

Industry Agenda

# Renewable Infrastructure Investment Handbook: A Guide for Institutional Investors

December 2016





World Economic Forum®

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The World Economic Forum is pleased to present the *Renewable Infrastructure Investment Handbook*, a guide for institutional investors interested in climate finance. This handbook is part of the World Economic Forum's System Initiative on Shaping the Future of Long-Term Investing, Infrastructure and Development and supports the Forum's decade-long effort to illustrate how investors with a long-term outlook can make meaningful change in economies and societies.

The adoption of the Paris Agreement on 12 December 2015 by 195 governments is a major turning point in the global fight against climate change. To date, 190 governments have committed to specific actions to reduce their national greenhouse gas (GHG) emissions, covering over 95% of total global emissions. While these efforts alone will not suffice in keeping the world climate-safe, these bottom-up national pledges will provide a solid foundation from which ambition can be ratcheted up in the coming years.

At the same time, the Fourth Industrial Revolution has contributed to a dramatic reduction in technology costs, and new and attractive economics of the sector provide an opportunity for investors to find stable, inflation-protected yields while accelerating much-needed deployment of clean energy.

The World Economic Forum platform exists at the intersection of energy, climate and investment, which gives us the unique opportunity to bring all parties together towards a mutually beneficial goal. This handbook comes at a crucial time, when the renewables sector constitutes a compelling alternative to the low-yielding global environment, while the world strongly needs radical change to its energy matrix.

We would like to thank the many World Economic Forum Partner companies that have contributed their expertise and leadership. In particular, we wish to express appreciation to Capricorn Investment Group, Caisse de dépôt et placement du Québec (CDPQ), PensionDanmark, GIC, CERES, and Bloomberg New Energy Finance.

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# Introduction

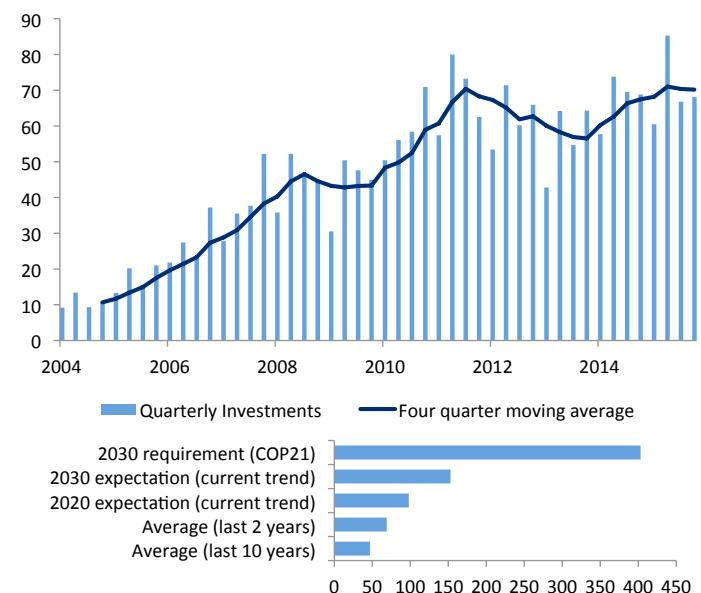
One of the most important challenges for institutional investors in the next several years is dealing with an environment of low-yielding opportunities combined with the rising need to deploy large amounts of capital and meet growing liabilities. At the same time, one of the most important challenges for the world as a whole is dealing with global warming and its proven economic impacts and negative consequences for humanity. While seemingly disparate, these two challenges have only recently converged to a point where they become synergistic. Renewable infrastructure has reached sufficient maturity to constitute a sound investment proposition and the best chance to reverse global warming.

Two key concerns that have historically inhibited investments in renewable infrastructure are size and risk. First, large institutional investors look for opportunities to deploy meaningful amounts of capital, which has not been previously possible in the incipient industry. Second, renewable energy has always been associated with frontier technology risks, outside the realm of feasibility for traditional investors. Both dynamics shifted in the past five years.

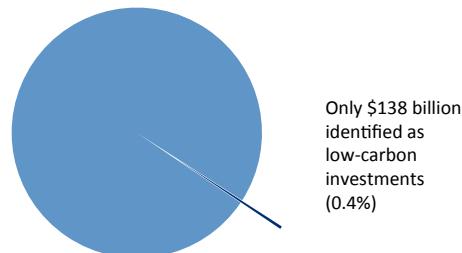
First, renewable infrastructure now exhibits sizeable investment potential. Conclusions from the United Nations Conference on Climate Change (COP21) in December 2015 highlight the need for an additional \$1 trillion in annual renewable infrastructure investment by 2030 to meet the goal of limiting global warming to 2 degrees. This need compares to a current annual average capacity investments of around \$200 billion. Furthermore, among the top 500 asset owners, including foundations, pensions and endowments, only 0.4% of total assets under management (AUM) have been identified as low-carbon investments (\$138 billion versus \$38 trillion AUM).

Second, and most importantly, renewable energy technology, especially solar and wind, has made exponential gains in efficiency in recent years, enough to achieve economic competitiveness and, in an increasing number of cases, grid parity. For instance, the unsubsidized, levelized cost of electricity (LCOE) for utility-scale solar photovoltaic, which was highly uncompetitive only five years ago, has declined at a 20% compounded annual rate, making it not only viable but also more attractive than coal in a wide range of countries. By 2020, solar photovoltaic is projected to have a lower LCOE than coal or natural gas-fired generation throughout the world. Renewable infrastructure has moved much closer to utility-like investments and no longer presents frontier technology-like risks.

Investments in Clean Energy (USD bn)



Asset Owners AUM



Source: Bloomberg New Energy Finance; CERES, Asset Owners Disclosure Project

Of course, some of the opportunities in renewable energy still present other types of risk, such as political or regulatory risk, especially in direct investments in emerging markets. Nonetheless, there is still a wide gap between perception and reality about risks and opportunities in the sector. Several risk-mitigation instruments, including political risk insurance, are available from international organizations.

This handbook aims to clarify these and other misperceptions around an industry that has evolved at a very fast pace, providing a quick reference guide for investors to step deeper into the sector. Section 1 provides an overview of the fast technological changes that have made renewables cross the economic efficiency threshold. Section 2 offers the landscape of renewable energy investments, detailing expected and realized risks and returns across asset classes. Section 3 highlights the key remaining risks in the sector, showcasing respective mitigating factors. Section 4 presents real-life examples from the experience of institutional investors, both in survey format and case studies. Section 5 concludes.

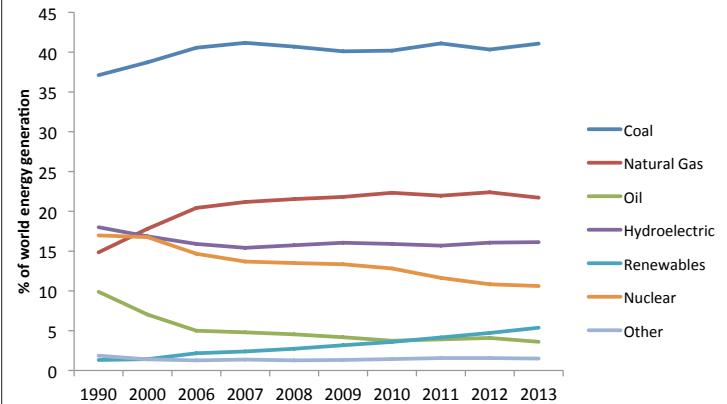
# The Technology Landscape

Even though the renewables proposition has always had environmental appeal, technology has historically been subpar in delivering appropriate returns to investors without an impact mandate. Inefficiencies in incipient solar and wind technologies have perpetuated a global energy matrix that still features coal and natural gas accounting for 62% of total generation. Nonetheless, exponential improvements in renewable technology, both in efficiency and cost, have made renewable energy competitive in the past few years.

On the efficiency front, it was only in the past five years, for instance, that commercially available solar panel efficiency jumped from about 15% to 22%, after two decades of near stagnation. In fact, research cell efficiencies now reach up to 46%, according to the National Renewable Energy Laboratory. Capacity factors for wind turbines have also improved substantially, from about 25% to 50% in the past decade, according to the (IEA).

Even more importantly, advances in manufacturing processes and economies of scale have considerably reduced production costs. For instance, solar photovoltaic system costs are mostly driven by module costs, which have recently benefited from high learning rates (price

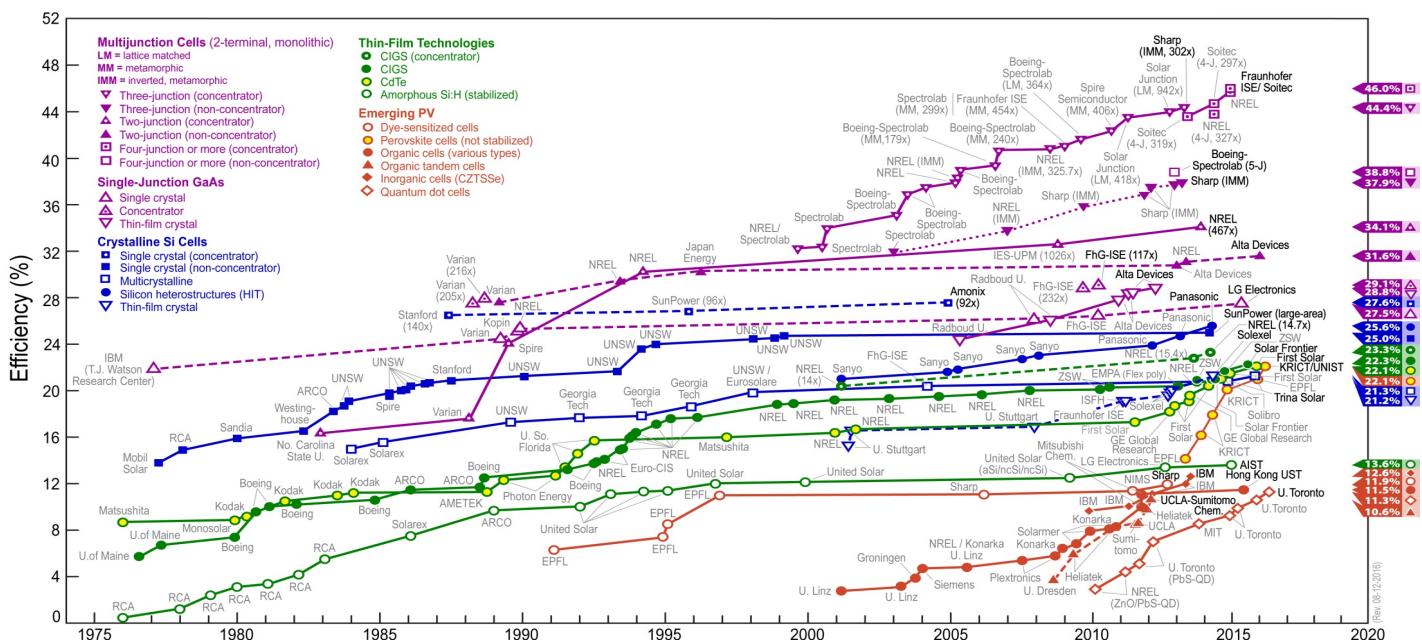
## World Energy Matrix



Source: World Bank

reduction for every doubling in production capacity) of up to 22%, and price compression of 80% since 2009, according to the International Renewable Energy Agency (IRENA). Wind turbine prices have fallen by more than 30% over the past three years.

## Best Research-Cells Efficiency



This plot is courtesy of the National Renewable Energy Laboratory, Golden, CO

A direct consequence of these efficiency gains and diminishing costs has been a dramatic fall in the LCOE across renewable technologies, especially solar, in the past few years. While the average global LCOE for coal has hovered around \$100/MWh for over a decade, solar has seen its cost plummet from around \$600 a decade ago to \$300 only five years later, and now close to or below \$100 for utility-scale photovoltaic. Wind LCOE is around \$50. In this sense, the two major sources of non-hydro renewable energy have reached grid parity in a number of countries. In an increasingly larger number of countries, it has become more economical to install solar and wind capacity than coal capacity.

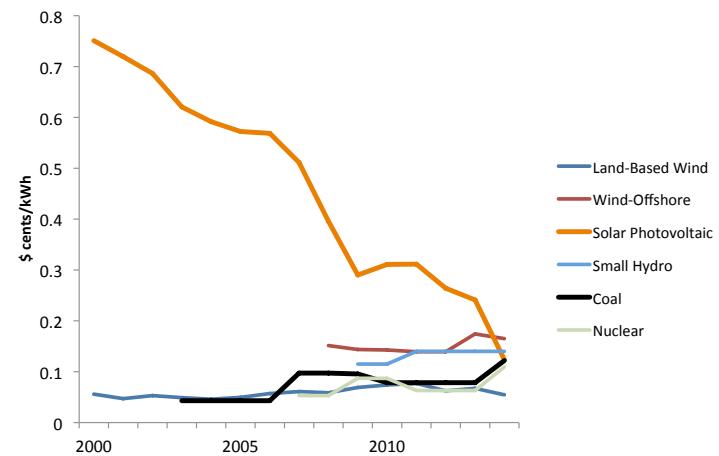
It is estimated that more than 30 countries have already reached grid parity without subsidies, and around two thirds of the world should reach grid parity in the next couple of years. If electricity costs were to rise by 3% annually, 80% of the global market would reach grid parity in the next couple of years, according to Deutsche Bank. Countries that have already reached grid parity include those in which demand is rising at a fast pace (e.g. Chile, Mexico) or insolation is high (e.g. Brazil, Australia).

Usually associated with intermittent generation (e.g. non-continuous sunlight, or wind currents), renewable-energy attractiveness has been additionally boosted by technological advances in battery and storage. Cost-efficient storage can overcome the seasonality issue of renewable power generation, and battery costs have fallen dramatically in the recent years. Boosted by the growth of electric vehicle markets, the average price of battery packs has fallen from \$1000/kWh in 2010 to \$350/kWh in 2015, according to the United Nations Environment Programme (UNEP). Further price compression is expected as electric vehicles become more widespread and battery production increases.

The evolution of renewable-energy technology has reached an inflection point in terms of cost-effectiveness and further improvements are poised to continue to come at an accelerated pace. Estimates by IRENA suggest solar LCOE will still fall by 59% over the next decade, while the same metric for wind will compress by 26% for onshore turbines.

These trends are relatively low-risk, with most necessary technologies already in development, and economies of scale continuing to be a self-reinforcing process. The fast adoption pace encourages supply expansion, which further reduces production costs and stimulates demand.

#### Levelized Cost of Energy (World Average)



Source: OpenEI, Transparent Cost Database

It is relevant to note that the mentioned evolution, market share gain and continued potential for renewable energy do not hinge on a subsidy advantage. In fact, according to the IEA, fossil-fuel consumption has received \$493 billion in subsidies in 2014, more than four times the value of subsidies to renewable energy.

Rapid technological advances and economies of scale have moved renewable energy from niche asset-class status restricted to investors with impact mandate to a sound stand-alone investment proposition. No longer classified as frontier technology, renewable energy has gotten much closer to utility-like infrastructure investments – and indeed outpaced fossil-fuel energy investment globally in 2015. In this sense, it is useful to examine the current investment landscape in the sector, identifying recent trends and opportunities.

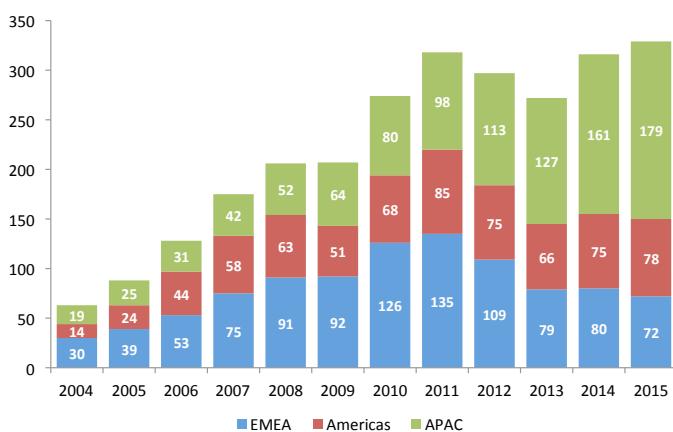


# The Market Landscape

According to UNEP and Bloomberg New Energy Finance (BNEF), total investment commitment to renewable energy across asset classes in 2015 was \$285.9 billion, surpassing the 2011 record. Considering the steep technological evolution and cost reductions, total generation capacity added rose significantly. In fact, 2015 was the first year on record in which the majority of global power-generation capacity addition was in renewables, excluding large hydro (53.6%).

Developing countries represented the majority (\$156 billion) of investment commitment to renewables in 2015, led by China (\$102.9 billion), India (\$10.2 billion) and Brazil (\$7.1 billion). Developed markets invested \$130 billion in 2015, led by Europe (\$48.8 billion), the United States (\$44.1 billion) and Japan (\$36.2 billion). In the past few years, developing markets have been the key growth area for renewables given demand potential, opportunities for steep technological improvements, and also partly driven by some cuts in support in developed economies.

Investments in Clean Energy (USD bn)



Source: Bloomberg New Energy Finance



In terms of technology, solar and wind continue to attract the most interest from investors, given mature technologies and proven business models. Solar investments amounted to \$161 billion in 2015, while wind attracted \$109.6 billion. All other renewable technologies combined (excluding large hydro) came to \$15.2 billion.

Investor exposure to the sector has been predominantly through asset finance (or direct investments into new-build projects, \$199 billion in 2015), while private equity and venture capital only amounted to \$3.4 billion in the same year. Public market equity investments represented \$12.8 billion. The other main categories of investment were small-scale solar projects of less than 1MW (\$67.4 billion) and corporate and government research and development (\$9.1 billion).

Asset finance has quickly grown to become the preferred source of exposure to renewable infrastructure, rising from \$52.6 billion in 2005 to \$152.9 billion in 2010, and \$199 billion in 2015. Roughly half of it (\$94 billion) was on-balance-sheet funding from utilities and specialist developers, while \$104 billion came from project finance (i.e. from investors or banks).

The composition of renewable infrastructure investments remains largely skewed towards debt financing. Development bank financing to clean energy represented \$83.9 billion in 2014, while the issuance of green bonds amounted to \$48 billion in 2015. On the equity side, YieldCos and project funds added up to \$7 billion in new issuance.

From a risk/reward point of view, renewable infrastructure offers a wide spectrum of investment opportunities, from relatively low-risk green bonds to illiquid direct investments. Granted, clean exposure to renewable energy may be harder to achieve through public market alternatives, as several issuers of green bonds or public equity are also involved in other businesses. Nonetheless, these alternatives offer some exposure to the desirable properties of renewable infrastructure, such as stable cash flows, inflation protection and long duration, and give smaller investors the opportunity to step into the sector without the need for dedicated infrastructure deal teams.

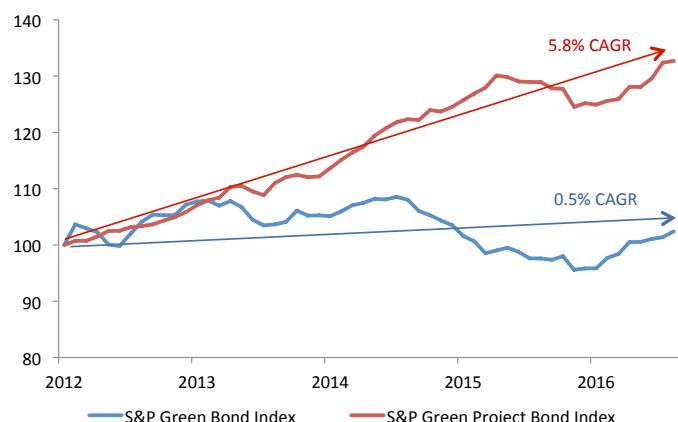
On the safer end of the spectrum, broader green bonds have been offering yields of around 1.6%, according to the S&P Green Bond Index (in which issuers self-report), after having compressed along with the US Treasury and corporate bond markets. Modified duration on the S&P Green Bond Index is currently about 5.3 years. Historical returns have been -0.5% in the past three years, while volatility was around 5%.

Renewable Infrastructure Investment Vehicles		
	Target Returns	Risks/Issues
Public debt (green bonds)	3-6%	Few “pure play” green infrastructure companies
Public equities	5-20%	Sector diversification limits
Infrastructure funds	7-20%	Fee structures, liquidity considerations
Direct project debt	6-10%	Illiquidity, deal pipeline
Direct project equity	12-18%	Illiquidity, deal pipeline

Green bonds as captured by the S&P index above may encompass a wide spectrum of corporates and different businesses. In this sense, a cleaner alternative is the S&P Green Project Bond Index, which tracks unlabelled bonds issued specifically for green projects and should bear higher correlation to the renewable energy sector performance. This index currently offers duration of 6.1 years. Average annualized returns over the past three years have been 6.5%, while volatility has been around 4%.

Moving up the risk spectrum to public equities, green indices also frequently incorporate different lines of business other than renewable energy, such as water, education and health. The S&P Global Clean Energy Index is a relatively pure alternative, tracking 30 global companies involved in clean energy production and equipment/technology. Its performance over the past three years has averaged 9.4% annual returns and 19.2% volatility.

#### Performance of Green Bonds (Jan 2012=100)



Source: S&P Dow Jones Indices

It is important to note that this performance blends results from pure technology companies and also production companies, with the latter representing the utility-like businesses. The performance of pure renewable energy production companies has been more volatile than the index, due especially to the underperformance of US YieldCos in 2015. YieldCos have suffered from a sharp change in investor sentiment last year. Instead of simply providing a pass-through from project cash flows to equity owners, as originally envisioned, US YieldCos turned to leverage and growth-seeking strategies, which initially excited investors but later led to concern about the sustainability of that growth.

Nonetheless, the business model of holding renewable energy assets and distributing most of the cash flows remains sound, offering investors the ability to differentiate technology and pure energy production. As originally envisioned, YieldCos should continue to support renewable infrastructure.

Further up the risk spectrum, infrastructure private equity funds offer diversified exposure to renewable infrastructure assets, an option appealing to investors without internal dedicated deal teams, but strong commitment to infrastructure exposure. According to the OECD, target returns on renewable infrastructure funds range from 7%-20%.

Finally, direct infrastructure investments provide the cleanest exposure to utility-like renewable energy assets, though frequently requiring internal dedicated teams. According to the OECD, target debt returns on direct investments range from 6%-10%, while target equity returns range from 12%-18%, though actual returns may be slightly lower.

In terms of historical performance of renewables, it is convenient to analyse the performance of two of the longest-running specialized equity indices, namely the NYSE Bloomberg Global Solar and Wind Indices. The difference in performance before and after 2013, when technology changed dramatically, is stark. Solar and wind companies returned on average -11.0% and -5.7% annually from 2006 to 2013, with 37% and 27% volatility, respectively. Technology was then incipient and generation largely inefficient when compared to fossil alternatives. After 2013, when solar and wind approached grid parity, performance has flipped. Solar has returned on average 10.3% annually, with 25% volatility, while wind has returned 17.5% annually, with 20% volatility.

Most importantly, it is crucial to note the shift, from high-volatility, frontier technology-like investments to more stable, utility-like assets. The change is as recent as three years and driven by exponential improvements in technologies and costs. With the attractiveness of renewable infrastructure from a fundamental perspective hardly in question anymore, remaining challenges should mostly relate to implementation and well-known risks linked to infrastructure generally.

# The Roadmap for Renewable Infrastructure

Risks around infrastructure investing in general and renewable infrastructure in particular can be broken down into three categories, according to the stage of development, from the pre-investment phase to construction (greenfield) and, finally, operation (brownfield). Even though not all of them can be completely hedged out, many risks can be mitigated and this section provides an overview of possible risks and available mitigation tools.

At the pre-investment phase, one of the most important challenges in renewable infrastructure investing is the available deal flow, especially for larger investors. Frequently, renewable-infrastructure opportunities are scattered, unique and projects not large enough to justify the due-diligence costs. Some of these challenges will be naturally overcome by market growth. As grid parity becomes more widespread, larger projects become viable.

Furthermore, international agencies have been working on aggregation tools that could help in pooling smaller projects into vehicles large enough to attract more institutional investors. One such example is the Climate Aggregation Platform, spearheaded by the United Nations Development Programme (UNDP) and expected to start by the end of 2016. The initiative will create a working group to promote engagement among key finance and industry stakeholders, develop a set of standardized toolkits, and provide in-country demonstrations and scale-up.

Nonetheless, most of the challenges encountered by institutional investors venturing into infrastructure are seen during the construction (greenfield) and operation (brownfield) phases of development. A convenient way to identify the most relevant risks, and respective mitigation tools, is through a practical example, and those compiled by the Global Infrastructure Hub (GIH) in its 2016 report on risk allocation are especially helpful. Even though the risks identified below correspond to those of a solar photovoltaic project, the extension is natural to other renewable-energy technologies.

At the greenfield stage, the first few key risks are related to land purchase and site approvals. The private partner is responsible for ensuring the suitability of the project site, including geology, security, pollution and having the necessary permits. Neither the government nor the contracting authority has the obligation to facilitate the issuance of permits. Besides thorough due diligence, the private partner can mitigate these risks through possible risk transfer to the engineering, procurement, construction (EPC) contractor.

Environmental and social risks are also the responsibility of the private partner. International lenders and development finance institutions are especially sensitive about these

risks, according to GIH. Private partners can mitigate some of these risks by making sure the contractor complies with permits and consents, including respective clauses in the contracts.

Design risk refers to the compliance with output and performance specifications, as any necessary changes would have to be approved by the contracting authority and delays would likely ensue. The usual mitigation is to include pass-through obligations to the contractors, and incorporate project-relief principles in the EPC contract.

Finally, construction and completion risks finish the list for greenfield stage projects. Those include labour disputes, quality standards, intellectual property rights breaches, cost overruns, delays and failure to meet the scheduled commercial operation date fixed under the power-purchase agreement (PPA). Delays lead both to additional construction costs and loss of revenue from the effectively shorter PPA term. Ultimately, the PPA contract may be terminated if delays are excessive (usually 18 months in emerging market contracts). The private partner can mitigate these risks with pass-through obligations to contractors (including delay-obligation damages), or engaging the consulting services of independent engineers (sometimes appointed by contracting authorities in emerging markets).

As project operation begins, a different set of risks arises, especially in performance and prices. The private partner is responsible for meeting the output specification metrics and matching expected generation costs. It typically is not possible, for instance, to add solar panels beyond what is contracted under the PPA. In this sense, the best mitigation tool is to pass the performance-specification responsibilities to contractors. In emerging markets, repairs might be allowed.

Resource or input risks can also be significant. For instance, interruption of crucial supplies could undermine project operation, though less so in solar and wind projects. While some of this risk can be passed through to contractors, this usually comes at higher fees as the interruptions are generally not in their control. In emerging markets, contracting authorities might be willing to share some of this risk, given that it can be driven by local political aspects.

Demand risk is also crucial in renewable energy deals (and infrastructure investments in general). As PPAs generally do not contain take-or-pay obligations, only actual power sold is remunerated. Even though there is no direct mitigation to demand risks (these are part of the due-diligence process and underwriting of macro assumptions), governments will stand behind the obligations of contracting authorities. Maintenance risks, or ensuring that the assets operate at



appropriate standards without incurring cost overruns, can be passed through to the operation and maintenance contractors.

Force majeure risks are usually well-provisioned. In general, private partners will be exempted from PPA obligations, such as the scheduled commercial operation date. However, private partners have to seek insurance to mitigate the loss of revenue and damages. Typical provisions include acts of war, acts of government, labour strikes, terrorism, earthquakes, floods and disruption of power-distribution systems.

Currency, interest rate and inflation risks are all borne by the private partners. PPA contracts may include an inflation adjustment to a specified index, but the basis risk that costs might evolve differently from the index is borne by the private partners. These financial risks are typically hedged via financial instruments (FX and rates forwards, swaps and options, inflation swaps).

Insurance risks might arise if proper due diligence is neglected. Particular types of insurance might not be commercially available and the private partners could, therefore, be exposed. Typical mitigation involves including an insurance adviser in the project.

Political risk has been one of the key issues concerning investors interested in long-term commitments, especially in emerging markets. In developed markets, this risk is usually listed as force majeure under the PPA. In emerging markets, some types of political risk (expropriation, nationalization) are treated as government default and the contracting authority will bear the risk. In any case, private partners have access to political risk insurance provided by international agencies such as MIGA and OPIC. Indicatively, OPIC political-risk insurance policies have up to 20-year terms, and premiums of around 35 basis points (or \$0.35 per \$100.00 insured annually).

Regulatory risk is also a major concern for long-term investors and more relevant for developed markets where political risk *per se* is contained. Changes in law, taxation and overall lack of stability in regulatory frameworks have made investors cautious about renewable infrastructure

investments. Usually, the contracting authority will bear the risk of changes in law but not in taxation. In some cases, force majeure might also be applied. For residual risks, insurance might be available. For instance, OPIC covers material changes in feed-in-tariffs, critical changes to taxation, revocation of permits and other regulatory risks.

Strategic risks relate to changes in shareholding and conflicts of interest between shareholders. PPA contracts typically require the original shareholders of the project company to keep a majority or control stake until three years after commercial operation starts. Private partners can mitigate this risk by creating a holding company for the project and establishing indirect mechanisms in the shareholder agreement.

Disruptive technology risks (also present during construction) expose private partners to the unexpected displacement of current technology. For instance, new technologies might be able to reduce power-generation costs but the private partner is not allowed to make the change under the PPA. For operating assets, there is no downside risk to the private partner, given the PPA. Typical mitigation involves adding clauses to the EPC contract to take full advantage of new technologies.

Finally, the risk of early termination exists when governments unilaterally decide to end contracts and private partners must, therefore, seek damages. Most efficient mitigation involves appropriately specifying termination triggers and respective remedies in the contract.

Although this list is not exhaustive and other mitigation tools may be available on a case-by-case basis, the above risks encompass a broad range of issues that might be currently hindering further investments in the renewable infrastructure space. The existence of alternatives to mitigate most of them suggests there is interest and opportunity in the sector. Tools will naturally evolve as the industry grows and as multiple stakeholders are given the opportunity to provide feedback and suggest improvements. In this sense, the next section provides an overview of the current state of affairs in terms of investor needs, perceptions and recommendations, taking direct feedback from institutional investors across geographies, sizes and mandates.

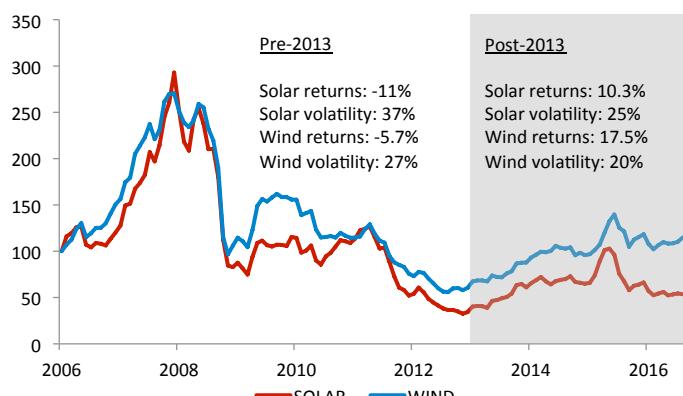
Risks	Description	Mitigation
<b>Land purchase and site</b>	Suitability of the project site (e.g. geology, security, pollution).	Thorough due-diligence; possible risk-transfer to EPC contractor; government has no obligation to speed-up permits.
<b>Environmental and social</b>	Environmental and social strategy (e.g. compensation for relocation).	Make sure contractor complies with permits/consents by including respective clauses in contracts.
<b>Design</b>	Design compliance with output/performance specifications; changes require consent by authorities.	Pass-through obligation to the contractors; project relief principles to be incorporated in contract.
<b>Construction</b>	Labour disputes, quality standards, IPR breaches, cost overruns.	Pass-through obligation to the contractors; some risks are exempted (e.g. force majeure)
<b>Completion</b>	Delays and cost overruns; failure to meet the scheduled commercial operation date.	Pass-through obligation (including delay obligation damages) to the contractors; independent engineer.
<b>Performance/price</b>	Meeting output specification metrics and costs; private partner cannot add more panels beyond contracted under PPA.	Pass-through obligation to the contractors; in EM, repairs might be allowed.
<b>Resource/input</b>	Interruption of necessary supplies for the project operation; in EM, this risk might be shared with authorities in some cases.	Some risk can be passed-through to the contractors, for higher fees.
<b>Demand</b>	PPA does not contain a take-or-pay obligation, so only actual power sold will be remunerated.	Governments will stand behind obligations of the contracting authority.
<b>Maintenance</b>	Maintaining the asset to the appropriate standards, subject to cost overruns.	Pass-through obligation to the operation and maintenance contractors.
<b>Force majeure</b>	Unexpected events beyond control of parties, compromising performance.	Private partner is exempted from PPA obligations, but should seek insurance to mitigate loss of revenue and damages.
<b>Currency and interest rate</b>	Private partner assumes all currency and interest rate risks.	Hedging instruments.
<b>Insurance</b>	Private partner is responsible for taking insurance for the project; particular types of insurance might not be available.	Thorough due diligence, including an insurance advisor.
<b>Political</b>	Government intervention, seizure, or expropriation.	Contracting authority will bear expropriation risk; force majeure may be applied; political insurance is available.
<b>Regulatory</b>	Change in law or taxation.	Contracting authority will bear change in law (not in tax) risk; force majeure may be applied; insurance may be available.
<b>Inflation</b>	Costs rising above expected under PPA.	Hedging instruments.
<b>Strategic</b>	Conflicts of interest, changes in shareholding; original private partner must remain in control.	Create a holding company for the project; indirect mechanisms specified in shareholder agreement.
<b>Disruptive technology</b>	Unexpected displacement of current technology, more applicable during construction.	Adding clauses to EPC contract in order to take full advantage of new technologies.

# The Existing Experience

A missing link between the attractiveness of this recently reinvented sector and relatively underwhelming realized investments can be better understood directly through the lens of investors. We have thoroughly interviewed a diverse group of institutional investors across geographies (Americas, Europe, Asia), sizes (from below \$50 billion assets under management to over \$500 billion) and mandates (sovereign wealth funds, pensions, insurances, asset managers) during August to October 2016. Their feedback is valuable in clarifying remaining challenges in the sector and in highlighting its appeal.

Broadly, the key reason for the lack of further investments in renewable infrastructure is the notion that it is not yet a stand-alone asset class (or that it cannot be compared to existing asset classes). Contracts are not standardized, regulation varies widely across countries and time, deals are scattered and due diligence is mostly conducted by existing infrastructure teams, on a case-by-case basis. As such, a publicly available and standardized track record in the sector has not been long enough to generate momentum among mainstream investors.

Performance of Equity Indices (Jan 2006=100)



Source: NYSE Bloomberg Global SOLAR and WIND indices

For those who are not invested meaningfully in the sector, lack of information is still the key reason for subdued involvement. The absence of specialized renewable infrastructure teams makes investments in the sector be qualified as niche, occasionally part of the regular infrastructure deal pipeline. Awareness of the recent track record in the sector may be a compelling enough reason for these investors, especially the larger ones, to step up. Indeed, some large investors have demonstrated strong interest in starting investments in the sector, only missing further studies and internal due diligence. The general perception, even among these investors, is that renewable infrastructure is worth considering. Given that such perception has been acquired only recently, it naturally takes some time to consolidate into actual investments.

Nonetheless, for those investors already involved, the remaining challenges in the industry are more well-defined and largely dependent on the size of each investor. While returns have been broadly similar, in the high-single digits, it is helpful to understand the profile of the investors and their preferences to recognize their challenges.

Some medium-sized investors, with AUM smaller than \$50 billion, have, on average, committed \$500 million to \$1 billion to the renewable infrastructure space and some started doing so about 10 years ago. Still, their main exposure is through public equities and funds. Their main challenge is being able to access the pipeline of direct investments, where opportunities are more compelling, but generally too large for individual investors of this size.

Large investors, with AUM between \$50 billion and \$500 billion, have, on average, committed \$1 billion to \$2 billion to the sector, having started about five years ago. Exposure is obtained largely through infrastructure funds. To these investors, the main challenge is still regulation, whether its excess or lack of stability, which makes legal costs a significant portion of total project costs.

Finally, for investors larger than \$500 billion in AUM, to whom most of the sector exposure is done through direct deals, the key remaining challenges are regulation and deal pipeline. On the latter, deals are generally too small to attract investors who need to deploy large amounts of capital.

While many of these concerns are valid, the sector has been evolving fast enough to provide some mitigation tools for each of these challenges.

First, the lack of standardization is being partly addressed by the existence of project developer guides, such as the IFC's guide on utility-scale solar photovoltaic power plants, which includes sample contracts for EPC and operation and maintenance (O&M). Further efforts to standardize the sector have been recently undertaken by the IRENA Solar Energy Standardization Effort, which will bring together public and private sector stakeholders to define a mutually acceptable template for solar project contracts and documents.

The issue of deal pipeline is less straightforward. Investors who have been ahead in the sector and successful in accessing a strong pipeline are those who have fostered long-term relationships with project developers, who are then able to pitch large, investable projects and execute them. For investors new to the sector, one alternative can be found in pools of deals, such as the recently created Climate Aggregation Platform. The initiative, spearheaded by the UNDP and the Climate Bonds Initiative, will bundle groups of small loans and assets into investable products large enough to attract global institutional investors. The platform, once fully

operational, will bridge an important gap for investors who would otherwise not be attracted by profitable projects with small dollar-value.

Finally, regulation has been the most cited challenge for investors looking into renewable infrastructure investments. While uncertainty in emerging markets' regulation is a hindering factor, developed markets were not exempt from being negatively viewed in this aspect, as over-regulation and lack of coordination generated significant legal costs for investors. Successful investors have generally managed to strike PPP contracts where the balance of risks between private and public stakeholders is adequate. Otherwise, mitigation tools for investors new to the sector include some types of insurance that, while not covering all regulatory risks, still cover those classified as expropriation or political violence. Indicatively, OPIC charges around 45 basis points (\$0.45 per \$100.00 insured) for expropriation insurance.

Institutional Investor Presence in Renewable Infrastructure			
Item/Size (AUM)	Very large	Large	Medium
<b>First investment in renewables</b>	7 years ago	5 years ago	10 years ago
<b>Commitment to renewables</b>	\$2bn to \$3bn	\$1bn to \$2bn	\$500mm to \$1bn
<b>Exposure</b>	Direct investments	Funds	Public equities and funds
<b>Returns</b>	High single digits	High single digits	High single digits
<b>Key constraint</b>	Regulation pipeline	Regulation	Most opportunities are in directs

While there is no easy solution to the regulatory challenge, the establishment of a widespread market for carbon would be a large step to coordinate efforts and provide investors with a globally accepted price for the output of their projects. Among the interviewed investors, only one currently makes use of

carbon prices directly in investment decisions. After the UN Paris Climate Summit in 2015, emission trading systems are already effective in more than 50 jurisdictions globally and the speed of adoption should increase given the ability countries will have to use carbon markets to meet their commitments. As a reference, carbon prices in California, the world's sixth largest economy and 14th largest emitter, are around \$13 per ton of CO<sub>2</sub>.

Other smaller concerns pointed out by interviewed investors relate to grid connection (or the lack thereof in certain jurisdictions), absence of a widely accepted valuation method for assets after PPAs expire and other risks linked to emerging markets. These are manageable risks, not unlike those related to infrastructure investments in general, and account for the additional return earned on top of pure fixed-income investments, while offering lower levels of volatility than those seen in equity markets. Most investors seem to understand these risks are part of the investment process but still require changes in their organizational structures and specialized teams to increase their comfort levels.

It is clear that investors have generally neglected the sector for a long time (arguably with reasonable justification) and the exponential changes in cost and efficiency have been too recent to have an impact on their mindsets. The challenges encountered by those ahead in the process are similar to those encountered by any investor in young fields. The difference is that what is young is the economic soundness of renewable infrastructure, not the technology itself. As such, the attractiveness of the sector will only increase as technology evolves further and economic soundness will be a given.

The remaining challenges encountered on a case-by-case basis will naturally disperse as the sector gains momentum and critical mass of sizeable deals. A catalyst for this process has been and will continue to be the 2015 Paris Agreement, which will further press for global changes welcome to the sector. Investors that understand the magnitude of the change will be able to capitalize on the rising trend while enjoying stable, infrastructure-like returns from renewable-energy investments.

Issue	Description	Consequence	Mitigation
Deal pipeline	Absence of large enough projects to attract big investors.	Renewables not seen as a standalone asset class, examined on a case-by-case basis, part of existing investment teams.	Successful investors have fostered long-term relationships with developers; Climate Aggregation Platform
Granularity	Consequence of deal pipeline, small and scattered deals do not have a common standard (e.g. contractual) to facilitate a continuous stream of investments	Investors find it necessary to have large teams to look at deals individually.	Standardization efforts such as IFC guides and IRENA's Solar Energy Standardization Initiative.
Regulation	Lack of stability in emerging market regulatory framework, or over-regulation in developed markets.	Legal costs constitute a significant portion of total project costs.	PPP contracts with adequate balance of risks between private and public stakeholders.
Terminal value	After PPA contracts are over, it is not clear how to value the residual assets.	Pricing and returns are subject to a wider uncertainty band.	Standardization efforts such as IRENA's Solar Energy Standardization Initiative.

# Appendix

## Case studies

### Caisse de dépôt et placement du Québec – Invenergy

Caisse de dépôt et placement du Québec (CDPQ) is one of the most important institutional investors in wind power. Canada's second largest pension fund manager has invested close to \$2.5 billion (US) in a dozen companies spanning North America and Europe, in both onshore and offshore projects such as the London Array wind farm whose 175 turbines cover 100 km<sup>2</sup> in the outer Thames estuary.

While CDPQ invested in a number of small projects at the turn of the years 2000, CDPQ's presence in wind power really took off in early 2013 when it first invested in Invenergy Wind, North America's largest independent wind developer and operator. Based in Chicago, Invenergy has developed and put into service 67 wind farms with a total capacity of 7,654 MW.

The story of that initial investment and of CDPQ's subsequent reinvestments highlights the opportunities and challenges institutional investors face as they consider renewable-energy transactions.

When CDPQ's infrastructure team first made the case for its initial \$500 million investment in Invenergy, the proposal was met with some resistance. Internally, some voiced concerns on the high manufacturing and construction costs, as well as the perceived regulatory risks over the continuance of production tax credits.

The infrastructure team, however, believed that project costs would come down through a fall in turbine and equipment prices as well as shorter project completion times. The team also felt that CDPQ could seize opportunities open to early movers. Moreover, it believed that investing in renewables – the future of energy – would make CDPQ a more knowledgeable investor in the overall energy sector.

The investment thesis was just that, a thesis, until CDPQ found what it viewed as a great partner. CDPQ started working with Invenergy and at first it only funded wind farms once they were put into service to avoid construction risks.

In 2014, however, seeing that Invenergy was delivering its projects on time and on budget, CDPQ decided to increase its stake and to invest directly in the private holding company. This stake now stands at 27%.

Returns on the Invenergy investments, which total close to \$1.5 billion, have outshone the returns on CDPQ's infrastructure portfolio. Moreover, the close partnership with Invenergy is providing CDPQ with additional transaction opportunities in a sector that has since become much more crowded.

### Capricorn Investment Group – Antelope Valley, Solar Star project

In 2009, Capricorn Investment Group made an investment in 4,000 acres of farmland in California, along with co-investor RRG, which in turn partnered with Sunpower as a solar developer for the power-purchase agreement (PPA) and interconnection agreement.

The thesis for this investment was to acquire strategically located farmland close to the then under-construction Southern California Edison substation and transmission network and to convert the farm into the world's largest solar project. The Antelope Valley Solar Star projects have an electricity generation capacity of 579MW.

In 2012, the solar farm was sold to Berkshire Hathaway for over \$2 billion. The main driver of returns for this investment was the increasing competitiveness of solar energy versus other sources of electricity.

Sierra Club endorsed the project in April 2013 as a "a true clean energy success story [...] What was once an old heavily-irrigated alfalfa field will now be part of one of the country's largest solar projects, providing enough clean energy to power 400,000 homes. The smart siting of this project allowed the developers to avoid damage to fragile desert wildlands and move the project along with local support."

The Antelope Valley project contributes to reducing carbon emissions by 775,000 tons a year, the equivalent of removing 3 million cars from the road for the next 20 years.

A \$1 billion bond offering in 2013 had a 5.375% interest rate (20-year maturity series A note). In March 2015, the Series B Senior Secured notes were issued for \$325 million at 3.95%.



## PensionDanmark – Brigg Renewable Energy Plant

Since early February 2016, 40 farmers in Lincolnshire, eastern England, have delivered straw to the Brigg Renewable Energy Plant and thereby supplying electricity corresponding to the consumption of 70,000 households. The Brigg biomass power plant consumes 250,000 tonnes of straw a year, which is secured through agreements with local farmers. The plant has a capacity of 40MW and an estimated annual reduction of CO<sub>2</sub> emission of 300,000 tonnes.

The 1.6 billion Danish krone investment in Brigg is the result of a joint venture formed in 2013 by Burmeister & Wain Scandinavian Contractor (BWSC), Copenhagen Infrastructure Partners (CIP) and PensionDanmark. The joint venture intends to build, own and operate biomass power plants primarily in Northern and Western Europe and North America. Brigg is the first of these power plants up and running and has proved that an innovative financing model can make a real difference.

Brigg is owned by the CIP fund, Copenhagen Infrastructure I (which has PensionDanmark as the founding and sole investor) together with BWSC. It is the first of four investments in biomass power plants in the UK. CIP is involved in the ongoing operation of the plant as asset manager ensuring the plants' high performance regarding straw supply and hedging strategy. Hence, Brigg is a typical alternative investment and, as such, an example of a direct infrastructure investment in a partnership between an industrial partner and an institutional investor.

Brigg is based on Danish biomass energy technology supplied by BWSC under a turnkey engineering, procurement and construction contract. Construction of the plant was contracted in August 2013, completed and handed over to the owners on 21 January 2016 after a construction

period of less than 27 months, three months ahead of schedule and within budget.

One of the reasons for the successful construction phase was the easy access to financing through CIP. Traditionally, infrastructure projects can involve a consortium of financing partners which increase the complexity of a project, especially when consortium partners need to agree on changes to the project. With the partnership between the contractor and technology provider and a single sourcing of financing, complexity was reduced. It was also instrumental that the contractor had a direct financial stake in the project securing the right alignment of interest. That the contractor and financier are also the owner and operator ensures alignment in the process of going from the construction phase to the operational phase.

The core of the plant is a boiler primarily used for burning straw from the Danish high-tech company Burmeister & Wain Energy. The steam created by the burning straw is conducted to a turbine generator, producing electricity for households and businesses in the vicinity. BWSC is responsible for operation and maintenance of the plant under a 15-year operation and maintenance agreement, which commenced on the date of completion of the plant in January 2016. BWSC is a global leader with more than 30 years' experience in developing, building and operating power plants.

CIP is focused on investments in energy-related infrastructure. Besides Brigg, three biomass plants are under construction in the UK with CIP as a joint venture partner and are on track for successful completion. For the investors, such investments are very attractive. The returns are solid and the risks are contained since costs are locked down in long-term contracts and the power is sold off on a long term PPA with a guaranteed minimum power price which qualifies for 1.5 ROCs (renewable obligation certificates).



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