ClimateWorks FOUNDATION

2050 Today

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Deep decarbonization: financing the rapid deployment of innovations after R&D

Pre-read packet

Background

There is broad consensus that deep decarbonization requires R&D for zero-carbon and carbon-negative technologies in the energy sector and beyond. But, even more pressing, these technologies must deploy at gigatonne scale. Even for commercially proven technologies, the path to market maturity and cheap financing is not assured. Solar PV, battery storage, and other now familiar technologies with established markets are still descending steep cost curves. To meet the pace and scale necessary to achieve 2050 decarbonization, these technologies and other new market entrants must continue to rapidly descend these curves. This session will explore the roles and mechanisms of public and private financing to accelerate deployment of innovation on the last (and sometimes overlooked) "D" after RD&D. We'll look to participants to provide fresh thinking on sources, directions, and structures of financing, and how they might be better be marshaled to accelerate innovation deployment toward full decarbonization by mid-century.

Session objectives

1. Evaluate where mid-century decarbonization targets oblige us to rethink assumption about investment sources, directions and structures.
2. Identify sources, directions and structures of financing to drive low-carbon innovations down the cost curve faster.
3. Identify insights for when, and how to finance effectively, high-cost per ton—but high abatement potential—sectors and technologies.

Deep decarbonization by 2050: rethinking the role of climate finance

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There is broad consensus that limiting global warming to well below 2 degrees Celsius requires a peak in carbon emissions by 2020, a stable and steep decline through 2050, and close to net-zero emissions after mid-century. Many important actors the world over are now aligning around this 2050 lens for climate mitigation, with the knowledge that near-term incremental efforts that reduce emissions today will not be sufficient in the long run. Deep decarbonization by mid-century requires step-changes and systemic shifts.

Myriad white papers, blogs, strategy documents, and essays published by foundations, experts, and policymakers outline the fundamental ingredients that are needed by 2050 to keep us well below 2°C. While the details differ, in general the models show a need for enormous progress on energy efficiency, decarbonization of electricity and fuels, electrification of most transport fleets, buildings, and industry energy needs, and massive investments in electricity generating capacity, grid infrastructure, and power storage. With all of these substantial needs, it may not be enough to simply extend and scale up current emission-reducing technologies and practices. Solving the climate problem may also require significant investments in both zero-emissions and carbon negative solutions as well, including nuclear energy, carbon capture and storage, soil carbon sequestration, and afforestation and reforestation. And, to compound the challenge, all of this needs to happen rapidly and contemporaneously.

Drawing our roadmap to 2050 in terms of the technology mix, sectoral priorities, and the necessary policy plays is critical. But, despite our progress in understanding the array of climate solutions needed, the investment implications of achieving midcentury decarbonization are less understood beyond encouragement to "scale-up." Given the fundamental role finance plays in all facets of the global economy, it's time to begin this discussion now: **How does a focus on 2050 change how we spend money today?**

As a starting point, it requires a major shift in our thinking: in a mid-century timeframe, where deep abatement needs to happen across *all* sectors, delayed investment in sectors with high abatement costs at best delays and at worst radically increases those high costs (more on this point below). **This means we must move away from the orthodoxy of investing in lowest-cost marginal abatement opportunities that maximize near-term emission reductions per dollar invested and delaying action in high-cost abatement sectors.** This "best immediate bang for your buck" approach, focusing on only the most commercially available technologies, won't get us close to where we need to be by midcentury (Vogt-Schlib et. al, 2018).

It also means we need to shift how we measure and map progress on climate finance. Aggregate volumetric goals have guided us so far: the "clean trillions" that are needed to meet the Paris commitments, or the less robust but politically agreed goal of mobilizing $100 billion per year by 2020 for climate mitigation and adaptation activities in developing countries. While these measures are important and can help catalyze action, they don't tell us enough about the type, source and target of finance needed for all sectors implicated in a mid-century decarbonization strategy[1]. Absolute financial metrics, when used in isolation, have a number of shortcomings that make them poor tools to measure investment progress against mitigation outcomes:

1. They are an input measure (investment) that does not reflect outputs or outcomes related to decarbonization.
2. They fail to account for technology cost reductions (e.g., $1 million of finance in solar PV today does not equal $1 million a decade ago, when costs were significantly higher), so the overall impact of a dollar invested changes as costs change. In fact, we should *cheer* reductions in volumetric financial flows to the extent that these are driven by falling technology costs.
3. Progress against the investment needs of a decarbonized economy cannot be measured in isolation. They must be accompanied by declining investment in high-carbon activities. In other words: you'll fail at your diet if you only track the number of salads eaten while ignoring the number of ice cream sundaes also eaten.
4. Perhaps most importantly, ex-post tracking of financial volumes does not allow mission-oriented funders to understand *where, when,* and *how* to allocate investments to have the greatest impact on decarbonizing the global economy by mid-century.

A number of efforts are now underway to add more nuance and complement the gross volumetric frames. For example, since last year CPI has included technology cost reductions in its Global Landscape of Climate Finance, and plans to advance this work in future years; CERES has recently provided an update to its Clean Trillion report, providing a breakdown of the investment needed for different clean energy technologies; and a number of organizations – ODI, RMI, CPI, E3G, and WRI – have been working to integrate high-carbon investments to show "net climate finance" at the national, institutional, or global scale. These new efforts reinforce the need to **shift our focus from the *quantity* of finance to the *quality* of finance** (to paraphrase Mazzucato and Semieniuk, 2018), **and how to use finance most effectively**. It is within this context that ClimateWorks and Climate Policy Initiative are establishing a new research agenda— Climate Investment Research Collaborative on Long-term Effectiveness (CIRCLE)—that explores the role of finance in addressing longer-term

[1] CERES has made some important progress with their recent update to the Clean Trillions report. More work is needed to understand financing needs and approaches across sectors and technologies not covered by CERES.

decarbonization needs. We seek to move the climate finance community beyond a gross volumetric progress frame to one that explores more precise ways to target and assess the impact and effectiveness of mitigation investments at global scale.

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*Climate finance for 2050 deep decarbonization requires a more nuanced understanding of what **types** of finance are needed, taking on which **risks**, for which **technologies** in which **geographies**, and at what stage along the **technology development spectrum**.*

We invite other individuals and organizations to join us in this research effort. Some of the tough questions we're starting with include:

1. **How do we prioritize investments along the technology development spectrum, and how should different financial actors be targeted as a result?**

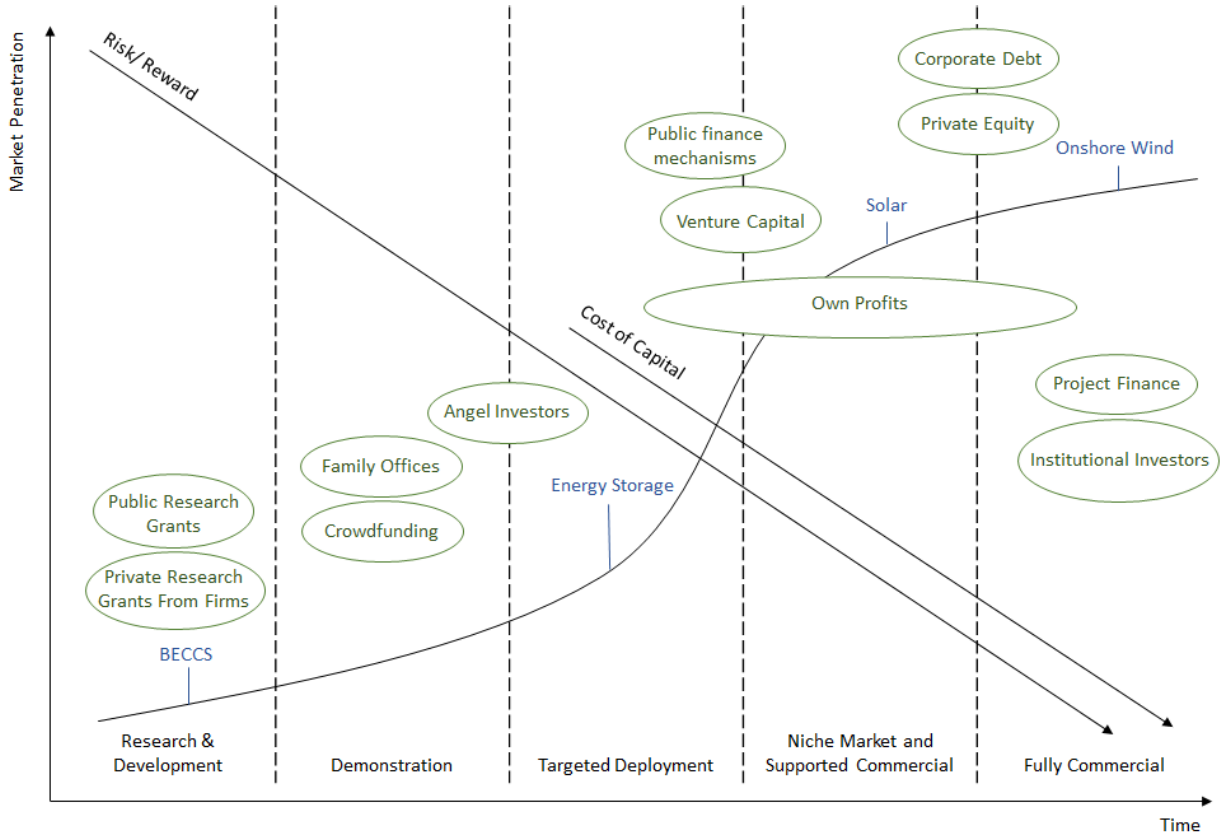
   While a fair amount of effort has been devoted to thinking through the role of different financial actors in financing renewable energy technologies (Tonkonogy, et. al., 2018, Mazzucato, 2018, Nelson and Pierpont, 2013), the 2050 frame is likely to change how we think about the type of innovations that require investment. Once we understand what to target, how do we begin to catalyze the appropriate financial actors to invest in those technologies or solutions, based on who is best suited to invest at different stages of technology development?

   We know that different types of financial actors are willing to bear different types of risks and rewards, with some investors taking more risk (higher potential rewards) at the earlier stages of technology development and lower risk (lower rewards) as the technology matures.

   A recent study of historic investment trends by different types of financial actors has also shown that different financial actors come with their own particular priorities, and create directions towards particular technologies with their investment decisions. Typical models of maturing innovations tend to emphasize the role of public investment at early stages (through RD&D), with private investors implicated during early commercialization and deployment stages and public efforts then only with public efforts then only focused on setting the right policy conditions as opposed to supporting investments. However, some analysis challenges whether the return expectations of private investors—in the form of venture capital— match the early commercialization needs of clean technology deployment. On the other hand, some research suggests that public investment can play an important role *throughout* commercialization and deployment stages, particularly downstream in the innovation chain. Green investment banks, loan guarantee programs, and other "industrial strategy" tools have helped accelerate the commercialization of low-carbon innovations.

More generally, such research points to the value of further analysis of the roles that different financial actors might be able to play along the technology development spectrum. Below is a framework to illustrate this (ideally the framework would be further improved by adding in the size of investment by each actor at each stage of technology development, and for different technologies).

Figure 1: Position of financial actors along the technology development curve

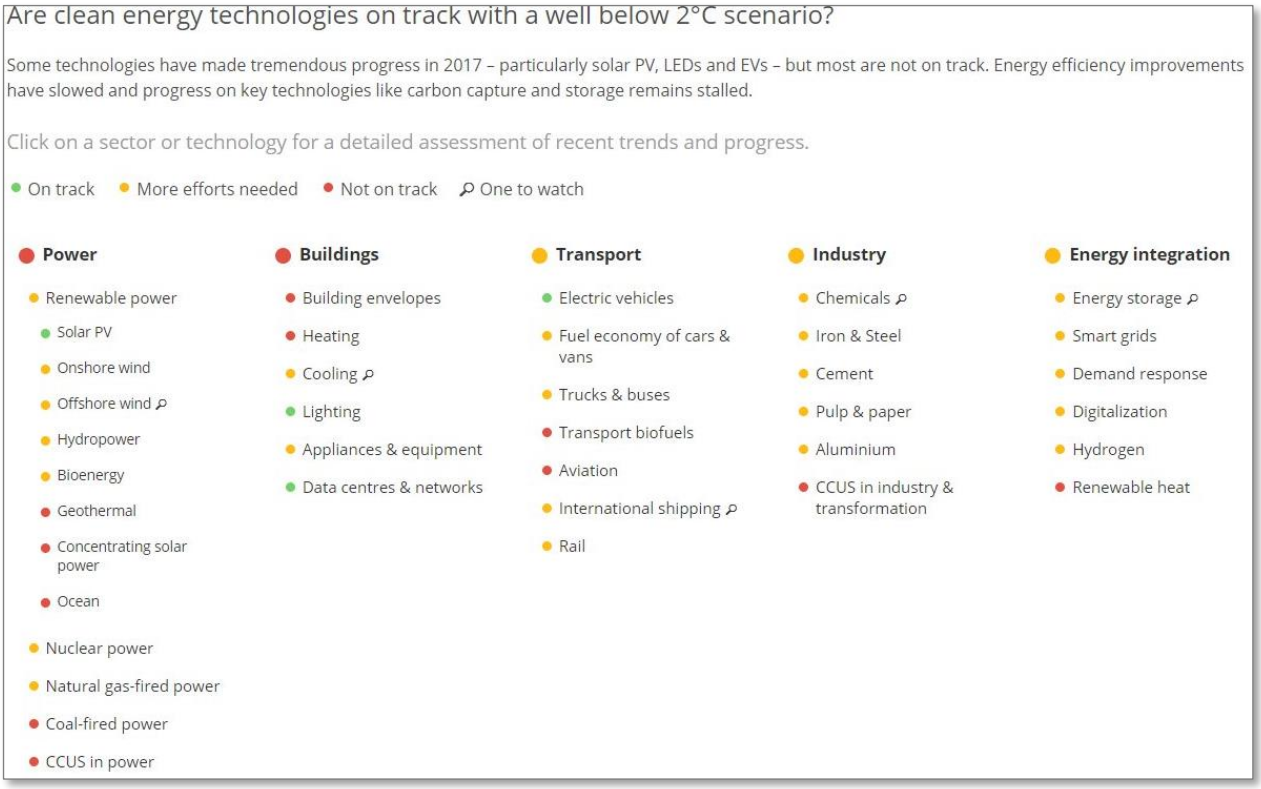


Source: author's own

Such a framework can help us see if investment is flowing to where we need it most, and help us think through the incentives and policies needed to target certain types of investors. By way of illustrative example, if we want to target advanced biofuels, and we know that private equity and venture capital make up 80% of advanced biofuel investments, we can then explore the appropriate incentives that can further stimulate investment from these actors (for example, through the creation of fund of fund structures that incentivize institutional investment into PE funds, or through public finance playing a risk-bearing or anchor role to unlock more private investment).

The International Energy Agency's Tracking Clean Energy Roadmap illustrates a relevant set of energy technologies against which progress could be mapped.

Figure 2: IEA's clean energy progress tracker



Source: IEA, Tracking Clean Energy Progress (2018)

2. **What tools can we use to target and prioritize investment for rapid diffusion of low-carbon innovations[2], looking across technology development spectrum and across geographies?**

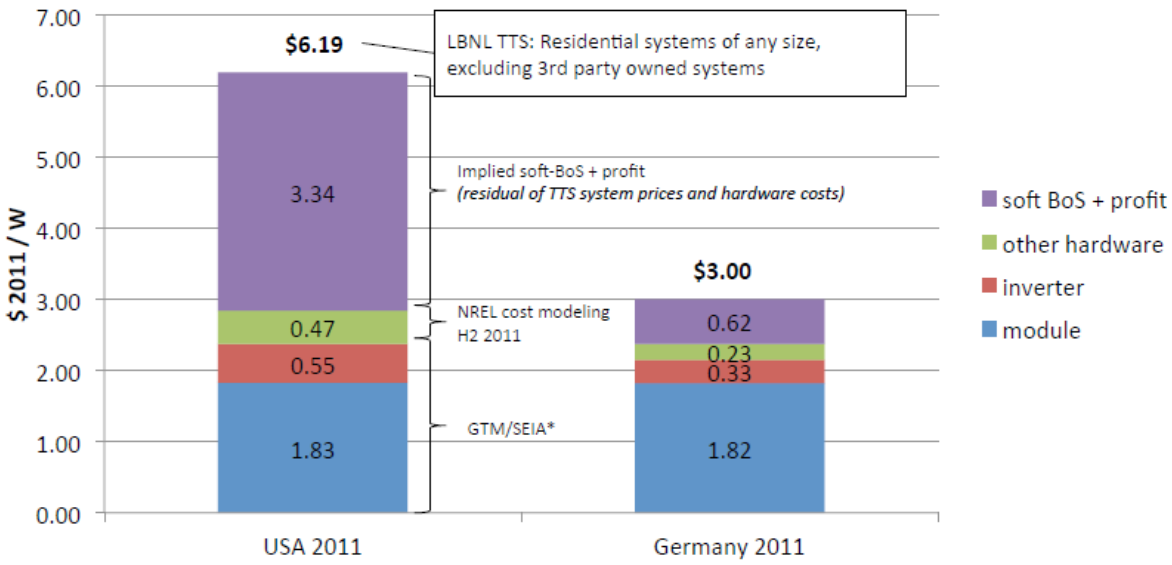
   Right now, the dominant criteria for official development assistance (ODA) for climate mitigation is either based on a social justice principle (i.e. prioritized for low income countries), or a country's abatement potential. Such approaches, while vital, don't guide us to where we need to invest in order to create the tipping points that will lead to full decarbonization. What tools can we use that will allow us to better prioritize climate finance focused on these goals?

[2] We use the term innovation here to comprise both novel technologies and application of those technologies to new markets and contexts. We also consider commercially available low-carbon technologies that are still seeing steep cost declines to be part of the innovation cycle. In the literature on innovation, the diffusion of a technological innovation into society can be considered in three distinct phases: pre-development, take-off, and breakthrough. Once the rate of change has decreased and a new balance is achieved, stabilization is said to have occurred. Therefore, a clean technology that is still experiencing cost reductions is innovating, as it has not yet reached stabilization.

Can cost analyses, like levelized costs of electricity (LCOE), provide a better way of targeting climate finance prioritization at a global scale? A more granular look at cost components (e.g., cost of local capital, balance-of-system costs like sales tax, supply chain costs, transaction costs), across technologies *and* across geographies[3], may guide us to which cost component needs to be targeted and changed in order to shift market dynamics toward decarbonization. It may also help us identify which geographies have the highest potential for cost declines, suggesting that targeted investment could lead to shifts in market dynamics as well.

Below is an illustration of how a simplified breakdown of solar PV LCOE can inform funders about which component(s) may be blocking the technology's uptake in specific markets (though a more detailed breakdown of the LCOE components would be even more informative).

Figure 3: Illustration of LCOE cost breakdown: US vs Germany residential solar PV (2011)



Source: LBNL (2013)

3. **How can we account for the role of both overseas *and domestic* investment in accelerating investment in low-carbon technologies in developing countries?**
Aghion and Jaravel (2015) make the case that directing innovation in developed countries to clean energy will lead to imitation of R&D efforts and adoption of clean energy technologies in developing countries. They argue that government R&D expenditure in developed countries will turn on the green 'innovation' machine in the 'North', which then will set in motion the green 'imitation' machine in the 'South' to adopt cleaner technologies developed in

[3] CPI's San Giorgio Group case studies series, which includes publications such as this provides a number of waterfalls on LCOE cost reductions in specific markets. More work can be done to apply this approach across markets and for different technologies.

the 'North'. This makes a case for accounting for unilateral policy and finance interventions by developed countries as important levers to accelerate low carbon investment in developing countries.

But why limit this argument to R&D? For instance, solar PV deployment in India has ultimately been aided by a cascade of domestic investments in the OECD and China, from R&D through deployment. U.S. R&D spending in the late 1970s drove costs down enough to allow for early stage policy support of deployment in Germany in the 1990s-2000, leading to state support to PV manufacturers and deployment in China in the 2000s-2010s. Investments in these jurisdictions drove solar PV levelized costs rapidly toward parity with high-carbon power generation, resulting in the highly competitive tenders under the Indian Government's solar auctions in recent years. Therefore, unmeasured but presumably enormous savings, and corollary unlocked investment dollars, accrued to the Indian economy due to domestic investments in the US, Germany and China. The same path might be mapped if we consider the maturation of low-carbon technologies in steel, transportation, or storage.

Climate-specific ODA will continue to play a critical role no matter what technological developments occur, not least because ODA can help build the enabling environment necessary *for* technology deployment and developing countries' capacity to effectively absorb low-carbon innovations. On the other hand, our framework for understanding how we address low-carbon development might better integrate domestic investments that reduce the cost of low-carbon alternatives and thereby make clean investment across borders more attractive.

To be sure, who "should" take on the burden of finance is a sensitive topic that reflects a broader set of value trade-offs, and there are certainly going to be winners and losers depending on the vantage point. However, we see merit in at least better tracking these technology maturation paths in order to better understand how to most effectively support catalytic initiatives in both developed and developing countries with the aim of providing cross-border decarbonization benefits.

4. **The high-hanging fruit: Is it time to view the McKinsey marginal abatement cost curves in a different light and focus on high-cost technologies?**
What does the 2050 orientation mean for the investments and technologies we prioritize? Adrien Vogt-Schlib, Gury Meunier, and Stephane Hallegatte (2018) argue that **we need to invest immediately in technologies and sectors that are most expensive and difficult to decarbonize, instead of those that are cheaper,** countering traditional climate economics rooted in marginal abatement cost curves that recommend capturing the cheapest opportunities to reduce emissions first. Vogt-Schlib et. al.'s argument is based on the idea that if everything needs to be decarbonized, and decarbonization takes time, then the appropriate investment (in dollar per ton terms) is first in sectors that are long and

expensive to decarbonize because effort needs to be distributed over a longer period of time to minimize costs. In most sectors, a late, abrupt transformation would be more expensive than a progressive, slow shift towards decarbonization, primarily due to "adjustment costs," like the costs associated with immediately scaling up a labor force to help with building efficiency retrofits and the associated cost of diverting a substantial share of the workforce and capital away from other productive uses in the economy.

Moreover, traditional marginal abatement cost models don't factor in a time dimension, and the fact that costs depend on the time it takes to implement a measure. Instead, emission reductions are determined each year independently in these models. In reality, abatement opportunities are rooted in capital investment decisions, which are locked in once made. Vogt-Schlib et al. have added these features to an abatement cost model and shown that it changes the results of what investments get prioritized: some higher cost interventions are prioritized, even if lower-cost alternatives are still available.

This complements an earlier (and independent) finding that investing early in expensive options allows for learning-by-doing over time and leads to cost declines as a consequence, pointing to another reason why funding higher-cost options may be an important mechanism to ensure overall lower-cost abatement (Wigley, et al. 1996).

Another interesting and related point is made by Heuberger et al (2018). A myopic strategy of waiting for a perfect cost-competitive "unicorn" technology, instead of supporting technologies that exist even if not yet cost-competitive, is delaying decarbonization and can lead to higher cumulative costs. Heuberger et al state, "a strategy of waiting for a unicorn technology that never appears could result in 61% higher cumulative total system cost by mid-century compared to deploying currently available low-carbon technologies early on." If this is correct, a framework that prioritizes only the lowest cost abatement opportunities may fail to prioritize higher-cost abatement opportunities that are critical to rapid decarbonization.

5. **What transactional or financial structuring innovations will be needed to support investments in new technologies?**

It's a given that every new technology under development will come with a unique revenue stream and set of risks. What financial instrument design innovations must we develop to best support these technologies and allow them to be attractive to investors? Work is already underway in the context of the Global Innovation Lab for Climate Finance, which has developed innovations in financial instruments related to a number of technologies: distributed solar, mini-grids, utility scale solar and wind, electric batteries for buses, and many more. Where can we expand this work to begin to target the harder to reach

technologies that we know will soon need financing structures to support their uptake?

We aim to further unpack these questions, and others, to form some guiding principles for climate finance over the next decade and beyond. We invite you to join us as we begin to think through the relevant questions and create new frameworks that can guide our near-term finance-related priorities to meet midcentury climate goals.

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