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Innovative Finance for Energy Innovation

Bill Gates made international headlines during the 2015 United Nations Climate Change Conference, or COP21, by announcing the Breakthrough Energy Coalition, a group of high net worth investors, including Jeff Bezos and Richard Branson, committed to invest $2 billion in energy research. Simultaneously, 20 heads of state pledged to double national funding for clean energy Research and Development (R&D) within five years. A year later, in December 2016, Gates launched his near $1 billion investment fund.[1] It is a high stakes effort to draw attention to what Gates and his co-investors see as the relative underinvestment in energy innovation.

That is not to suggest that clean energy innovation is not happening — it most certainly is, as evidenced by the declining costs of wind and solar and increasing efficiency.[2] But clean energy innovation — and follow on testing and demonstration — is not occurring at the pace needed to meet COP21 targets. In the race against climate change, with energy demand and emissions increasing even as many nations move towards cleaner energy sources,[3] clean energy innovation assumes a critical role.

There has been wide acknowledgement by the World Bank and the International Finance Corporation concerning the infrastructure needs — and associated costs — of reducing global output of greenhouse gases (GHG), from scaling up renewable energy production, increasing energy storage capacity, to modernizing the grid.[4] Achieving the stated 2 degree Celsius Scenario (2DS)[5], however, requires yet-to-be-demonstrated technological breakthroughs: even if all countries were to meet their COP21 pledges, global emissions reductions are estimated to be only half what is required to meet the 2DS.[6] Despite this gap, little has been said about the financing needs associated with energy innovation.

The implementation of the Paris Climate Change Agreement depends upon developing and implementing technologies that significantly reduce global GHG emissions. Both infrastructure overhauls and technological research require resources, but the type of financing mechanisms — whether traditional or innovative — will differ.

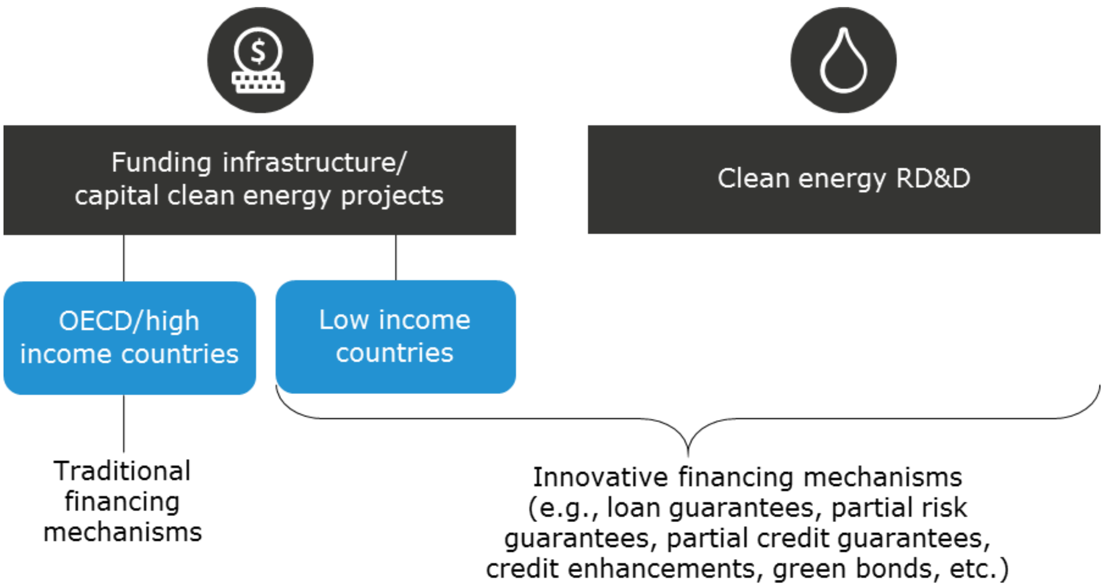

Figure 1: Energy Financing Needs and Mechanisms

- **Clean energy infrastructure projects in developed markets** — Developed economies can Clean energy infrastructure projects in developed markets: Developed economies can modernize the grid to include energy efficient and carbon neutral technologies. Associated financing needs can be largely met with traditional tools, such as government-issued bonds, deployed in a new context. Already there exists a range of financing tools, such as Clean Renewable Energy Bonds (CREBS) and Qualified Energy Conservation Bonds (QECB)7, designed to generate upfront project capital. State-level Energy Investment Partnerships (EIPs), or Green Banks, are employed across the country to leverage private sector funding via tax-exempt bonds, loans and tax credits.8 Renewable Energy (RE) stocks, yieldcos and mutual funds can provide predictable cash flow and link clean energy projects with mainstream investors and private equity assets.
- **Clean energy infrastructure projects in developing/emerging markets** — These projects are typically characterized by higher risk and uncertainty, hence, increased cost of capital. Traditional finance tools may be ill-suited to meet these project need as they may be deemed too high-risk or lack short-term returns. The development community has responded both with direct aid and grants, as well as innovative financing and risk mitigation mechanisms — loan guarantees, partial risk guarantees, partial credit guarantees, and other credit enhancement approaches and instruments intended to reduce project and investment risks.9 Each of these measures can serve to reduce risk and encourage the participation of private capital in the energy infrastructure space.
- **Technological research, development & demonstration (RD&D)** — New and improved clean energy technologies should precede infrastructure overhauls in developed and developing markets alike and may require long-term, enduring investment. To this end, financing tools are needed to generate capital. Given that traditional financing mechanisms have not succeeded in motivating sufficient movement of funds towards clean energy research, this paper explores in particular the relevance of innovative financing mechanisms, similar to those deployed to fund clean energy infrastructure in higher risk emerging markets.

Energy Finance Supply & Demand: Righting the balance

Innovation can require investment. Yet, even as the global community has increasingly reached consensus on the urgent need to reduce GHG emissions, clean energy innovation has been plagued by endemic investment shortages. These can be largely attributed to several characteristics unique to the energy industry that discourage venture capital investment.[10]

The technical lifecycle of an emerging technology is typically industry agnostic and follows a set trajectory: 1) early stage R&D, 2) demonstration and scaling of the technology, and 3) commercialization of the product and project rollout. The technological lifecycle may grind to a premature halt for any number of reasons: if results prove unsatisfactory, if cost outweighs benefits, if a market is absent, etc. If, however, a technology appears promising and develops along the outlined trajectory, the researchers and developers can progressively engage with different funders, detailed in Figure 2.

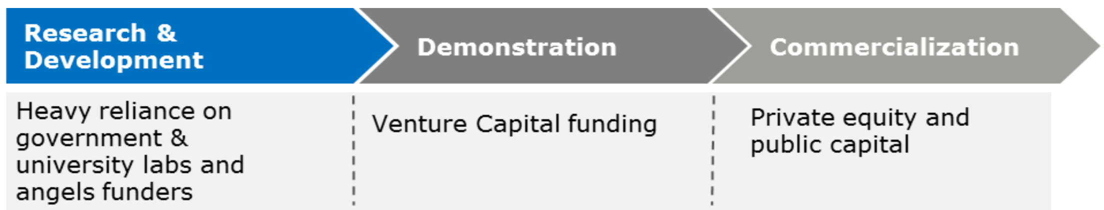

Figure 2: Technical Lifecycle & Funding Sources

In 2013, the U.S. government — the international leader for government spending on energy R&D — spent $5.3 billion on energy R&D.[11] This figures equates to less than 20% of what was spent on healthcare R&D ($31 billion) and a fraction of resources devoted to defense R&D in the U.S. ($69.8 billion).[12] The American Energy Innovation Council states that "the federal commitment to energy RD&D is less than one-half of 1 percent of the annual nationwide energy bill," or, less than Americans spend annually on potato and tortilla chips.[13]

U.S. government spending on energy R&D has trended gradually downward: the Congressional Budget Office notes that direct spending has declined over time, reaching $10 billion (in 2011 dollars) in 1980 and dropping to $3.4 billion in 2012.[14] The same report, however, stresses that tax preferences for clean energy research — valued at $20.5 billion in 2012 — provide government with another tool to support clean energy RD&D. The 2009 launch of ARPA-E, the DOE's flagship funding shop for energy innovation, point cautiously towards increased U.S. government support for energy RD&D.

Venture capital (VC) is also in scarce supply. A 2016 MIT study notes a surge in VC investment between 2006 and 2011, with $25 billion invested in the 'cleantech' sector. The results, however, left investors sour: investors lost over half of their investment. More than 90 percent of cleantech investments after 2007 failed to return the investment, while those that did generate returns yielded returns at a lower rate than medical or software technologies.[15]

Soon after the costly VC experiment with cleantech, investment in the industry dropped: in 2014, energy technologies[16] captured only about 4% ($1.87 billion) of total VC investment in the U.S. ($48.3 billion). For perspective, VC investment in software and biotech totaled $19.8 billion and $6.0 billion in 2014, respectively.[17] Public capital markets — generally used to fund technology in the final stages — have been a larger, if more volatile, source of funding, generating $2.9 billion in Q2 of 2014.[18]

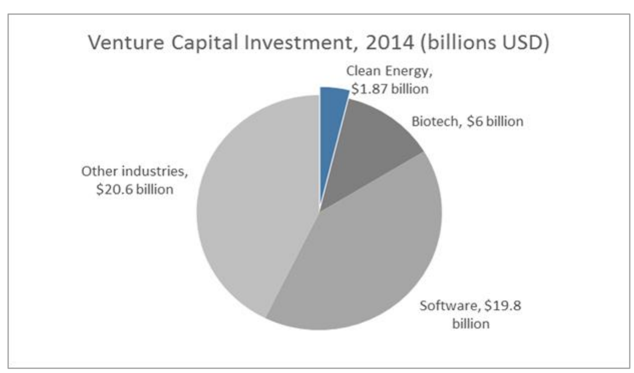

Figure 3: Venture Capital Investment, 2014

Venture capital's hesitation over cleantech technologies is understandable: whereas IT investments can feasibly expect a 10x return on investment within a few years, clean energy investments are characterized by a longer timeline, larger upfront capital needs, lower returns and higher risk. Development of new software can be completed and rolled out to market within a few years, or even months. Energy is unique, however, in the extended duration of the research, development, demonstration & commercialization (RDD&C) lifecycle: as a product progresses through its lifecycle, each phase can be highly time consuming, measured in years rather than months, and can entail high capital demands.

Furthermore, the uptake of new clean energy technologies is slow and often requires costly updates to supporting infrastructure.[19] Uncertainty about the longevity of government support and consumer willingness to adopt low carbon alternatives can make the valuation of early stage clean energy technology challenging. With all this in mind, the National Renewable Energy Laboratory compares clean energy R&D to the chemical and pharma industries: "long development cycles, strict government regulations, and strong incumbent players.[20] The aforementioned MIT study concludes that "cleantech clearly does not fit the risk, return or time profiles of transitional venture capital investors."[21]

There are also a number of obstacles to VC involvement in clean energy connected to market dynamics. The natural gas revolution in the U.S. and subsequent drop in price, for example, has lessened the perceived demand for and appeal of clean energy research in recent years.[22] The historically cyclical movement of energy prices can produce incentives contrary to the long-term investment needed to see clean energy technological innovations through to completion. The clean energy industry may also have been discouraged by resistance from some state governments and utilities as well as policy volatility.[23] While the 2015 extension of federal solar/wind tax credits was forecasted to generate 20 GW new capacity in new solar production and 19 GW in new wind,[24] the preceding lapse of the wind production tax credit generated uncertainty and may have negatively impacted VC investment. A combination of government signaling and market forces may point, in party, to why VC investment in clean energy innovation has limited prospects.

Getting To Net Zero Emissions: Investing in clean energy infrastructure and RD&D

Lowering the aforementioned barriers to clean energy innovation could encourage investments in high need, high potential areas. An investment needs assessment for clean energy transformation should be based in the identification of both 1) technical and 2) infrastructure gaps. In the immediate wake of COP21, attention focused on the latter — specifically, the price tag associated with the conference pledges. The EIA estimated infrastructure investment requirements through 2030 to total $13.5 trillion, roughly $1 trillion annually.[25] Although global investment in clean energy infrastructure has increased five-fold in less than a decade, from $60 billion in 2006 to $310 billion in 2014, it falls well short of this figure. At present, the vast majority of investment is concentrated in wind and solar. Regionally, roughly one half — $154 billion — was invested in the APEC region in 2014 and $78 billion invested in the Americans and EMEA each.[26] Although a sizable funding gap remains, many of the necessary financing tools — including tax exempt bonds and loans — have been successfully deployed on the state or local level and offer precedent for other localities and countries.

Cost estimates to achieve COP21 objectives, however, act under the assumption that governments currently possess the technology needed to shift to low carbon alternatives without significantly altering lifestyles. The estimates omit the funding requirements associated with RDD&C that could hold the promise of generating innovations that allow the global community to reach or exceed the stated 2 degree Celsius goal.

Although it goes unstated (and, largely underfunded), continuous clean energy innovation is an assumption of policymakers — a number of COP21 commitments hinge on implementing technologies that are still in the demonstration or development phases.[27] Though not an all-inclusive list, research investment is needed to overcome the enduring technical gaps:

- **Carbon capture & sequestration (CCS)** — In the International Energy Agency's proposal to reduce global industry carbon emissions to meet the 2 degree scenario, some 30% of planned reductions would come from CCS.[28] However, CCS is not yet at a point where it is ready for large-scale implementation, placing our emissions reduction strategies in the precarious position of counting our chickens before they hatch. At present, 'high capacity' plants sequester roughly 2 MtCO2/year.[29] Meeting the IEA's aforementioned target would likely require either: 1) 50,000 such plants; or 2) plants with the ability to sequester larger volumes of carbon. Such a large-scale demonstration requires financing (and time) to build and monitor. Additional outstanding research questions remain around the safest places to inject sequestered carbon and monitoring procedures following sequestration.
- **Energy storage** — The technologies for intermittent sources of renewable energy such as wind, solar PV, and hydro have been successfully implemented in a range of geographies. Rapidly declining costs — of solar PV in particular — boost commercial viability. Without addressing the challenges associated with intermittency however, renewable energy cannot be deployed to provide baseload, reliable electricity nor power vehicles for long distances. While some countries, such as Germany, plan to balance this limitation in the short-term with flexible gas-fired generators able to power up quickly,[30] the challenges of intermittency remain.
- **Low carbon fuels/biomass** — Industry accounts for nearly 40% of global CO2 emissions, roughly two thirds of which is accounted for by the chemical, iron & steel and cement industries.[31] Their demand for extremely high temperatures is not possible with electric power, leaving these industries with no available alternative to fossil fuels. Given industry's large carbon footprint, further investigation into the use of biomass as a carbon neutral alternative to petroleum is needed.[32]
- **Nuclear —** Nuclear power offers a compelling clean power alternative. However, concerns about safety — particularly with regards to waste disposal — have prevented scaling up to date.[33] If safety concerns can be sufficiently addressed, nuclear power could offer an uninterrupted source of clean power that could counter/complement concerns about intermittency of renewables.

In this context of underinvestment, the initiative of the Breakthrough Energy Coalition is a new and needed source of clean energy financing, but part of a larger puzzle. To scale necessary financing for clean energy innovation, government actors should consider employing innovative finance — such as mechanisms that shift the timeline on financial returns — in order to help leverage additional capital.

Employing Innovative Financing Mechanisms to Drive Energy Innovation

Achieving technical advancements in these and other promising areas will likely require additional public and private investment. Yet, with market forces falling short on generating sufficient levels of private sector interest, we consider how governments could incentivize — in a cost effective way to taxpayers — additional private sector dollars.

Mission Innovation, the accompanying public sector initiative to Gate's Breakthrough Energy Initiative, features the most obvious tool — more direct government investment in energy R&D. While more R&D should generate more technologies rising to demonstration, governments also possess a range of other tools to facilitate the flow of private sector capital.[34] In addition to directing limited government funds to fill existing funding gaps (the industry 'valley of death'[35]), government could leverage additional capital, reduce investment risk and guarantee a market for successful innovations. Here, we offer several recommendations on how to do so, drawing upon best practice in infrastructure, scientific collaboration and the fledging field of social finance.

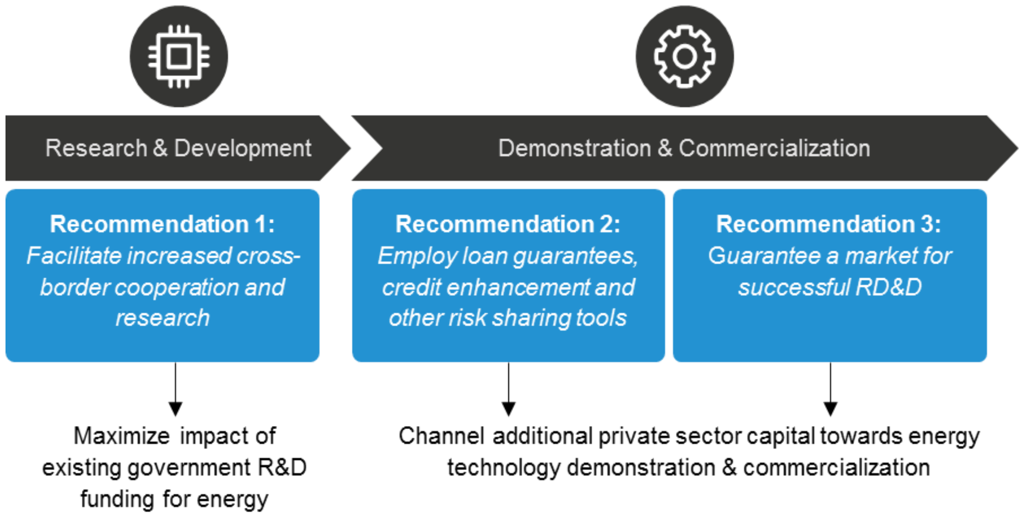

Figure 4: Recommendations to Drive Clean Energy Investment

1. Facilitate increased cross-border cooperation and research to maximize the impact of available resources

In Paris, world leaders agreed that a reduction in carbon emissions demands a coordinated, global approach. The consensus was that clean energy innovation is not zero sum; emission reductions made in one corner of the globe benefit everyone. Having long recognized, the U.S. National Labs are participants in international scientific collaboration: the National Energy Technology Laboratory has MOUs with Israel, Poland, Japan, Brazil, China, South Korea and the UK for collaboration on a range of fossil energy technologies, including CCS and coal gasification.[36] The National Renewable Energy Laboratory provides technical support to developing nations, facilitating the uptake of existing wind, solar PV and other low carbon alternatives.[37] Such cross-border cooperation can make maximal use of existing resources.

Those instances notwithstanding, much publically funded clean energy RDD&C remains governed by national borders. Historically, the majority of government spending on clean energy RDD&C has originated from national, rather than international, levels. Recent exceptions have emerged: the Global Climate Fund (GCF), established in 2010, aggregates funding into a single pool and directs resources to adaptation and mitigation projects that the Fund identifies as highest impact.

Mission Innovation — the intra-government commitment to double clean energy R&D in the next five years — could amplify its impact were it to borrow from this still early-stage approach and pool R&D funding from all participant nations, rather than each pursuing its individual energy agenda. Such a common funding pool could also enable funders to designate low-income countries largely void of preexisting energy infrastructure as test beds for new clean energy technologies. Such an approach could yield development dividends by allowing these nations to leapfrog over a carbon-dependent infrastructure, whilst building the technical knowledge base for the scale up of technologies globally.

The U.S government has employed a multi-agency approach in deploying household level energy efficiency technologies: members of the Interagency Task Force to Promote a Clean Energy Future for All Americans include the Executive Office of the President, U.S. Department of Energy, U.S. Environmental Protection Agency, U.S. Department of Housing and Urban Development, U.S. Department of Agriculture, and U.S. Department of Labor. More substantively, loan programs housed in the Federal Housing Administration and U.S. Department of Housing and Urban Development provide affordable financing option for household energy efficiency improvements. Applying such a collaborative approach to RDD&C on a global level, governments could maximize the impact of available resources and accelerate the cross-pollination of ideas and technical progress.

2. Employ loan guarantees, credit enhancement and other risk sharing tools

The global development community offers a promising model in the use of innovative finance tools to tackle large-scale challenges — vaccination, infrastructure, etc. — with high capital requirements. Many of these tools — including mechanisms to reduce risk and low or no-cost financing — can be deployed to reduce the obstacles that deter private investment in clean energy RD&D.

The U.S. Department of Energy Loan Program Office (LPO) already employs this approach, with a $30 billion portfolio of loans, loan guarantees, and conditional commitments. LPO targets advanced fossil, nuclear, renewable and energy efficiency projects in the initial phases of commercial deployment. LPO's role in financing early solar is a prime example of the ability of public resources to leverage additional private capital: by providing $10.5 billion in loan guarantees to 11 early-stage solar PV projects in 2010 and 2011, LPO facilitated the entry of commercial financing.[38] LPO's financing support is partially accountable for the steep drop in solar prices and increase in domestic PV capacity, reaching 24GW in 2015, up from only 4.8GW in 2013.

There are opportunities to apply the LPO financing model to earlier phases of the innovation lifecycle: research, development and demonstration. ARPA-E, for example, functions primarily as a grant program (with additional efforts to connect grantees with commercial funders) and concentrates on RD&D funding. Since its creation in 2009, ARPA-E has been met with high levels of demand from the research community: over the course of three funding rounds in 2009 and 2010, ARPA-E received 4,788 applications of which it was able to fund 121 projects — less than 1 percent.[39] There is a significant opportunity to boost the output of clean energy RD&D through the application of LPO-styled financing tools.

Creative uses of financing mechanisms have been employed throughout the technological lifecycle. Each mechanism tends to suit a single stage of the lifecycle, accordant with the risk level and accessibility of alternate capital. Given the interdependence of stages in the technological lifecycle, it is key to properly distribute financial resources across lifecycle, ensuring that no single step generates a bottleneck in overall innovation.

3. Reduce perceived risk by guaranteeing a market for successful RD&D

One of the characteristics distinguishing clean energy innovation from IT is the target market: whereas IT entrepreneurs target the individual consumer, most clean energy innovations will be sold to utilities, rather than directly to consumers. This market dynamic frequently places governments in the role of consumer. Internationally, public utility ownership remains the norm, although privatization has increased in recent years. In the United States, public sector electricity utilities represent a smaller share of the market — although they comprise 60.9% of domestic electricity utilities, they serve only 15% of American households.[40] By acting as early adopters of new energy technology, public sector utilities could generate a first mover effect, shifting customer expectations and driving privately owned utilities to follow suit.

The International Finance Facility for Immunisation (IFFIm) approach to vaccine funding offers a creative example of shifting market incentives and timelines that could be adapted and deployed in the energy market. Two aspects are worth highlighting: first, IFFIm frontloads the availability of donor committed funds to facilitate long-term planning and predictability. Donors make commitments as far as two decades into the future, which are then used as collateral to sell 'vaccine bonds,' generating capital available for immediate use. To date, IFFIm has raised more than $5 million, three times the donor funds received over the same period.[41] Given the immediate financing needs of energy RD&D, such a financing mechanism would allow donor governments to distribute their contributions over a period of time without forcing researchers to await fund availability.

Second, vaccine developers fear that while the *need* for a particular vaccine exists in developing countries, the market for such a vaccine (i.e. ability to pay) is often lacking. To resolve this misalignment of incentives, UNICEF's Supply Division, in collaboration with GAVI, issues calls for supply; essentially, a wish list of top priorities. If a researcher develops and produces a vaccine that meets the specifications, donors guarantee that they will purchase a preestablished number of vaccines at a set price, significantly reducing the associated risk.[42] Similarly, government electricity providers could conceivably guarantee investors a commercial market for products that meet predetermined specifications. Both elements of the IFFIm funding mechanism — accelerating the availability of donor funding via bonds and guaranteeing a market — could be adapted to clean energy RD&D to provide immediate access to increased funding and shorten the ROI timeframe.

The three recommendations proffered here — cross-border cooperation and research, government-sponsored risk sharing tools and ensuring markets for successful innovations — are not envisioned as comprehensive. However, if pursued, they could deploy existing government resources to maximal impact and channel additional private capital towards clean energy.

A Troika for Energy: Politics, science and finance

In the face of $13.5 trillion needed to fund the global clean energy infrastructure transition,[43] it is easy — and tempting — to ignore the additional resources needed for clean energy RD&D. This could be a dire mistake, one that may leave the signatories of the Paris Climate Agreement with a set of partial technological solutions, prevents communities from taking full advantage of promising innovation and sinks resources into infrastructure that is immediately scalable but can only go partway in reaching the 2050 target carbon emissions reductions.

Generating sufficient resources for energy innovation includes identifying the best fit funding mechanisms. To raise the capital to build and deploy clean energy infrastructure in the United States and other developed nations, traditional financing tools adapted to the energy context (green bonds, CREBs, QECBs) may fit the bill. The technology is proven and the investment environment is low-risk. The situation differs, however, in developing markets. Though investing in the same infrastructure, the increased political, economic and currency risks demand the application of loan guarantees, credit enhancement and other risk sharing tools in order to attract private capital. Likewise, clean energy RD&D is a high-risk endeavor, with long timeframes and large upfront capital needs. Direct government funding alone is not enough; innovative finance mechanisms are critical to attract and retain private sector investment. Innovative finance mechanisms can addresses these concerns, distributing risk across parties, countering the deterrents to investment with positive tax benefits, and ensuring technological uptake to shorten the ROI timeframe.

2015 ended on a hopeful note, with 195 global leaders overcoming the challenges of collective action to sign the first universal climate agreement. In the following months, the ratification of the Agreement[44] brought it into force on October 4, 2016. Successful implementation of the Agreement in the decades to come rests on continued political will, technological innovation and financing.

About the Author

Jessica Kuntz | jkuntz@deloitte.com

Jessica Kuntz provides strategic support to U.S. government agencies including the U.S. Department of Energy and U.S. Department of Human Development. She has worked on issues related to the prioritization of clean energy research and strategies to leverage private sector capital in the energy sector.

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