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# CHANGING THE CLIMATE OF CAPITAL
## The Stanford Sustainable Finance Initiative

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*Abstract*

*Since the Rio Earth Summit in 1992, the world has made measurable but inadequate progress on climate change and, importantly, the global context in which we confront the crisis has changed. This paper takes a critical look at how current efforts have yet to adjust to the world that has emerged and defines course corrections future efforts will need to employ. It sets the stage for a new Stanford University initiative that will work with businesses, financial institutions, and governments to more effectively catalyze decarbonization and climate resilience.*

## INTRODUCTION – HOW DID WE GET HERE?

The purpose of this paper is to introduce an ambitious new initiative at Stanford University that will draw on expertise across the entire campus with particular attention to business, law, economics and advanced data analytics with the goal of accelerating the transition to a decarbonized global economy. In order to understand the potential and imperative of the Stanford Sustainable Finance Initiative (SFI), this paper places the current state of climate finance in historical context, highlights detours from expected pathways since 1990, identifies four key areas within which current efforts are falling short, and offers three course corrections to reframe the global effort and that will define Stanford's approach.

This paper is written for an audience familiar with climate change science, technology, and policy and their attendant terminology, challenges, and debates. We hope it delivers fresh thinking to a tireless effort and serves as the basis for collaboration within and among Stanford and forward-thinking investors, business leaders, entrepreneurs, and policy makers.

## Hope and Challenges

The causes and dangers of climate change have been broadly understood since the late 1970's. For the purposes of this paper, we consider "the first period" of climate action starting with the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992. Progress on climate has been both slow, particularly on the policy front, and fast, like the recent adoption curves of wind, solar, and electric vehicles. To put the current moment and 2050 climate goals in context, it is useful to recognize progress over the past thirty years and the new challenges that will shape the second, and final, period for climate action.

While deep gaps exist between where we are and ought to be,[1] and new and formidable political headwinds have moved to centerstage, several accomplishments over the first period give reason for optimism. To name a few:

- The science of climate change moved from plausible and hypothetical to consensual and empirically confirmed.
- Innovations in technology and deployment practices drove costs of clean energy from politically prohibitive toward parity with fossil fuels in some locations. By 2018, in some markets, new solar plus storage became cheaper than operating existing coal plants.[2]
- Carbon pricing initiatives were implemented in many core nations and regions. By 2018, 20% of global GHG emissions were covered under a pricing regime.[3]
- In December 2015, 195 countries signed the Paris Agreement to limit global warming to no more than 2 degrees Celsius and the agreement includes a framework for reporting on and strengthening commitments to achieve the goal.[4]
- Starting in 2015, global investment in renewable energy has topped $300 billion per year[5] and corporate procurement is on track to top 4 GW of new renewable generation capacity in 2018.[6]

To have a shot at achieving net-zero greenhouse gas (GHG) emissions between now and 2050, efforts must attend to four critical areas: 1) catalyzing private investment, 2) measuring, disclosing, and managing climate risks, 3) dealing with stranded assets, and 4) transforming legacy systems. Emerging themes in these areas threaten to dampen an already insufficient rate of climate progress. To make necessary headway in the second period, communities and polities across the world must gain the upper hand on the following challenges:

- Rationalizing the diverse portfolio of instruments and institutions deployed around climate action to make more efficient and effective use of scarce public investment, fiscal, and regulatory capacities.
- Ensuring that carbon-intensive production systems, market designs, business models, and financial practices accurately account for climate risk to realize the economic potential of sustainable technologies.
- Managing the decline of asset values and communities, particularly when these losses are borne by state-owned firms, banks, and politically sensitive interests.
- Mobilizing financial, intellectual, and political resources and investing in changes at the system level rather than in the margins of existing energy and other core economic sectors.

## Three Areas of Divergence Mark the Passage from 1990 to 2020

In charting a course to 2050, assumptions of economic, political, financial, legal, technological, and geopolitical dynamics circa 1990 require wholesale reimagination.[7] Failure to build into the emergent world of 2050 – that is to miss the following detours – will lead to a proliferation of stranded assets that will slow down the pace, and intensify the pain, of transitioning to a sustainable economy. Indeed, a failure to account for deviations from assumptions prevalent in 1990 has already brought about ineffective initiatives to reinvigorate the post-Paris limbo in climate affairs.

Below are the three key areas of divergence that are already reshaping the contours of the world into which the climate crisis was born.

### 1. Macroeconomic weakening

With hindsight motivated by the 2008 financial crisis, Western economists and governments have become increasingly aware that macroeconomic conditions have shifted away from a flywheel of 3% annual growth. This reality is showing up as stable or lower productivity, stagnant real wages, and increasing ratios of debt to national incomes. Attention to this trend was initially offset by demand for capital goods and services from emerging markets and by the early impacts of information technologies. More recently, awareness of structural rather than cyclical stagnation is growing.[8]

Macroeconomic stagnation complicates climate finance in critical ways. The following obstacles are worth noting:

- Stagnation nets lower levels of fiscal and borrowing capacity to support infrastructure adapted to new technologies and sustainability goals.
- In developed and developing economies, reduced or negative demand growth for climate-related services like energy generation and transmission exacerbates the tension between new build (renewables) and stranded assets (fossil).[9]
- Private investment strategies that stress liquidity are preferred in order to avoid macroeconomic risks.[10]
- Policies to restore or maintain growth and growth expectations in the private sector are favored.
- Asset owners, firms, and communities tend to become increasingly defensive of established budgets in the face of declining incomes and to hide behind the invisibility of deferred infrastructure investment or maintenance.

### 2. Technological innovation

Although the effects — economic, political, financial, geopolitical, and social — of data science, automation, robotics, and artificial intelligence are described and contested with various degrees of depth and accuracy, there is widespread agreement that by 2050, technological change will have further disrupted the world and its challenges. The impacts of these technologies on climate risks and actions will be both general and specific. Generally, the substitution of knowledge for natural resources (as well as labor) promises environmental benefits. As each unit of value added to the economy is driven by more efficient use of the materials consumed in its production, the by-products that appear as pollution decline correspondingly. Specifically, applications of technology in energy (e.g., fixed and flexible supply integration, demand-side management, new industrial materials), agriculture and forestry (e.g., precision farming with more efficient water and fertilizer use, remote monitoring and analysis systems), mobility services (e.g., virtual and automated, shared vehicles), and urban form (e.g., drone delivery, land use design in post-congestion cities) should facilitate the speed of implementing climate friendly solutions.

The techno-optimist view of the future has several potential implications for climate policy and politics. More specifically:

- As much as dedicated climate actions will drive toward a sustainable future, it is likely the pace and scale of the technological innovation exogenous to climate actions, will, of itself, be a primary cause of climate risk management success or failure.
- Productivity and growth of discretionary capital stocks, especially in public finance, are likely preconditions for extensive investment in climate specific applications of new technologies.
- The evolution of applied data science and artificial intelligence (AI) to risk metrics and management in dynamic systems will increase macroeconomic capacity to manage unmonetized sustainability risks and policy responses.

### 3. Non-convergence in Asia

In the 1990s, national income growth dawning a new era of social, political, and economic organization was close to an article of faith. Authoritarian rule was expected to give way to middle-class demands for democracy and the rule of law; competitive markets were expected to replace state-driven misallocations, rent-seeking, and corruption; liberalization of trade and finance were to displace state banking and protectionism; technological development would serve to push toward more egalitarian citizenries; and externalized environmental costs would be adequately priced through transnational political actions. Approaching 2020, these forecasts seem to lie somewhere between Western self-deception and nostalgia. The sharpest points of contrast are often exposed in Asian, particularly Chinese, patterns of rapid development.[11]

The anxieties and debates about the failure of this predicted new era to emerge make multilateral coordination of climate strategies even more problematic. The friction is most evident in the operations and reforms of state finance systems. While the centrality of climate finance is recognized in the post-Paris agenda, most strategies are still largely predicated on the assumption that emerging-market financial systems will uniformly converge from public to private funding, from bank lending to capital markets, and from local/national to global capital flows. There has been an astonishing silence about the structure, incentives, and empirical behavior of the state-driven finance regimes that provide the bulk of resources to infrastructure in Asia where climate outcomes will be largely decided. Climate finance debates and initiatives that do not take state-driven finance into account will compromise heavily their own effectiveness and relevance.

## Structural Barriers Challenging Next Level Ambition

The following section identifies four categories of structural barriers governing the current state of climate finance and highlights specific weaknesses and frictions therein. To some extent, progress has been limited by failures of execution; mostly however, it is failures of imagination that have kept the next level out of reach.[12] That is, efforts born from a world-view that fails to recognize the way in which 1990 assumptions have diverged on the path to 2020, as articulated in the previous section. These four categories map to the four areas on which the Stanford Sustainable Finance Initiative will focus, as detailed in the final section of this paper.

**1. Public spending has yet to catalyze private investment at the requisite speed and scale.**

***Inefficiency and inconsistencies are limiting the potential of public finance***. While the private sector has begun to respond to market signals and has made limited progress, public investment in the low-carbon transition has been inefficient and insufficient, thereby limiting private investment and the expansion of public investment beyond the electric power sector.

Spawned in part by non-binding global climate accords, and in larger part by domestic pushes for global economic supremacy in emerging industries regarded as key, public investment in Germany (e.g., feed-in tariffs), China (e.g., manufacturing subsidies) and the US (e.g., tax credits and renewable portfolio standards) has driven down the cost of renewable energy worldwide. But the public dollars that succeeded in driving down the cost of renewables came at a cost that will be difficult, if not politically impossible, to afford in pursuit of decarbonization in mobility, agriculture, industry, and the built environment.[13] Furthermore, as long as governments continue to subsidize fossil fuels (to the tune of over $5 trillion worldwide in 2015[14] ) and lend to high-carbon infrastructure projects at preferential rates, public investment in decarbonization and resilience will be laden with inconsistencies.

***Public spending is no longer enough in market-driven systems***. In market-based finance systems, public investment, no matter how efficient, cannot fill the roughly $1.5 trillion gap that exists between current spend (in energy efficiency, renewables, transmission and storage, and low-carbon generation) and the $2.3 trillion the International Energy Agency forecasts, annually through 2040, to limit warming to 2 degrees Centigrade.[15] Closing the gap will hinge on the participation of private investors. Private investment in clean energy has been hovering at roughly a third of prescribed levels since 2014.[16] With a few exceptions, private investors have been rationally responding to market signals. The exceptions are both systemic in nature, namely a herd mentality and the related forces of inertia and career risk, and episodic, as in the highprofile failure of the first wave of cleantech venture capital investing. Private capital pursues investments that promise appropriate risk adjusted returns. It does not flow to "fill gaps" or through altruistic currents toward the pursuit of long-term harmony, at least not at adequate scale under the dominant neoliberal paradigm that governs the majority of the $100 trillion held by institutional investors worldwide.[17] Efforts that rely on the former will fail to move the latter.

Beyond converting degrees to dollars, aggregate volumetric goals – such as $1 trillion or $2.3 trillion – don't address the type, source, and target of finance needed for a multi-sectoral decarbonization strategy and are therefore of limited value.[18] To be sure, efforts to track climate finance flows are primarily in service to policy makers, philanthropists, and advocates. But beyond informing advocacy and policies that shape markets, which itself is a critical perquisite to achieving decarbonization, even improving the specificity, sophistication, and efficacy of finance measurements will have limited direct impact on private markets. As noted above, the private investors whose capital is required don't (yet) aim for global emissions targets.[19]

***Scaling private investment hinges on better and more sophisticated interfaces***. The second area for improvement encompasses both the interface between public and private investment and between sustainable investment products and the investment processes, compensation structures, and governance of institutional investors. The barriers to private investment in novel resource-efficient opportunities are well documented and include organizational design, incentive structures, liquidity preferences, networks favoring legacy systems, limited capacity to price risk, and a dearth of aligned access points; all of which work against long-term goals.[20] In response, a wave of new investment products and vehicles have emerged to address some of these barriers. From low-carbon ETFs, to green bonds and green banks, to ten-figure impact investment funds, activities among proactive and opportunistic investors have increased allocations to capture the lower hanging fruit in the sustainable assets tree. But this increased investment is predicated on low-carbon and resource efficient assets meeting return expectations and the rise of sustainability in the consciousness of millennials and billionaires. It would be folly to bet the global climate on such fickle forces.

***Business and financial innovation will be critical***. In parallel to designing sophisticated public-private partnerships and overcoming the structural barriers driving short-termism, the pursuit of innovative mechanisms and models must continue in earnest. Over the past several years, business and financial innovation in pursuit of sustainability has been growing steadily – cutting across both state (in the form of green bonds and thematic mandates in national development banks) and market driven systems, and driving levels of investment beyond even the most optimistic forecasts (see: green bonds' four-year rise from scratch to $155.5 billion in 2017 and corporate renewables procurement approaching 4 GW in 2018.) Even in the decimated funding landscape for early-stage cleantech, an enlightened and robust ecosystem of innovative vehicles, incubators, and accelerators blending and bridging government, university and philanthropic capital have begun to fill the vacuum left by the exodus of mainstream venture capital (see: PRIME Coalition, Cyclotron Road, Breakthrough Energy Ventures, and CREO Syndicate, US State green banks, among others.) In 2017, as a precursor to SFI, Stanford researchers published a framing paper identifying the barriers to institutional investment in clean energy and a suite of eight solution papers illuminating paths to overcome them.[21]

Yet all of these signs of progress merely underscore the need and opportunity for new models to optimize public and private risk bearing at scale. The world still lacks the ability to deploy critical technologies across multiple sectors where economic and policy headwinds remain, and it risks locking-in polluting infrastructure in many regions because that infrastructure is today easier than lower-carbon infrastructure to finance. A systematic and coordinated approach to financial innovation will be necessary to simultaneously hit the world's financial and climate targets.

**2. Climate risk isn't properly measured, disclosed, or managed.**

***More talk, more carbon***. The G20 Financial Stability Board has identified climate change as a systemic risk to global financial stability. Its Task Force on Climate-related Financial Disclosures (TCFD) has increased understanding and awareness of both "physical risks" (driven by acute and chronic extreme weather) and "transitional risks" (brought about by rapid technology and policy changes).[22] As the messengers of climate risk evolve from environmental advocates to titans of finance, policy, and industry, asset owners and executives are more actively seeking information regarding the financial impacts of climate change. But despite increased awareness among asset owners and C-suite executives of a looming disruption, and laudable efforts by both activists and pension funds from New York to California, the page count of reports and recommendations written on climate risk could be higher than the dollar value of assets bought, sold, or repriced as a result.[23]

***Scenario analyses are divorced from the laws of physics***. An emerging field of consultancies and software as a service (SaS) providers offer "scenario analyses" to help investors and executives predict the financial and operational implications of possible climate policy and technology pathways and their likelihood to occur. Such an analysis considers various input parameters (e.g. macroeconomic trends, technology mix and production capacity assumptions, market price assumptions, policy pathways, etc.) and yield outputs than can be used to estimate the value of a company, a project, or portfolio under any given scenario. These scenario analyses are generally built around the IEA 450 scenario, which offers models for specific policy and technology pathways to 2 degrees, and voluntary disclosures that exist under heterogeneous and non-comparable regimes. While currently best-in-class, these models lack the sophistication to match the extreme complexity of the systems within which their assumptions are made. Further limiting the usefulness to investors, current analyses render findings largely independent from the laws of physics – that is, the impacts on physical assets (and in turn, intangibles) as the climate changes.[24] A small and growing group of companies are building software with predictive capabilities to understand how asset values change as seas and temperatures rise, rain falls, and land burns with greater veracity. But to date, the efforts are small-scale, and the data and models are not sophisticated enough to compel investors to change course.

***Risk is the new carbon price***. We are at the dawn of a new era where investment will flow toward decarbonization and climate resilience, not as a result of a carbon price, but from the internalization of risk. Signs of the magnitude and centrality of climate risk analysis are emerging. Putting a price on carbon was always about repricing carbon-intensive assets. But a critical look at carbon pricing shows that these efforts have largely failed to achieve desired results.[25] The transition from price to risk will accelerate to the extent investors employ institutionalized techniques developed to manage other types of commercial risk.

***Central banks must play a central role***. Sustainability risks, largely because they are mismanaged or ignored, ultimately fall on government balance sheets, indirectly via state-owned firms, or are ultimately assumed as national liabilities (e.g., US flood insurance, CA wildfire losses, etc.). As a result, because of their mandates to preserve financial stability, sustainability has become the charge of central banks. The good news is that central banks have proven to be more effective than other government agencies in identifying and pricing risks, responding to them by credit creation and allocation, and coordinating behavior to a useful degree among their peer institutions transnationally.

TCFD's efforts to supplement, enhance, and accelerate the voluntary initiatives of private firms around climate risk disclosure is in recognition of the contingent liabilities confronting central banks. Rising to the call, in 2018, a leading group of central banks in both advanced economies and emerging market nations formed the Network for Greening the Financial System (NGFS). These banks and associated regulators are engaged with analytical work across national economies to identify, quantify, and elaborate macroeconomic strategies for dealing with sustainability risks that threaten financial and economic stability. In order to yield meaningful asset repricing, these coordinated analytical efforts must produce a new portfolio of regulatory, pooling, and financial instruments to distribute risks more efficiently and fairly among the private and public organizations positioned to bear them.

### 3. Stranded assets must be dealt with.

*Note: because managing the liabilities of stranded assets and the understanding of system transformation and integration (covered in the next section) are at the frontier of climate finance, the following challenges are more anticipatory – they identify points of friction and areas for investigation rather than a critique of how existing efforts don't go far enough.*

***Incumbent industries are mounting politically significant resistance***. The sectors whose value chains are most exposed to losses as a result of decarbonization contribute significantly to state and regional economies, and are mobilized to avoid and delay the transition. State and private owners of fossil fuel energy sources top this list. Other value chains with incentives to delay include steel, cement, and industrial agriculture. The intensity of resistance to writing-down assets is correlated with 1) the strength of monopoly power of capital and labor in affected sectors, 2) the threat to embedded regulatory power, 3) amortization, which renders young fleets of capital assets particularly vulnerable to substantial financial losses, and 4) the macroeconomic capacity of state enterprises, state banks, and state balance sheets to absorb these losses without destabilization. Responses among countries and firms facing the growing risk of loss include financial hedging, political resistance, demands for subsidized risk pooling, and public compensation for lost asset values. The problem is less in the actors themselves than in the economic, political, and legal systems in which they have learned to operate effectively. These systems, adapted to established technologies, must evolve to meet the innovations that are reshaping the future.

***Designing viable response strategies based on capacity is imperative***. National systems vary widely in their definition, valuation, and scope of compensatory practices associated with stranded assets. In state-driven financial systems like China, political administration of operational or capital losses is favored over legal and regulatory practices. In market-driven financial systems, legal, regulatory, and bankruptcy reorganization processes prevail. Viable strategies to smooth and distribute the unavoidable frictions of transition must align with the financial system through which they will be implemented.

***Innovative remedies can expedite progress + some examples***. Innovative remedies to fund stranded asset liabilities will accelerate the pace and scope of the transition. To date these strategies have been highly localized, even as their political and economic dynamics begin to attract attention. For example, in India, financially non-performing (state bank) loans in the energy sector are being evaluated against growing future evening load not yet likely to be cost-effectively supplied by other flexibility services. In the US, states where the all-in costs of new renewables are lower than the variable cost of existing coal plants, special purpose securities may capture some of the value added to the system to compensate owners and aid disadvantaged communities. Globally, multilateral stabilization funds can be targeted to provide climate related assistance to nations with heavy asset exposure associated with young vintages of emissions intensive capital, macroeconomic constraints on state asset write-downs, and substantial economic losses associated with commodity exports.[26]

### 4. Systems must be fundamentally – and massively – transformed.

***History points to early or fast movers gaining advantage***. The broad outline of economic history suggests that wealth and well-being have grown through transitions between production systems. These transitions are generally led by innovations in technology that push out potential productivity frontiers,[27] but both absolute wealth and relative shares are associated with adaptations of social, economic, political, and cultural institutions that better fit with the characteristics of the new technologies. In effect, those (countries, regions) who benefit fastest and, frequently, most from growth favoring transitions will be those not just with access to technological knowledge, but those who can shift early to new market and policy designs, re-allocate technology and regulatory risks, and reform business models at a scale sufficient to tip political and consumer demands in favor system change. [28]

***But…success of fast movers is not guaranteed***. The dynamics of system transition are neither certain, immediate, nor simple. Several factors contribute to lags and unanticipated consequences of transitions.[29] These factors include: 1) the experimental nature of re-designing collective and embedded institutions that had been a source of jobs, know-how and wealth in prior production systems; 2) the challenge of marshalling the political and social support to enact reforms across the systemic landscapes; 3) the availability of resources, human and financial, to build out the altered infrastructure required by technology innovation; and 4) the strategies and capacities of competitors to appropriate early mover returns. The lag between Thomas Edison's development of the first commercial electric dynamo in New York (1892) and a sustained and major change in the measured rate of associated productivity increases was arguably a half century.[30] Restructuring of the US production system around centrally supplied power occurred under the pressures and centralized authority of war administration, which provided incentives in the form of state mandated capital, assured profit levels, and ambitious production targets facilitating complete factory redesigns.[31]

***The recipe needs tweaking but early experience suggests ingredients***. Much analysis remains to be done to predict success for nations moving ahead with systemic transitions. Early experience suggests the following conditions contribute favorably:

- General economic capacity in, or policy commitment to, sophisticated manufacturing (equipment) or knowledge intensive technology-led development. (Germany; US; China).
- Limited or exhausted fossil resources and high fossil energy costs or insecurity combined with high availability of low-cost flexible energy services (Denmark; Chile).
- High (macro) economic growth, low capital costs, and government ability to mobilize and dedicate public capital to innovative technologies (Germany, US, China, India).
- Collective decision capacity for coordination and alignment across internal systems; credible risk underwriting by national financial systems (China, Germany, Denmark).
- High cultural value of sustainability services (Scandinavia, Germany) or local pollution impacts correlated with climate damages (China, India).

Unforeseen developments that have hindered decisions to commit to transition or the pace of change after commitments have been made include: macroeconomic weakness and uncertainty manifest in rising perceptions of longer macro-risk; high returns and monopoly power in installed firms and labor forces adapted to established production patterns (China generation and grid SOEs); regulatory commitments to established market designs (EU Energy Policy; India non-performing loan policy); and central state inability or failure to fund large scale infrastructure (US).

## The Stanford Sustainable Finance Initiative (SFI)

Many top universities are working on climate finance. That is as it should be; this is a colossal problem that demands the attention of myriad minds. Stanford, a leading academic institution with an established history of innovation and entrepreneurship, is particularly well-equipped to design and apply new approaches to the decarbonization transition. The school counts hundreds of science and engineering faculty working on climate-relevant technologies. Stanford is located in the heart of Silicon Valley, which for years has tried – and, as this paper has noted, in important ways failed – to scale up low-carbon technologies, meaning that Stanford sits in the center of the region that, arguably more than any other in the world, has scrambled to confront climate change. In addition, Stanford sits on the edge of the Pacific Ocean and thus straddles the East-West divide, a divide whose bridging will, also as already discussed in this paper, be so crucial to addressing the global climate challenge.

And Stanford has a long tradition of interdisciplinary work, an approach that will be critical in tackling this most complex of environmental problems. In launching the Sustainable Finance Initiative, the University will bring new horsepower to the table by harnessing its expertise, especially in areas not usually thought of as climate-related (business, law, development economics, advanced data analytics), toward the goal of accelerating a decarbonized global economy.

**Course Corrections**

In recognition of the ways in which the world has changed since 1990 and of the challenges hamstringing current efforts in climate finance, SFI has charted three "course corrections" in pursuit of 2050 climate targets. These pivots apply to climate efforts globally, and they will undergird all of SFI's work.

***Shifting frameworks***. Three adjustments to the classic climate frame stand out: 1) moving from carbon pricing to climate risk to reprice assets; 2) moving from projects on the margins to effecting production systems; and 3) shifting the lens from micro to macroeconomics.

***Targeting delivery***. Knowledge and mechanisms to transition technologies and sectors must move from general to local. The optimal design of system transformation demands deep competence in local knowledge and coordination. Information not translated into local knowledge, calls for reform without a local partner, absence from the scene when compromises are negotiated, moral advocacy without local ownership of the changes in contest, finance without supervision in its employment – all are increasingly likely to promise uncertain or imperfect results beyond 2020. In the end, the political economy of systemic transition is inevitably local.

***Converging with Asia***. Attention has been paid to China and India because of the volume of their emissions, but they have been routinely treated as finance and technology takers whose development and geopolitical paths would retrace the West's. The mechanics of state enterprises and banks have remained obscure and isolated, even though these entities are among the leading developers and funders of climate infrastructure. Post-2020, this lack of attention to Asia cannot continue without destructive consequences. Information technology development is the heartbeat of new Asian growth models. Capital supplies are concentrated in Asia. Geopolitical rivalries will be brokered along the Belt and Road. To not acknowledge, learn from, and participate actively in the roll-out of these processes will hamper the quest for sustainability.

SFI will orient its choice of projects and modes to deliver its contributions consistent with these course corrections. Building on Stanford's capacity to generate and apply knowledge, and leveraging faculty, students, and the university's power to convene, SFI will work to develop system transforming policy, business and finance solutions — in partnership with government and market participants in specific countries and regions -- with the goal of unlocking public and private capital flows at the speed and scale required to transition to decarbonization and climate resilience.

**Focus Areas**

SFI will organize its work across four focus areas, which mirror the preceding categories of critique in the "Structural Barriers Challenging Next Level Ambition" section, and aspire to address them.

**1. Catalyzing private spending**

SFI will pursue commercially realistic opportunities to design financial vehicles and business strategies tailored to the specific risk and opportunities associated with new low-carbon infrastructure and national energy, mobility and agriculture transitions. Specific areas of investigation will include blended finance (the use of public or philanthropic capital to mobilize multiples of additional private capital), purpose-built public and private equity vehicles, new business model design, and the effectiveness and impacts of green bond issuances. Interventions will be considered across the technology development cycle - from early-stage to full-scale deployment and within targeted markets.

**2. Measuring, disclosing, and managing climate risk.**

Technology transitions, policy pressure, and the physical impacts of climate change are creating financial loses (and gains) born by investors, insurance companies and tax payers. Building on the rise of voluntary and mandated initiatives for disclosure and management of sustainability risks, SFI will explore the frontier of risk metrics and management, including the application of big data analytics and artificial intelligence to the computation of physical and transition risks to companies, portfolios, and sovereigns. SFI will work collaboratively with financial institutions to develop new commercial products in insurance, hedging, and customized risk management services. Specific areas of investigation include analysis of how risk is transmitted through an economy (e.g., flood insurance and wild fire liability in the US), sovereign risk and central bank regulatory reform, and AI products for corporate risk and financial management.

**3. Dealing with stranded assets**

Global barriers to scaling-up capital include lower macroeconomic growth, infrastructure illiquidity, and the management of consequential stranded asset values on government and corporate balance sheets. SFI will develop and test the use of stabilization funds, securitization, and green bonds as a means to help governments manage the liabilities of stranded fossil generation assets. These liabilities also include jobs and communities left behind by low-carbon transitions. Initial work in this area includes supporting just transitions through financial markets in US states and stranded assets in China.

**4. Transforming systems**

New paradigms will be needed to integrate resource efficient technologies and infrastructure, at-scale, into legacy systems across the electric power, mobility and agriculture sectors. These transitions, considered at the country and regional level, will require intelligent market design and sophisticated risk and business models. Systems that efficiently and effectively navigate these production frontiers first will generate outsized returns. At the same time, emerging economies can build infrastructure that leap-frogs existing paradigms and technologies; positioning themselves to be more efficient, flexible, resilient, and environmentally sustainable. De-risking these new energy and infrastructure solutions will require systems-thinking and analysis to identify the most promising opportunities and largest risks. Exemplary projects include: market design and energy reform in India and system integration at the regional level in China and Southeast Asia.

**The Engine: How SFI Will Work**

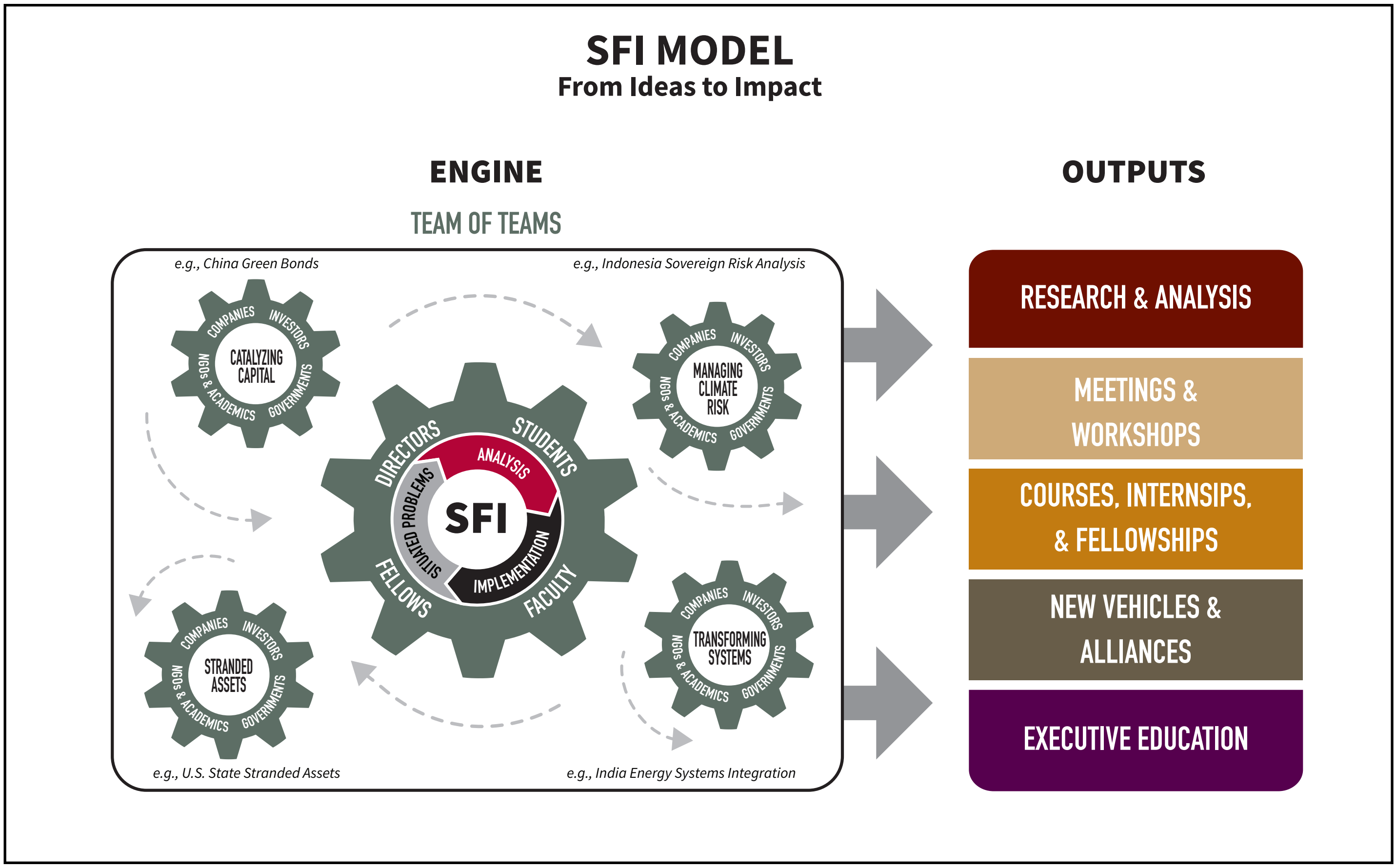
Technology is global; technology systems are local. Economics is global; political economy is situated and driven by coalitions of interested actors. Stanford has evolved along both lines: global in its science labs; situational in the roles it has played in the systemic change that has become Silicon Valley. As the context around climate action has shifted, it is appropriate to shift the strategy behind delivery of academic research and analysis. Organizational boundaries appropriately defined for parallel computing programs that enable AI are different from those needed to imagine, gather data on, and contribute to sorting out the market designs, business models and financial vehicles among participants in China's energy transition.

SFI will be structured with delivery channels built around situated problems. The Initiative will coordinate Stanford faculty, fellows and students to work in collaboration with government and market partners in specific countries and regions to tackle specific barriers to decarbonization and climate resilience.

SFI will be organized around two principles: project selection and team architecture. Projects most apt for SFI contribution will have the following characteristics:

- Elements of innovation, where adaptive finance, policies and business forms apply;
- Stanford faculty or fellows have expertise to advance the state of knowledge;
- Salience to a partner in the host polity with decision authority for, and interest in, a locally recognized and articulated problem to which Stanford can add value through its specialized knowledge and expertise;

- An existing or emerging coalition that brings together engaged corporations, financial institutions, regulators, non-profit or academic analysts to work with a locally present civil society organization or coordination mechanism.
- A defined implementation pathway toward specific outcomes.
- Significant impact potential considering both the specific issue in question and its effectiveness in the light of the wider dynamics of the inter-related elements of systemic transition.




SFI's operating model will be a team of teams. SFI's core team, comprised of its directors, fellows and advisors, will select projects, provide resources, and ensure that the operation of individual project teams is consistent with the global context and principles as defined in this paper. Project teams will operate in locations around the world on salient problems in collaboration with other relevant actors whose complimentary knowledge is necessary to yield innovative solutions.

# Conclusion

The 2015 Paris Agreement was both an end and a beginning. It marked the end of climate skepticism, high costs for key renewable energy projects, and deeply fragmented commitments among nations to participating in the sustainability agenda. Paris also marked the beginning of a new period in which climate programs must operate in recognition of political, economic, and technological shifts in the global order. Going forward, climate action must be reframed with attention to aligning solutions more explicitly with the emergent trends in a restructured global context. The most pressing problem is the massive scaling-up of investment for low-carbon and climate resilient infrastructure. At the same time, this scaling-up of targeted capital must be managed in conditions of macroeconomic weakness, common to advanced economies and emerging markets, that have reduced public investments, constrained fiscal and monetary capacities to tax and assume risks, and deferred infrastructure investment relative to competing demands for public expenditure. We can no longer consider climate separate from economic development. This reframing, when resituated in the specifics of a changing world context, defines the mission of SFI's work.

# Endnotes

1 Global greenhouse gas emissions were up in 2017, so too were investments in oil and gas, while investments in renewables have plateaued. In 2017, demand for coal rose for the first time in four years. Perhaps most unsettling of all, climate impacts are *accelerating* beyond what was to be expected under scientific consensus.

2 Xcel Energy, *2016 Electric Resource Plan: 2017 All Source Solicitation 30-Day Report* (Public Version), December 28, 2017, https://www.documentcloud.org/documents/4340162-Xcel-Solicitation-Report.html.

3 Though as Jeffrey Ball writes in *Foreign Affairs*, the more meaningful statistic is the minuscule percentage of emissions that are covered at a price high enough, according to economists, to really do anything about emissions. Jeffrey Ball, "Why Carbon Pricing Isn't Working," *Foreign Affair*s 97, no. 4 (July/August 2018), https://www.foreignaffairs.com/articles/world/2018-06-14/why-carbon-pricing-isnt-working.

4 It is important to note, even if the countries that ratified Paris do what they committed to do in their Nationally Determined Contributions (NDCs), the world will blow through 2 degrees warming. Indeed, it appears very likely that many of the Paris signatories will fail to meet their NDC pledges.

5 Abraham Louw, *Clean Energy Investment Trends*, 2017 (Bloomberg New Energy Finance: 2018), https://data.bloomberglp.com/bnef/sites/14/2018/01/BNEF-Clean-Energy-Investment-Investment-Trends-2017.pdf.

6 "BRC Deal Tracker," Business Renewables Center, http://businessrenewables.org/corporate-transactions/.

7 Thomas Heller, Three Perspectives: Climate Sustainability and Finance, Stanford University, November 2017, https://energy.stanford.edu/sites/default/files/hellerpaper_4pub.pdf.

8 Neil Irwin, "Is This a Mid-1990s Moment for the Economy? Three Reasons for Optimism", *New York Times*, September 9, 2018

9 World Bank Group, "Global Economic Prospects: The Turning of the Tide?" June 2018, pp. 21-48

10 2° Investing Initiative, "All Swans Are Black in the Dark: How the Short-term Focus of Financial Analysis Does Not Shed Light on Long-term Risks", February 2017

11 "How the West got China wrong," *Economist*, March 1, 2018, https://www.economist.com/leaders/2018/03/01/how-the-west-got-china-wrong.

12 It is both the responsibility and luxury of academia to zoom-out from the trenches and offer frameworks, critiques, and recommendations for those who can't afford to see the bigger picture. The analysis herein is offered as a means to achieve next level ambition, and not meant to throw stones at the visionary, capable, and hard-working leaders engaged in myriad of climate activities that are achieving measurable results.

13 On September 11, 2018, in the lead-up to the Global Climate Action Summit, California Governor Jerry Brown signed an Executive Order committing the state to total, economy-wide carbon neutrality by 2045 (B-55-18). If the world's fifth largest economy indeed pursues decarbonization across all sectors (not just electricity, but transportation, heating and cooling, industry, etc.) in the next period, and is able to lead other economies to follow, the possibilities for climate policy will have radically expanded.

14 David Coady et al., "How Large Are Global Fossil Fuel Subsidies?" *World Development* 91 (March 2017): 11-27, https://doi.org/10.1016/j.worlddev.2016.10.004.

15 International Energy Agency, "Introduction and Scope," in *World Energy Outlook* 2016, https://www.iea.org/media/publications/weo/WEO2016Chapter1.pdf.

16 Ceres, a sustainability advocacy group, set the bar at $1 trillion per year because their metric builds on Bloomberg New Energy Finance (BNEF) data, which does not include energy efficiency, electricity networks (transmission and storage) or low carbon sources (nuclear, CCS, etc.), whereas the IEA target of $2.3 trillion does.

17 Naomi Klein, "Capitalism Killed Our Climate Momentum, Not 'Human Nature,'" *Intercept*, August 3, 2018, https://theintercept.com/2018/08/03/climate-change-new-york-times-magazine/.

18 In its May 2018 report, "In Sight of the Clean Trillion", the sustainability non-profit Ceres made important progress toward illuminating financing needs and approaches but more work is need to cover sectors and technologies outside their scope, https://www.ceres.org/CleanTrillionInSight. Further progress is evidenced by Climate Policy Initiative (CPI) adding technology cost reductions to its 2018 Global Landscape of Climate Finance (Buchner, et. al), and number of organizations (ODI, RMI, CPI, E3G and WRI) are working to show "net climate finance".

19 By private investors, we mean institutional investors in the form of pension and sovereign funds, insurance companies, university and foundation endowments, and banks. High net worth individuals and families have emerged as pioneers of new forms of sustainable investing, breaking through many of the barriers limiting activity among their institutional counterparts. The private sector can be further divided into 1) asset owners whose primary activities are to design and follow a portfolio strategy, generally in accordance with traditional portfolio theory and to allocate capital across asset classes, relying heavily on third-party investment managers and; 2) asset managers who invest capital on behalf of their limited partners ("the owners") in projects and companies and whose incentive structures drive them toward assets that generate outsized returns quarterly for public equities and over a 3 – 5 year horizon in private equities, further they are rewarded for pursuing strategies that fit neatly into the asset-class silos of their limited partners.

20 Ashby Monk, Rajiv Sharma and Duncan Sinclair, Reframing Finance: New Models of Long-Term Investment Management, Stanford University Press August 2017; Ashby H.B. Monk, Sarah Kearney and Alicia Seiger, Energizing the US Resource Innovation Ecosystem: The Case for an Aligned Intermediary to Accelerate GHG Emissions Reduction June 12, 2015, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2617816

21 "Research Papers," Stanford Clean Energy Finance Forum, https://energy.stanford.edu/clean-energy-finance/research-papers.

22 Task Force on Climate-Related Financial Disclosures, *Final Report: Recommendations of the Task Force on Climate-Related Financial Disclosures*, June 2017, https://www.fsb-tcfd.org/publications/final-recommendations-report/.

23 In contrast, strategies in pursuit of sustainable alpha amount to hundreds of billions of dollars through both carve-outs and business-as-usual allocations.

24 Newsflash: as the climate changes, reversion to the mean is a thing of the past.

25 Ball, "Why Carbon Pricing Isn't Working"

26 These examples draw from work that is, or will be, housed at the Sustainable Finance Initiative.

27 W. Brian Arthur, *The Nature of Technology: What It Is and How It Evolves* (New York: Free Press, 2009).

28 In common business parlance, "you can't put a jet engine on the Wright brother's plane; you have to rebuild the frame." For more technical, but very clear and accessible, accounts of the systemic nature of economic transition, see Carlota Perez, *Technological Revolutions and Financial Capital: The Dynamics of Bubbles and Golden Ages* (Cheltenham: Edward Elgar, 2002), for highly technical theorization see Richard G. Lipsey, Kenneth I. Carlaw, and Clifford T. Bekar, *Economic Transformations: General Purpose Technologies and Long-Term Economic Growt*h (Oxford: Oxford University Press, 2006).

29 Douglass C. North, "Institutions," *Journal of Economic Perspectives* 5, no. 1 (winter 1991): 97-112. https://www.aeaweb.org/articles?id=10.1257/jep.5.1.97.

30 David, Paul A. "The Dynamo and the Computer: An Historical Perspective on the Modern Productivity Paradox." *The American Economic Review* 80, no. 2 (1990): 355-61. http://www.jstor.org/stable/2006600.

31 David M. Kennedy, *Freedom from Fear: The American People in Depression and War*, 1929-1945 (Oxford: Oxford University Press, 1999).

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