanford Global Projects Center (GPC). His current research focus is on the design and governance of institutional investors, with particular specialization on pension and sovereign wealth funds. Outside of Stanford, he is the co-founder of Long Game Savings, a personal finance application that uses gamification and behavioral finance to encourage positive financial behaviors. He is also the co-founder and President of Real Capital Innovation, a software company that facilitates dynamic portfolio construction and management for long-term investors. He received his Doctorate in Economic Geography at Oxford University and holds a Master's in International Economics from the Universite de Paris I - Pantheon Sorbonne and a Bachelor's in Economics from Princeton University.

Soh Young In is Research Director in Sustainable Finance at the Stanford GPC and also leads the Financial Innovation research at the Stanford Sustainable Finance Initiative (SFI). Her research focuses on aligning the financial system with a low-carbon economy and catalyzing sustainable finance. Her research has supported investors, entrepreneurs, and policymakers to drive positive social and environmental impact alongside financial results. Her project on an innovative energy investment platform has been supported by the Precourt Institute for Energy, Bank of America, the US Department of Energy, Activate at the Lawrence Berkeley National Lab and Google. She received her Doctorate in Civil and Environmental Engineering at Stanford University, Master's in International Policy Studies at Stanford, and Bachelor's in Economics and Statistics from Columbia University.

Copyright © 2020 by the *Brown Journal of World Affairs*

This article focuses specifically on the last requirement: the characteristics of investment capital needed to support clean energy innovation. Investors are key players in the future of energy, as they must drive innovation in the financial system to meet the scale of capital needed to transform the energy industry. Both a lack and misalignment of investment capital have hindered important technological leaps in sustainable energy.[2] One such example is the severe financing shortage in commercializing novel clean energy technology. The most prominent financing issue associated with commercializing novel clean technology (cleantech) has been termed the "valley of death," which refers to the pattern in which most early-stage cleantech is severely underfunded, resulting in innovation being abandoned before reaching full-sized deployment. There are many causes of this "valley of death," but the common threads among them are the sheer number of financial risks in the energy industry and the inability to fully understand and manage these risks within the energy ecosystem.[3]

In this article, we approach this funding shortage and widening "valley of death" in the energy sector from a new perspective. We investigate underlying structural and organizational barriers in today's capital markets and discuss how to innovate the financial industry. Our discussion attempts to move the focus of current energy finance and investment research from a deal-by-deal perspective to a continuous process that involves asset owners, asset managers, and entrepreneurs. This shift in perspective is important because "investors are often presented with a 'deal' rather than a historical understanding of a company, while entrepreneurs themselves are often faced with countless types of investors, from pensions and sovereigns to tax-equity providers."[4] In our view, long-termism has been continuously undervalued as a key success factor, despite its strong potential to align various players in the ecosystem. Instead, asset owners and managers are often forced to rely on short-term and costly financial products and services to fund the long-term global project of energy transformation. The financial innovations described in this article focus on how to foster such long-termism and catalyze patient and smart long-term investment capital to support energy innovation. These goals can only be achieved by innovating the governance of the investment organizations themselves, transforming the management and operations of investors via new collaboration, and increasing cooperation among asset owners and managers.

Investment Barriers to Energy Innovation

For energy entrepreneurs, the arduous lab-to-market pathway demands large-

scale capital with a long-term commitment. Throughout the lab-to-market journey, an energy startup or project is exposed to different risks that change meaningfully over time. For example, there may be risks related to the progress and stability of technology development; to the technology's addressable market and competitive landscape—including whether the market even exists and is accessible, whether it is too early or too late to enter into the market, or whether the market is large enough to provide desirable returns—; and to government policy and regulation, which come into play for technology development and market penetration—such as the extent to which future preferential tax policies or state mandates for the contribution of sustainable energy to the total energy mix will affect the economics of novel cleantech.

The investor's job is to assess the risks faced by the company or project and the likelihood that it will overcome those risks to deliver the promised returns. Therefore, energy startups often must perform multiple expensive performance trials, which may require several hundred million dollars and five to ten years to complete.[5] Meanwhile, investors also fear the "unknown unknowns"—the risks that come from unexpected situations—which are huge when these projects pan out over the span of two decades. The pace of technological change means that our global economy will undoubtedly look different in 2040, leaving many investors wondering whether they should be investing in technologies that will not see huge payoffs until the distant future. All of these challenges mean that early-stage investors often need to see sufficient amounts of financial capital to have confidence that a company can overcome key hurdles or have diverse exit strategies in a range of industries and sectors. This way, investors will have an appetite to become involved and get a new technology moving toward the market.

However, cleantech does not just need to solve early-stage funding issues; its development requires funding at two critical stages: the early stage (when technology risks are high) and the commercialization stage (when marketing risks are high). These distinct stages and risk profiles lend themselves to different investor groups, further complicating the pathway to commercial scale for entrepreneurs. To successfully develop energy technology, it is important to strategically balance between short-term and long-term risks. Investors assess and manage these risks within unique timeframes, which are determined by the investor's preference for liquidity risks. Whereas short-term investors search for projects they can liquidate within three to five years, long-term investors may have a decade or longer to meet their obligations. Some risks become more uncertain if the duration of the assets is long, while others are the opposite. For instance, if the invested capital is tied up for the duration of the asset, an illiquid

investment can expose investors to interest rate risk.

The accumulation of knowledge regarding the unique risks involved throughout the energy development pathway suggests that the future of cleantech capital investment is now a question of how to channel diverse sources of funding to allow startups to separately manage different types of risks along the entire lab-to-market timeframe while meeting investors' own risk and return needs.[6] However, the ecosystem for clean energy investments has historically been highly fragmented and characterized by friction-inducing information asymmetries. Neither like-minded investor groups nor entrepreneurs and potentially appropriate investor profiles are typically aware of each other. The absence of a cohesive investing ecosystem contributes to the "valley of death" by significantly inhibiting critical information flow, investor confidence, and, consequently, consistent capital allocations toward novel clean energy development.[7]

The absence of a cohesive investing ecosystem contributes to the "valley of death" by significantly inhibiting critical information flow, investor confidence, and, consequently, consistent capital allocations toward novel clean energy development.

Indeed, the extent to which the investing ecosystem has managed to align investment opportunities and risks with the appropriate investor types clearly distinguishes the three waves of clean energy investments: cleantech 1.0 (pre-2006), 2.0 (2006-2011), and 3.0 (the current cleantech investing landscape). During cleantech 1.0 and 2.0, the bulk of cleantech investments came from venture capital (VC) and private equity (PE), skyrocketing to $1.7B in 2006 and reaching a peak of $4.3B in 2011.[8] While VC/PE investments have been one of the primary sources of capital available to startups that face huge technology risks in the energy sector, traditional VC/PE fund structures and strategies have been at odds with the time horizon and capital constraints of clean energy investments.[9] The high-risk profile of VC funds, for example, means that many of their bets fail. As such, they focus on relatively smaller, capital-efficient, and diversified investments that can scale quickly and come with predictable exit options. In terms of PE funds, the high fees often demand general partners (GPs) to exit an investment in five to eight years in order to have any chance of earning their carried interest. If they wait longer, the high base fees erode the performance, making it very difficult to beat hurdles in years 10 and beyond.

Neither of these models aligns with the longer time horizon of energy innovation projects.[10]

Thus, structural discrepancies between traditional VC/PE models and the energy innovation pathways have led many early-stage, fiduciary-bound investors to write off investments and withhold further funding from potentially successful cleantech companies.[11] Without a cohesive investing ecosystem in which diverse investor groups could connect with cleantech companies at the appropriate times (which is characteristic of the current wave of cleantech investments), early-stage investors faced huge losses during cleantech 1.0 and 2.0. The failure to meet the unique capital requirements of novel energy innovation has fueled the growing consensus that the traditional VC/PE models are insufficient for bridging the "valley of death."[12]

While a broad spectrum of capital seemingly demands energy transformation, today's financial services industry has been dominated by short-term incentives and outcomes misaligned with these demands. However, we think capable asset owners with long-term perspectives—long-term investors (LTIs)—such as pensions, endowments, sovereign wealth funds, family offices, and foundations, are perfectly suited to help bridge this financing gap.[13] In fact, the investment profile of LTIs makes them exceptionally positioned to support the development of transformative cleantech innovation and other long-term investment opportunities. Given their long-term obligations, this investor group is often more comfortable integrating long-term risks in investment decision-making, such as those posed by climate change; as a result, they tend to be better suited to scale up innovation and realize appropriate returns over the required timeframe. Nevertheless, most of today's asset management services and products do not take account of this unique investment profile, which is why the existing suite of clean energy investment products cannot meet LTIs' needs for high returns. The only way to align the underlying assets with the LTIs' needs and constraints is to consider novel ways of accessing this marketplace, including help in launching new products and strategies.[14]

Why A New Type of Financial Innovation Is Needed

Bringing radical innovation to our global energy markets depends on meeting the unique capital requirements of clean energy ventures while also ensuring that those ventures meet the risk and return needs of investors. Of all the types and categories of investors in the world, the long-term asset owners seem uniquely positioned to align the needs of the investors with those of

the underlying assets. Unfortunately, we observe deep structural issues in the financial system that prevent this alignment, resulting in a gap in the market for long-term capital commitments. Of all the constraints, challenges, and limitations, two stand out.

First, LTIs need high investment returns to meet their long-term obligations, such as paying pensions or funding universities. To achieve these high returns, many funds have turned to external managers in riskier and more illiquid asset classes, such as private equity. This shift has meant higher returns, but also higher fees and costs paid to the managers—that is, VC/PE funds, hedge funds, etc. —tasked with investing their capital. Beyond the fact that it has done very little to solve the pension funding gap, this move toward high-cost investment products has created a few problems.[15] Asset management has become the most profitable industry in the world; the easiest path to becoming a billionaire today is to set up an alternative asset management firm and manage pension capital. This potential for enormous wealth means that the asset managers, who are inherently oriented toward the short-term, are far better resourced than the LTIs to identify and invest in high-performing assets. Most LTIs see the resources available to asset managers as an insurmountable competitive advantage, which means that they are unwilling to cultivate their own resources and longer-term approaches to drive high performance. They see "alpha," (i.e., active return on an investment) as something that can only be obtained via these external managers, which means that there are not many long-term investment products that have managed to align LTIs and their long-term capital with long-term projects and assets, such as those related to clean energy and green infrastructure.

Second, the high cost of asset management itself contributes to the difficulty of allocating long-term capital to such long-term projects and assets. LTIs currently have roughly $100 trillion in risk capital; still, the gaps in funding for green infrastructure are enormous and not shrinking.[16] Part of the problem is that high-cost asset management cannot align with the long-term nature of these assets—the terminal value of the investments paid to pensions and endowments would erode too much over time, given decades-long commitments to pay guaranteed base fees for asset management.[17] Without a shift to long-term, low-cost investment vehicles, financing the clean energy transition will have to rely on governments alone, without private capital to drive entrepreneurs and novel solutions into the global marketplace. The role of public financing of innovation in actively shaping and creating markets should not be understated, but public finance is increasingly scarce relative to the amount of capital needed to solve our grand societal challenges, all the more so as governments seek to respond to the

COVID-19 pandemic. In addition, most of the innovation in the investment industry over the past 50 years has been focused on short-term market arbitrages, rent-seeking, and winning zero-sum games, rather than sustainable growth and long-termism.[18] Going forward, we need new types of innovation focused on long-term investment performance. We need innovation that fills "structural holes" in the marketplace. Because it is not in the economic interests of asset managers to lead this type of innovation (even if it is in their children's interests), we need LTIs to lead this wave of investment innovation. This task will be difficult, to say the least.

Going forward, we need new types of innovation focused on long-term investment performance.

Organizational Barriers to Financial Innovation

The nature of long-term asset owner investors—managing $100 trillion of risk capital that powers the asset management industry—is almost universally traceable back to some governmental decisions.[19] For instance, governments choose to prefund pensions, give tax breaks to foundations or endowments, smooth resource revenues through a sovereign wealth fund, and so on. As a result, today's governments are among the primary reasons why contemporary society is capable of accumulating more financial capital than investors during any other time period, even if we seek to create robust pension governance structures that separate the LTIs from their governmental origins (i.e., corporate governance of the pension fund itself, the bureaucracy and culture are difficult to fully eliminate from government influence). Consequently, LTIs face a daunting path to innovation, often one as difficult as you might find within government bureaucracies.

LTIs are frequently under-resourced and ill-prepared for innovative thinking about how to manage themselves and their portfolios. For instance, historically innovation has not been a priority for pension fund boards. In fact, boards generally push management teams to be efficient, which stifles innovation.[20] We refer to firms that can combine efficiency and innovation as organizationally ambidextrous, and these are very rare.[21] But for pensions and other LTIs, this combination is necessary. These investors must remain efficient in their daily jobs and still find ways to experiment and execute the complicated innovations needed to sustain long-term sustainable performance—especially if we are to have any hope of unlocking this capital for climate solutions. However, research

has never uncovered a proper research and development team inside a pension fund that helps bad ideas to fail fast and good ideas to thrive. If sustainable change is going to come to the world of finance and investment, it will depend upon transforming the management style of long-term asset owners—the very base of the financial system. Yet these organizations often struggle to innovate. Three notable barriers to their innovation include misaligned services, rigid interpretations of governance rules, as well as a tendency toward herd mentality, and the so-called "two brained" problem.

First, while it is standard practice for asset owners to depend upon financial service providers, such reliance has been found to hamper funds' ability to innovate. For example, asset owners task investment consultants with formulating and implementing their investment strategy and asset managers with overseeing their investments.[22] These service providers are often necessary to realize asset owners' investment goals; however, the former does not want to see the latter solve their own problems because that would mean lower fees and revenues.

The mismatch in liquidity periods between LTIs and most asset managers points to another key innovation barrier. Private equity, venture capital, and other financial intermediaries often raise funds two to three years after their current fund, while the time horizon for long-term capital owners can be ten times that. Given this time constraint, PE/VC funds will tend toward investments with short-term gains so that a performance record can be established in time for the follow-up fund. As cleantech and other long-term investments may not produce any returns over the course of a two or three-year time period, managers struggle to raise capital around these assets (even if invested in attractive investments). For the LTI, then, it becomes difficult to allocate to longer horizon investments—regardless of whether the returns promised are the same—because the shorter horizon offers concrete evidence that a manager is doing his or her job correctly.

Second, strict interpretations of prudent-person rules and fiduciary standards push LTIs to herd and "follow the leader" among industry peers. But if pension fund governance and laws demand a fund not do anything its peers would not do, it becomes difficult to find pension fund leaders willing to move their organizations and the industry as a whole toward new strategies and products. This herd mentality sometimes leads to perverse governance rules around "no. l funds," or working only with established firms; we call this "individually rational but collectively crazy" behavior. The inability to deviate from the status quo may explain why LTIs have historically refrained from putting their unique long-term perspectives on the agenda in an otherwise short-term oriented fi-

nancial industry.[23]

Finally, there is often a disconnect between the C-suite level setting the investment strategy (horizontal oversight) and the level of the portfolio managers handling the transactions and executing on that strategy (vertical responsibility). The "two-brained problem" exists when these two "brains" are misaligned and do not communicate. Indeed, it is notable that the CEOs of global asset owners typically have a limited influence on line portfolio managers' actual decision-making by the line portfolio managers or their own organizations' processes adopted in specific. It would be expected that such "two-brained" organizations are lacking in their ability to effectively mobilize new ideas, even when these ideas may exist at the top of the fund.

These hurdles are but a handful of the barriers that these funds must overcome if they are to experiment or innovate in the way they invest in startups or other corporate energy innovators. As we have seen, innovative thinking in the financial sector is hardly a foundational value, which means that we are in effect asking these funds to do something that is wholly unnatural to them. As a result, the average asset owner board is generally unaware of either the need or the process to resource an innovation strategy properly. Given the industry's restrictive origins and considerable remaining barriers to innovation, asset owners are in for a challenge if they are to unlock their capital for cleantech and other long-term investment opportunities.

Three Innovations in the Financial Industry

In short, asset owners looking to the market of financial products have struggled to find offerings that align with the requirements of the energy sector and its set of opportunities. Ironically, long-term investors with a structural affinity to such long-term energy projects have been relying on short-term asset managers with structural constraints that limit the attractiveness of those very assets. While the reduction of information asymmetry and transactional costs is the theoretical function of asset managers (i.e., financial intermediaries) today's asset management services are not fulfilling this role for LTIs in the domain of energy innovation.

The stark tension between the potentially impactful role LTIs can play and the extent to which today's investment industry has disallowed for the realization of this potential points to the need for serious innovation of the financial industry if we are to allocate sufficient capital commitments toward the global energy transition. The big question we now face is how to resolve the tension

between these two issues: the origin of funds seems to demand that innovation is needed, and the design of these funds seems to suggest innovation is impossible. How do we catalyze these funds to change and adopt new strategies to invest in new products? In our experience, it means filling the knowledge gap in creative ways. In this section, we describe how innovations can occur among these conservative asset owners.

First, we suggest innovating the governance of asset owners by building and executing clear mandates to asset managers and aligning their investment portfolios with sustainable growth and long-termism. From interviews with energy entrepreneurs and investors, we identify two trends: investing in this space is no longer "philosophically-driven" (for altruistic or other reasons) but "financially-driven;" and the frontline of the ecosystem no longer calls it "clean technology" but "sustainability." These trends call for a re-informed conversation between asset owner investors and managers. For a returns-seeking long-term investor, the rationale for investing in this space would be quite straightforward to their asset managers. However, when it comes to which investment opportunities might fit the objectives of the investor, asset managers need to be provided with clear mandates and evaluation criteria that accurately reflect their objectives. Our own research indicates that asset owners have not provided such clear directions to their asset managers, as they lack internal knowledge or capabilities to make such mandates.

In this regard, we suggest the concept of "materiality" might be useful in renewing the conversation between asset owners and asset managers such that the latter can better understand how to align the former's objectives with the investments they make on their behalf.[24] Whether or not something is deemed "material," (i.e., useful for decisions) depends on the entity evaluating the issue in question. Asset owners should communicate their objectives such that asset managers have a clear understanding of which investment factors are of meaningful importance, or material, to their clients' objectives. Especially for investors, material issues are defined by their unique time horizon for investments.[25] Different investment objectives among investors equate to different investment time horizons; the longer the time frame an

Different investment objectives among investors equate to different investment time horizons; the longer the time frame an investor has, the more energy projects become attractive and thus material to the investor.

investor has, the more energy projects become attractive and thus material to the investor. Contemporary research introduces materiality as a reference point with which to evaluate and make investment decisions; it has become relevant to building investment mandates and evaluation criteria.[26] Moreover, as Rogers et al. highlight, materiality should be viewed, not as "a state of being," but rather as a dynamic concept that may evolve over time.[27] Ensuring that investment mandates clearly reflect the patience and long-term nature of the asset owner's capital and are updated to communicate their potentially evolving preferences would help not only the asset owner but also their managers to reorient themselves and to adopt new strategies for investing in new energy products.

Unfortunately, we often need financial crises to drive fundamental changes to how assets are governed and managed. For example, in the early 2000s, the "Perfect Storm" crisis showed us that low asset returns and low interest rates can happen at the same time. This led to the rise in "Liability Driven Investing:" in the late 2000s, the global finance crisis drove boards of the LTIs to reconsider how they access markets, pushing many funds to internalize some of their asset management. After the 2008 global financial crisis, the LTIs began to think in terms of the drivers of returns—factor-based investing. The current financial crisis, triggered by a global health crisis, will push firms to reconsider how they integrate long-term risks into their portfolios. In our view, this will be a significant driver of sustainability integration and could help to push capital toward innovative climate/cleantech products.

Second, we suggest innovating asset management models so that they can better align investment opportunities and risks with the appropriate investor profiles. By doing so, new energy developers might be capable of leveraging the consistent funding necessary to the success of long-term innovation. While the fate of all investors in energy innovation is (or should be) an interwoven one, most investment vehicles in this space, such as VC/PE firms, do not facilitate information and investment flow according to this view. Traditional financial intermediation models have contributed to much of the information asymmetries among investor groups and the fragmentation of investor networks that permeate the clean energy ecosystem.[28] As a result, we cannot effectively mobilize sufficient capital to bridge the clean energy "valley of death."

But neither the importance nor the huge potential of financial intermediaries in catalyzing more funding should be overlooked. In principle, the role of the financial intermediary is to reduce market friction by providing reliable information and lowering transaction costs, which is helpful to both investors and entrepreneurs.[29] Investors need considerable support in identifying and

analyzing new energy companies and projects without compromising returns, as do entrepreneurs in finding appropriate investors; financial intermediation is an efficient matchmaker. Our interviews with three novel investment vehicles whose purpose is to intermediate specific investor types indicate that substantially more clean energy capital can be mobilized when financial intermediaries adequately tailor to investors' needs.[30]

In light of these findings, our 2018 study specifically proposes "anchor," "balanced barbell," and "boundary spanner" as new financial intermediary functions to be coordinated in one coherent investment platform that overcomes ecosystem fragmentation, information asymmetries, and the resulting loss of investor confidence in energy innovation.[31] The anchor sources early-stage priming capital that prefers high-risk/high-return investments, such as VC/PE funds. In addition, this intermediary synchronizes early and late-stage investors from the outset by providing private information to potential late-stage investors, offering early-stage investors the flexibility to accommodate for different outcomes. Then comes the balanced barbell, which focuses on raising capital from various late-stage investors by labeling the ground for and connecting both sides of the barbell. It stabilizes the marketplace by facilitating knowledge-sharing and transactions between the startup, early-stage investors, and late-stage investors. Third, the boundary spanner sources scaled, long-term capital (such as LTIs) by providing private information about cleantech ventures in a highly transparent and trustworthy manner tailored to their unique investment criteria. Boundary spanners, in the organizational literature, function to build strong relations among entities. In cleantech, the boundary spanner helps foster previously absent alliances of LTIs and other investors, thus laying the groundwork for an aligned cleantech investor network. The coherent investment platform coordinates activities among key intermediaries and actors, facilitates intelligent information flow across the entire innovation pathway, and thus enhances investor confidence. Such cohesiveness would help facilitate consistent innovation funding by connecting cleantech ventures with suitable investors at the appropriate times and vice versa, for a successful clean energy lab-to-market journey.

Finally, another way to foster innovation is via cooperation, so we propose collaborative models as a way of driving innovation.[32] In the current financial climate, investors strongly emphasize startups' human capital (top management team characteristics), intellectual capital (patents), and social capital (strategic alliances with other organizations) when evaluating them and making investment decisions.[33] Startups face significant obstacles in accessing finance because of information asymmetries, such as a lack of proven assessment frameworks.[34] We

suggest that bridging organizations that facilitate collaboration and knowledge-sharing is key to energy transformation. It is important to design and manage a sustainable investing ecosystem that will channel diverse funding sources to entrepreneurs in the cleantech sector. In the future, we will need innovative knowledge-sharing platforms that can facilitate cross-scale linkages, improve communication channels, and create opportunities for collaboration. This allows for entrepreneurs, investors, and policymakers to set new target levels and modify policy to reach those levels as new information is generated on the investing ecosystem's attributes.

Conclusion

In this article, we highlight structural and organizational friction that prevents the finance and LTI industries from moving toward long-term innovations, including which mandates asset owners give their asset managers and how asset managers service their asset owners. We also point out pathways that can drive the industry forward. In fostering long-termism in the energy transition, we suggest that a new type of innovation needs to take place, and it should include innovation in governance, management, and collaboration and cooperation. We advise that bridging organizations that facilitate collaboration and knowledge-sharing is key to energy innovation and thereby to the global energy transition.

The colossal challenges facing society—climate change risks, rapid urbanization, and global population growth, to name a few—will not receive the funding required if we cannot mobilize long-term investors to support long-term decarbonization objectives and climate-resilient development. But short-termism dominates today's financial industry, and this orientation has failed to meet the preferences of those investors who take a longer perspective on investments, as well as the capital requirements of potentially successful innovation in clean energy technology. New innovative financial products and services that adopt a long-term view—one that integrates into its decisions distant risks that may be uncertain in the short run but are highly probable over years, decades, and centuries—are thus needed to fill a critical market gap. WA

Notes

1. "China Just Switched on the World's Largest Floating Solar Power Plant," *The World Economic Forum*, 2017, https://www.weforum.org/agenda/2017/06/china-worlds-largest-floating-solar-power/; "Carbon Capture and Storage: Canada's Technology Demonstration Leadership," *Natural Resources Canada*, 2013, https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/files/pdf/11-1416_eng_acc.pdf; B.R. Karthikeya, P.S. Negi, and N. Srikanth, "Wind resource assessment for urban renewable energy application in Singapore," *Renewable Energy* 87 (2016): 403-14.

2. "Accelerating Sustainable Energy Innovation," *The World Economic Forum*, 2018, http://www3.weforum.org/docs/Accelerating_sustainable_energy_innovation_2018.pdf; "Crossing the Valley of Death; Solutions to the Next Generation Clean Energy Project Financing Gap," *Bloomberg New Energy Finance*, 2010, https://about.bnef.com/blog/crossing-the-valley-of-death-solutions-to-the-next-generation-clean-energy-project-financing-gap/; A.H. Monk et. al., *Energizing The US Resource Innovation Ecosystem: The Case for an Aligned Intermediary to Accelerate GHG Emissions Reduction* (Stanford Global Projects Center & Stanford Steyer-Taylor Center for Energy Policy and Finance, 2015).

3. S. Y. In and A.H. Monk, *Financing Energy Innovation: The Need for New Intermediaries in Clean Energy* (Stanford Global Projects Center, 2018).

4. Ibid., 26.

5. S. Ghosh and R. Nanda, *Venture Capital Investment in the Clean Energy Sector* (Harvard Business School, 2010), 11-020.

6. In and Monk, *Financing Energy Innovation*; M. Mazzucato and G. Semieniuk, "Financing Renewable Energy: Who is Financing What and Why It Matters," *Technological Forecasting and Social Change* 127, (2018): 8-22.

7. In and Monk, Ibid

8. See *Cleantech 3.0: Venture Capital Investing in Early Stage Clean Energy,* (Boston: Ceres and Clean Energy Venture Fund, 2017), https://www.ceres.org/sites/default/files/reports/2017-11/Ceres_CleanTech-VentureCapInvest_110917.pdf.

9. Ghosh and Nanda, *Venture Capital Investment*; Monk et. al., *Energizing The US Resource Innovation Ecosystem*; "Accelerating Sustainable Energy Innovation," *World Economic Forum.*

10. In and Monk, *Financing Energy Innovation.*

11. A. Katz, "Bogus Private-Equity Fees Said Found at 200 Firms by SEC," *Bloomberg*, 2014; R. Nanda, K. Younge, and L. Fleming, "Innovation and Entrepreneurship in Renewable Energy," in *The Changing Frontier: Rethinking Science and Innovation Policy,* (Chicago: University of Chicago Press, 2014): 199-232; *Cleantech 3.0*; In and Monk, Ibid.

12. B. Gaddy, V. Sivaram, and F. O'Sullivan, *Venture Capital and Cleantech: the Wrong Model for Clean Energy Innovation* (MIT Energy Initiative, 2016); In and Monk, Ibid.

13. In and Monk, Ibid; C. Kaminker and F. Stewart, *The Role of Institutional Investors in Financing Clean Energy* (OECD, 2012); Mazzucato and Semieniuk, "Financing Renewable Energy;" Monk et. al., *Energizing the US Resource Innovation Ecosystem*.

14. In and Monk, Ibid.

15. A review of U.S. pension funds shows that underfunding remains pervasive (Healey et. al (2012); *Pew Charitable Trusts*, 2017), and all the fees paid to Wall Street have not made pensions any more secure (Monk and Sharma, 2018).

16. Sergio Schmukler, "Institutional Investors: The Unfulfilled $100 Trillion Promise," World Bank, 2015, https://www.worldbank.org/en/news/feature/2015/06/18/institutional-investors-the-unfulfilled-100-trillion-promise; "Infrastructure Productivity. How to Save $1 Trillion a Year," *McKinsey*, 2012, http://www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/infrastructure-productivity.

17. In and Monk, *Financing Energy Innovation*.

18. Mazzucato and Semieniuk, "Financing Renewable Energy;" See "The Financial System We Need," *United Nation Environment Programme,* 2016*,* https://unepinquiry.org/wp-content/uploads/2016/09/The_Financial_System_We_Need_From_Momentum_to_Transformation.pdf; A.H. Monk and R. Sharma, "'Organic Finance': The Incentives in Our Investment Products," *The New Oxford Handbook of*

Economic Geography (2018): 591–611.

19. Monk and Sharma, Ibid.

20. A. H. Monk, R. Sharma, and D. L. Sinclair, *Reframing Finance: New Models of Long-term Investment Management*, (Stanford University Press, 2017).

21. C.A. O'Reilly III and M.L. Tushman, "The Ambidextrous Organization," *Harvard Business Review* 82, no. 5 (2004): 74.

22. Gordon L. Clark and A.H. Monk, "Ambiguity, Contract, and Innovation in Financial Institutions," *Competition & Change* 20, no. 3 (2016): 187–203.

23. Leo Lewis and Patrick Temple West, "Pension fund giants team up in attack on 'short-termism,'" *Financial Times*, 2020.

24. R. G. Eccles et al., "The need for sector-specific materiality and sustainability reporting standards," *Journal of Applied Corporate Finance* 24 (2012): 65–71; J. Grewal, C. Hauptmann, and G. Serafeim, "Material sustainability information and stock price informativeness," *Journal of Business Ethics* (2012): 1–32.; M. Khan, G. Serafeim, and A. Yoon, "Corporate Sustainability: First Evidence on Materiality," *The Accounting Review* 91 (2016): 1697–1724.

25. J. Rogers and G. Serafeim, *Pathways to Materiality: How Sustainability Issues Become Financially Material to Corporations and Their Investors*, (Harvard Business School, 2019), 20-056.

26. T. Kuh et. al., "Dynamic Materiality: Measuring What Matters," (2020); S. Y. In, R. Eccles, and Y.J. Lee, *Looking Back, Looking Forward: Scientometric Analysis on 47 Years of ESG Research* (Stanford Global Projects Center, 2020); Bob Eccles, "Dynamic Materiality and Core Materiality: A Primer For Companies And Investors," *Forbes*, January 17, 2020.

27. Rogers and Serafeim, "Pathways to Materiality," 20-056; M. Khan, G. Serafeim, and A. Yoon, "Corporate sustainability: First Evidence on Materiality," *The Accounting Review 91*, no. 6 (2016): 1697-1724; T. Kuh et. al., "Dynamic Materiality."

28. In and Monk, *Financing Energy Innovation*; From the general partner (GP)/limited partner (LP) structure, for instance, GPs have a fiduciary duty to provide a profile of return and risk to their LPs that is better than what outside investors can otherwise achieve. Meanwhile, GPs are not obliged to make their data fully available or to standardize for the general market.

29. See Franklin Allen and Anthony M. Santomero, "The Theory of Financial Intermediation," *Journal of Banking & Finance* 21, no. 11-12 (1997): 1461-1485; Douglas W. Diamond, "Financial Intermediation and Delegated Monitoring," *The Review of Economic Studies* 51, no. 3 (1984): 393-414; Diamond, "Monitoring and Reputation: The Choice between Bank Loans and Directly Placed Debt," *Journal of Political Economy* 99, no. 4 (1991): 689-721; R. T. Ramkrishnan and A.V. Thakor, "Information reliability and a theory of financial intermediation," *The Review of Economic Studies* 51, no. 3 (1984): 415-32; John H. Boyd and Edward C. Prescott, "Financial Intermediary-Coalitions," *Journal of Economic Theory* 38, no. 2 (1986): 211-232.; Allen N. Berger and Gregory F. Udell, "Relationship Lending and Lines of Credit in Small Firm Finance," *Journal of Business,* (1995): 351-81.

30. In and Monk, *Financing Energy Innovation.*

31. Ibid.

32. Monk, Sharma, and Sinclair, *Reframing Finance.*

33. Joel A. C. Baum and Brian S. Silverman, "Picking Winners or Building Them? Alliance, Intellectual, and Human Capital As Selection Criteria in Venture Financing and Performance of Biotechnology Startups," *Journal of Business Venturing* 19, no. 3 (2004): 411-36.

34. Pelen Demirel et al., "Born To Be Green: New Insights Into the Economics and Management of Green Entrepreneurship," *Small Business Economics 52*, no. 4 (2019): 759-771; Demirel and Stuart Parris, "Access To Finance for Innovators in the UK's Environmental Sector," *Technology Analysis & Strategic Management 27*, no. 7 (2015): 782-808; B.H. Hall and J. Lerner, "The financing of R&D and innovation," *Handbook of the Economics of Innovation* 1 (North-Holland: 2010): 609-639; A. P. Petkova, A. Wadhwa, X. Yao, and S. Jain, "Reputation and decision making under ambiguity: A study of US venture capital firms' investments in the emerging clean energy sector," *Academy of Management Journal* 57, no. 2 (2014): 422-48.

View publication stats