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Electricity in the age of climate infrastructure

Financing phase two of the renewables revolution

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Summary

- In the global push for climate-friendly infrastructure, no task is more central than the modernization of the world's electric power sector.
- By 2050, renewable sources—wind, solar and hydro—are projected to produce two thirds of the world's electricity, and electricity is projected to overtake oil as the world's main way of consuming energy.
- Creating the conditions to employ variable renewable energy on this scale is a massive undertaking, entailing a continued buildout of renewable generation capacity and sweeping changes across the electricity value chain.
- We believe that the next phase of the renewables revolution presents opportunities for investors to pursue both financial and sustainability objectives. To do so, they need a good grasp of the addressable opportunities in a competitive and dynamic market and the ability to measure the impact of investments on the environment and on their portfolios.

A note on sources

Sources cited in this report include global bodies such as the International Renewable Energy Agency, consultants such as DNV GL and McKinsey & Co. and information providers such as Bloomberg New Energy Finance (BNEF). Our most frequently cited sources are BNEF and the 2018 edition of the *World Energy Outlook*, the comprehensive annual publication from the International Energy Agency (IEA), which works to ensure reliable, affordable and clean energy for its 30 OECD member countries.

The IEA generates projections of future energy demand using its World Energy Model, which models global energy demand in 25 regions of the world. The 2018 *WEO* offers projections for three distinct, policy-based scenarios. The New Policies Scenario incorporates existing government policies and measures as well as the likely effects of announced policies. It is the IEA's central scenario, or base case, and is the basis of the projections cited here unless otherwise noted. The IEA's other two scenarios are its Current Policies Scenario, which considers only the impact of policies in effect as of mid-2018, and its Sustainable Development Scenario, which posits additional steps toward sustainability goals.

Scenario-based analysis makes sense given the large number of variables involved in long-range energy projections and is used by most of our sources. As with the IEA's data, we cite the base case unless otherwise noted.

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Bigger, smarter, greener grids

With the effects of climate change growing more obvious, the global push for sustainability is gaining momentum. Governments, corporate leaders, investors and researchers are working to calibrate risks and promote solutions.[1] Inevitably, infrastructure assets are a major focus. As the fulcrums for most economic activity, the systems providing energy, power, transportation, water management and other essentials represent current problems and future solutions all at once. It is no exaggeration to say we have entered an age of climate-focused infrastructure.

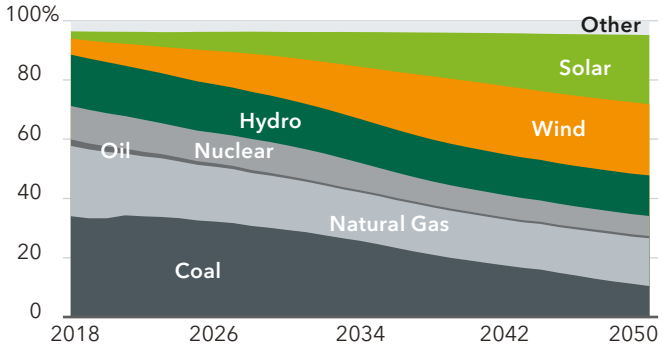
The defining trend of this age is the push to modernize and expand the world's electric power infrastructure. Climate concerns are now combining with technological advances to transform a sector which, despite the mainstreaming[2] of wind and solar power, still relies mainly on fossil fuels and centralized architectures that date back a century or more. By 2050, however, wind and solar sources are projected to produce nearly half of the world's electricity, with hydropower's contribution bringing the renewable share to two-thirds. In the same timeframe, electricity is projected to overtake oil as the world's main way of consuming energy. See the charts below.

This unprecedented transition reflects environmental urgency and technological disruption in almost equal measures. At present, coal remains the predominant fuel for electricity generation, and coal-fired power plants are the largest single source of energy-related greenhouse gas emissions, according to the *World Energy Outlook 2018* from the International Energy Agency (IEA). But the majority of these coal plants (especially in the developed world) are antiquated, as are many nuclear plants. As old plants are retired, the increasingly attractive economics of wind and solar power make them prime choices (along with natural gas in many regions) for new capacity.[3]

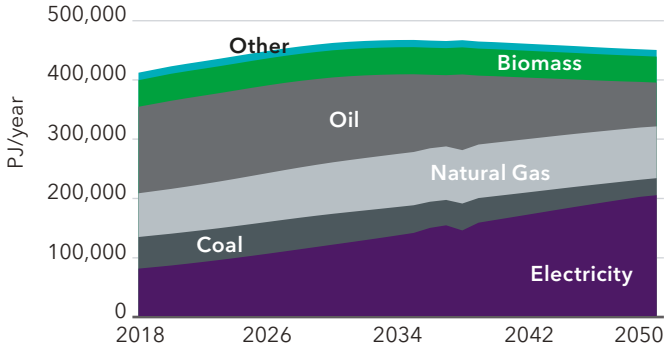
Creating the conditions to employ variable renewable energy on this scale is a massive undertaking. It entails a continued buildout of renewable generation capacity as well as sweeping changes in how electricity is distributed, stored and regulated, and in how providers and users interact with one another. Bloomberg New Energy Finance (BNEF) calculates the global investment need for wind and solar generation capacity at US$ 9 trillion by 2050. For investors, the transition presents a wide set of opportunities, as well as the challenges one might expect in such a dynamic setting.

A growing role for renewables in generating electricity—and for electricity in meeting final energy demand

Current and projected sources for electricity generation



Electricity's share of final energy demand



Sources: For left chart, BlackRock using data from IEA, Bloomberg New Energy Finance, May 2019. For right chart, BlackRock, using data from DNV GL, May 2019. Final energy demand accounts for direct use of energy carriers in transport, buildings and manufacturing. Power generation is excluded. PJ: one quadrillion joules. Important Information: Any opinions or forecasts represent an assessment of the market environment at a specific time and are not intended to be a forecast of future events or a guarantee of future results. There is no guarantee that any forecasts made will come to pass.

1 See *Getting physical: Scenario analysis for assessing climate risks*, published in April by the BlackRock Investment Institute. 2 Described in our 2015 paper, *The mainstreaming of renewable power*. 3 For more on the role of natural gas, see *The global energy and power transition*, June 2018.

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Surging renewable generation

Wind and solar power currently account for 6% of global electricity generation, according to the IEA, up from 0.2% in 2000. Some countries, such as Germany and Spain, are at shares of more than 20%. In the U.S., California can source close to 30% of its power from non-hydro renewable sources, while states such as Iowa and Kansas can exceed that proportion, according to the U.S. Energy Information Administration.

As with many technologies, greater scale brings lower prices, driven here by improved wind turbines and more efficient solar panels, among other factors. Over the last ten years the global average levelized cost of electricity (LCOE) declined an estimated 83% for solar photovoltaic (PV) and 52% for onshore wind, according to BNEF. In many locations it is becoming cheaper to build new renewables than to continue operating old nuclear and coal plants with high marginal costs. By 2030, new-build renewables will be less expensive than existing fossil fuel plants in most countries, if the reference case in McKinsey's *2019 Global Energy Perspective* comes to pass.

Electrifying everything

As renewables provide more and more of the world's electricity, electricity is serving an increasing share of the world's energy needs. Overall energy demand is expected to plateau and begin a gradual decline in the 2030s as energy efficiency increases around the world. The experience in electricity markets will be very different, however. Electricity use will increase 162% by 2050, energy services firm DNV GL projects in its *Energy Transition Outlook 2018*, thereby increasing its share of final energy demand from 19% to 45%.

Urbanization and growing middle classes in emerging markets are the most powerful drivers of new demand for energy in general and for electricity in particular. Electricity use by millions of new household appliances in the developing world will be considerable.

But electricity's ascent is also being driven by deeper change in developed and developing economies alike. Increased demand from electric vehicles, industry and homes will help reduce carbon emissions—a priority around the world. Digitization is another driver, as information technology becomes embedded in more and more activities via cloud computing and the networking of nearly everything. DNV GL projects a quadrupling of electricity used for computational purposes by 2050.

The combination of greater reliance on electricity for basic needs and a greater share of power coming from variable renewable sources has already begun to drive deep changes in how power systems are designed and operated. The overarching trend is a move away from centralized systems built around fossil, hydro and nuclear power sources to decentralized systems that can accommodate fluctuating output based on the availability of wind and sunshine.

Sustainable investing, resilient portfolios

We believe that the next phase of the renewables revolution presents opportunities for investors to pursue both financial and sustainability objectives. However, there's plenty of due diligence needed in both realms.

On the financial front, the first step is deciding what's investable within the global megatrend. Competition for institutional-quality investments is strong. China and India, two major participants in the transition, are difficult for international capital to access, at least for now, and other markets have varying needs for non-domestic financing. Local resources and regulatory regimes differ, and while the global opportunity set offers potential diversification benefits, it takes local expertise to target them. It's also vital to look ahead to disruptive developments such as the impact on wholesale electricity prices as more renewable power comes from "behind the meter" generation on customer premises.

Sustainability-focused investors may find the transition a good source of impact investments to augment the mix of screening, scoring and thematic strategies typically used to pursue sustainability goals.[4] As in sustainable investing more generally, the chief concern here is measurability. Because renewable power investments directly address a fundamental cause of climate change, their potential impact is significant. They can also diversify climate risk exposure in other parts of the portfolio, helping to improve possible outcomes in scenarios where policymakers and business move more aggressively to curb fossil fuel use. Last but not least, renewable investments can provide a window on one of the most important trends unfolding around the world.

Overall, it's important to remember that these investments represent exposure to a fast-changing sector. A good grounding in the global trends at work is essential to the task of building a resilient, diversified portfolio. In the pages that follow, we map the transition and explore how participating in it can help investors make progress toward their goals.

4 See *Sustainability: The future of investing*, published in January by the BlackRock Investment Institute.

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Evolution of the value chain

Few human creations match the scale, complexity and resource-intensity of the world's electrical power systems. These qualities help to explain why, despite significant developments over the years such as the unbundling of utilities in major markets, the sector has yet to see disruptions on a par with those experienced in the telecommunications sector, perhaps its closest cousin. Today, however, the conditions appear to be in place for an accelerated evolution.

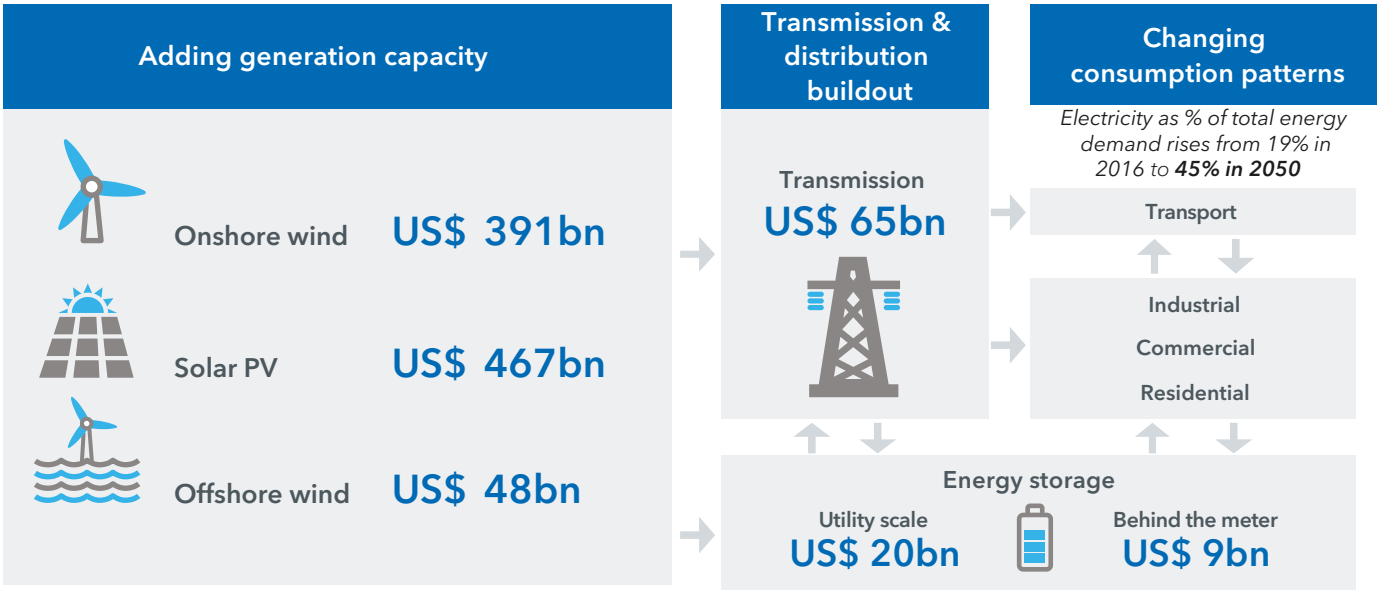
The evolution is global, but, like the power systems themselves, shaped by local economies, regulations and energy sources. Here we present the global themes we see as most relevant for renewables investors, saving our regional views for the next section.

The electricity infrastructure chart below highlights the role of renewables in reshaping the entire power value chain, from generation to transmission and distribution to consumption. Generation is getting greener, transmission is getting more extensive, smarter and less centralized, and end-use is spreading from familiar 20th century applications like electric lights and air conditioning to 21st century applications such as electric cars and buses.

The U.S. dollar figures in the chart are BlackRock estimates of the global five-year addressable investment need. Some context: The world's consumers spent US$ 2.5 trillion on electricity in 2017, almost double the amount in 2000, according to the IEA. Total power sector investment in 2017 was US$ 750 billion, exceeding investment in oil and gas for the second consecutive year.

Impact of renewables on electricity infrastructure

Expected change and five-year financing need[5] in three segments



Source: BlackRock using data from BNEF, May 2019.

5 The dollar figures are BNEF's expected investment need from 2018 to 2023 in countries BlackRock considers suitable for institutional investors. Our list includes 30 countries in Europe, North America, Latin America and Asia Pacific and excludes China and India. Criteria: OECD membership or equivalent regulatory regime; market size; and availability of contracted cash-flows for generation assets via feed-in tariffs, corporate and utility PPAs and other mechanisms.

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Generation

Segment snapshot

For wind and solar power to provide nearly half of the world's electricity in 30 years, a huge amount of generation capacity must be added. In the markets we've designated as addressable, one terawatt (TW)[6] is expected to be built over the next five years, according to BNEF. Continued gains in efficiency, private sector uptake, the eagerness of regional governments to capitalize on local renewable resources and the widespread social commitment to renewables are all helping to drive the buildout.

In wind, onshore marches on as offshore goes global: Onshore wind technology is more mature, but still improving, with the IEA looking for average costs to fall by 5% to 15% in most regions by 2030. Onshore wind capacity is expected to see a record 60 GW in installations in 2019, a third more than 2018, with growth in all regions. More efficient turbines enable upgrades of older wind-generation sites in prime resource locations, as well as new capacity at sites with lower wind resource.

Offshore wind, previously limited to northern Europe, is now expanding in other regions, with the U.S. and Asia Pacific nations the leading adopters. A 2019 Wood Mackenzie report projects that in the next ten years, cumulative offshore capacity in the Asia Pacific region (excluding China) will reach almost 19 GW, up from just 111 MW at the end of 2018, led by growth in Japan, Taiwan and South Korea. Advances in wind turbine design that improve the scale and power production of offshore farms are the main reason. Average costs for offshore wind fell by 39% from 2009 to 2018 according to BNEF. See the falling costs chart below.

Solar sees increasing share: Solar photovoltaic power currently lags wind generation in installed capacity, but is expected to equal or overtake it in years to come. It has seen the most rapid cost reduction of any energy source over the past decade, as well as the most growth (albeit from a low base) according to DNV GL. A growing portion of these solar additions will likely be rooftop installations on offices, industrial buildings and homes. Innovations such as floating solar plants—gaining traction in Asia Pacific nations where land is short—help the technology make further inroads. Japan, China and Singapore all have floating solar plants (as does the UK), and South Korea is building the world's largest, according to a 2018 World Bank report.

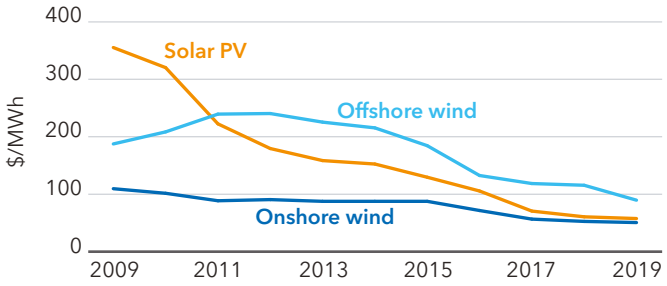
Investment dynamics

With the mainstreaming of renewable power, established generation assets are now sought-after investments. Higher valuations and lower implied discount rates reflect this development. See the high demand chart below. In our view, current valuations make brownfield investments more challenging than greenfield ones today, and we believe some investors are underestimating the operational risks in physical assets like wind and solar farms. Accepting lower returns on established assets means investors have less of a buffer when things go wrong. Assets at the development or construction stage provide more optionality, with more levers to pull when surprises occur. The potential return premium provides an additional risk buffer.

As subsidies are phased out in many regions, the risk that the investment strategy will be impacted by policy change is greatly diminished. Market risks increase, however, making it more important to focus on the multiple dimensions of project quality, including strategic positioning, assumptions around future power prices and production, and long-term operations and maintenance costs.

Wind and solar costs continue to fall

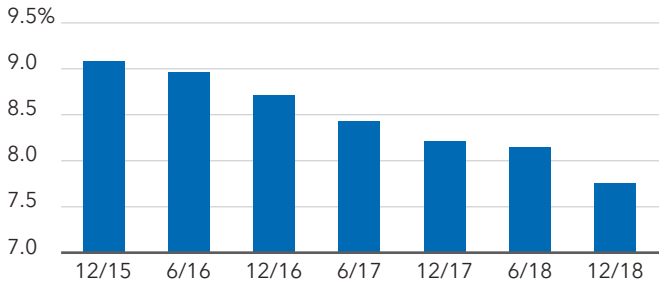
Ten-year change in levelized cost of electricity



Source: BlackRock, using data from Bloomberg New Energy Finance, March 2019. Note: All LCOE calculations are unsubsidized. MWh: megawatt hour.

High demand lowers capital costs for brownfield assets

Implied levered cost of capital for renewables assets in selected markets



Source: BlackRock, using proprietary data from BlackRock's Renewable Power Group, May 2019. Implied levered cost of capital (discount rates) for onshore wind, offshore wind and solar assets in the U.S., UK, Ireland, France and Norway, independently verified on a semi-annual basis.

6 One TW equals a thousand gigawatts (GW) and a million megawatts (MW). The capacity of a typical U.S. coal plant is about 600 MW, according to the EIA.

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Transmission and storage

Segment snapshot

Expanding and re-engineering the grid is a multifaceted project. Along with adding transmission and interconnection assets, it requires better power-storage systems, revised transmission and distribution policies, new business models and the application of new digital tools. In 2017, the IEA reports, investment in electricity networks rose to more than US$ 300 billion, its highest level in nearly a decade, but this was driven mainly by increased electricity demand in the developing world. DNV GL projects that annual grid investment associated with adding variable-generation sources will exceed US$ 300 billion by the late 2040s, and then level off.

Strengthening and extending grids: Grid design is complex, but rests on the simple need for real-time balance between electricity supply and demand. Grid operators have the task of delivering reliable electricity supplies by balancing:

- The requirements of a volatile, but somewhat predictable, demand profile.
- The constraints of available generation technologies, which may not be capable of responding instantaneously to changes in demand.
- The constraints of the grid infrastructure in moving electricity to where it is needed.

The rise of variable renewable-generation sources calls for new approaches to balancing, especially when solar and wind reach a combined share of capacity above 30%. Smart meters and other digital solutions are enabling demand-side management, and new interconnections are facilitating flows between regions. Blockchain technology shows promise as a tool for supporting decentralized management. In Europe, virtual power plants—which aggregate supply- and demand-side resources and connect them to markets that would be out of reach for the individual components—now account for 15 GW of capacity, according to the IEA.

Improved storage: Better storage systems are key to a renewables-driven electricity supply, enabling energy to be stored during peak production times and released when wind or sun is less available or pricing is attractive. Storage systems also provide ancillary services such as frequency regulation, which enhance the reliability of the grid. Costs are projected to keep falling for lithium ion batteries (the leading technology), helped by advances for automotive use. Batteries account for less than half the cost of a storage system, but costs for system hardware and engineering and construction are falling as well. See the efficiency gains chart at right.

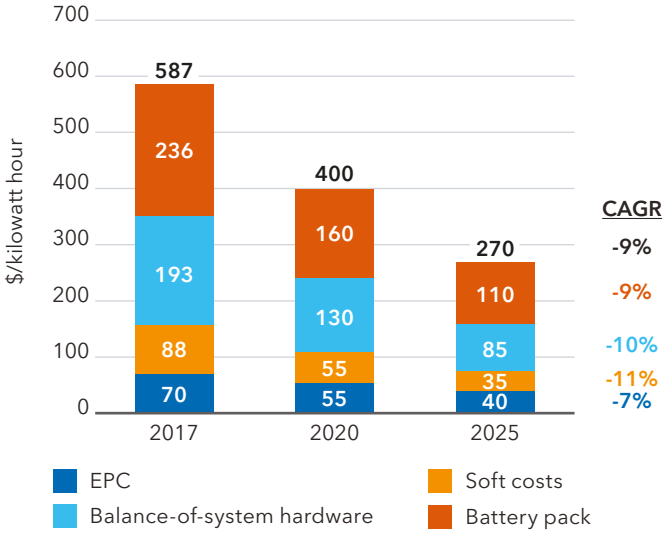
BNEF projects that global cumulative storage deployments will grow from less than 20 GW today to more than 940 GW by 2040, with total investment projected at US$ 1.2 trillion. BNEF expects utility-scale systems to predominate until the mid-2030s, and then to be overtaken by behind-the-meter, or customer-premise installations.

Investment dynamics

Amid all the financing activity in transmission and distribution, a significant slice is suitable for infrastructure investors. While much of the investment in grids and grid management will come from utilities, collaborations with utilities and governments are possible. Opportunities to get infrastructure-type exposure to storage are on the rise, as integration with the renewable power generation assets or end users becomes more common. Co-located storage can improve the productivity of wind and solar farms, and behind-the-meter storage can be a helpful component of corporate power-purchase agreements (PPAs).

Efficiency gains in energy storage

Cost trends in primary system elements



Source: McKinsey, June 2018. Cost of a 1-megawatt energy storage system with a 1-hour duration by segment. **EPC:** Engineering, procurement and construction. **Battery pack:** cost includes battery-management system, cells and modules. **CAGR:** Compound annual growth rate, 2017 to 2025.

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Consumption

Segment snapshot

The growing demand for renewable power is a global trend with two distinct sub-trends. In the developed world, overall electricity use is increasing moderately, with key growth drivers—digitization and the increasing use of electricity in transportation, heating and light industry—offset somewhat by the push for greater energy efficiency. Yet as fossil-fuel power plants are replaced and companies, government entities and individuals actively seek electricity from renewable sources, wind and solar power are claiming an increasing share of the power pie and growing briskly.

Meanwhile, the developing world is seeing robust growth in overall electricity use as populations move into the middle class and the nearly one billion people who still lack electricity gain access to it. In these countries, too, electric cars and data centers are helping to drive current and future electricity demand. Expansion in fossil fuels will help meet that demand, but a growing share of new capacity is coming from renewable sources.

The evolution of the off-taker: Corporate renewable power-purchase agreements set a record in 2018, according to BNEF, as global companies purchased 13.4 GW of power, more than double the 2017 total. PPAs are spreading beyond the tech giants and other big companies that pioneered them to smaller firms aggregating their purchases. The corporate embrace of sustainability goals is one factor, but cost is increasingly another. MGM Resorts, for example, will save money by severing its ties with a utility in favor of a PPA that will bring solar power to its 13 Las Vegas casinos, the company reports.

A 2018 study by the International Renewable Energy Agency (IRENA) identified corporate users of renewables in 75 countries and put total corporate sourcing of renewable power in 2017 at 465 TW hours, close to France's electricity demand. Production for self-consumption accounted for 35% of the total, followed by purchase of unbundled energy attribute certificates at 28% and corporate power purchase agreements at 25%.

Electrifying transportation: Electric vehicles (EVs) will reach cost parity with those powered by internal combustion engines in the mid-2020s, McKinsey projects, largely through improvements in battery efficiency. The IEA expects half of all light vehicles sold globally to be EVs by 2033, with Europe crossing the line first, in 2027. EVs will need chargers in homes, workplaces and public spaces, using alternating current, direct current and wireless technologies. Some 40 million chargers, valued at US$ 50 billion, will be in place in the U.S., Europe and China by 2030, McKinsey projects, including US$ 10 billion worth in the U.S. and US$ 15 billion worth in Europe.

Investment dynamics

Corporate PPAs are an attractive component of investments in renewable generation capacity if structured properly. By arranging to sell a project's power output to a strong counterparty at a set price—usually for ten years or more—a project can mitigate the risk of fluctuations in the price of electricity. Utility PPAs can be attractive for the same reason, and utilities often prefer to partner with outside capital on new renewable capacity rather than building and owning it themselves. The buildout of EV charging infrastructure also has possibilities for infrastructure investors, either via aggregated portfolios or through investments in companies focused on the installation or operation of EV charging infrastructure.

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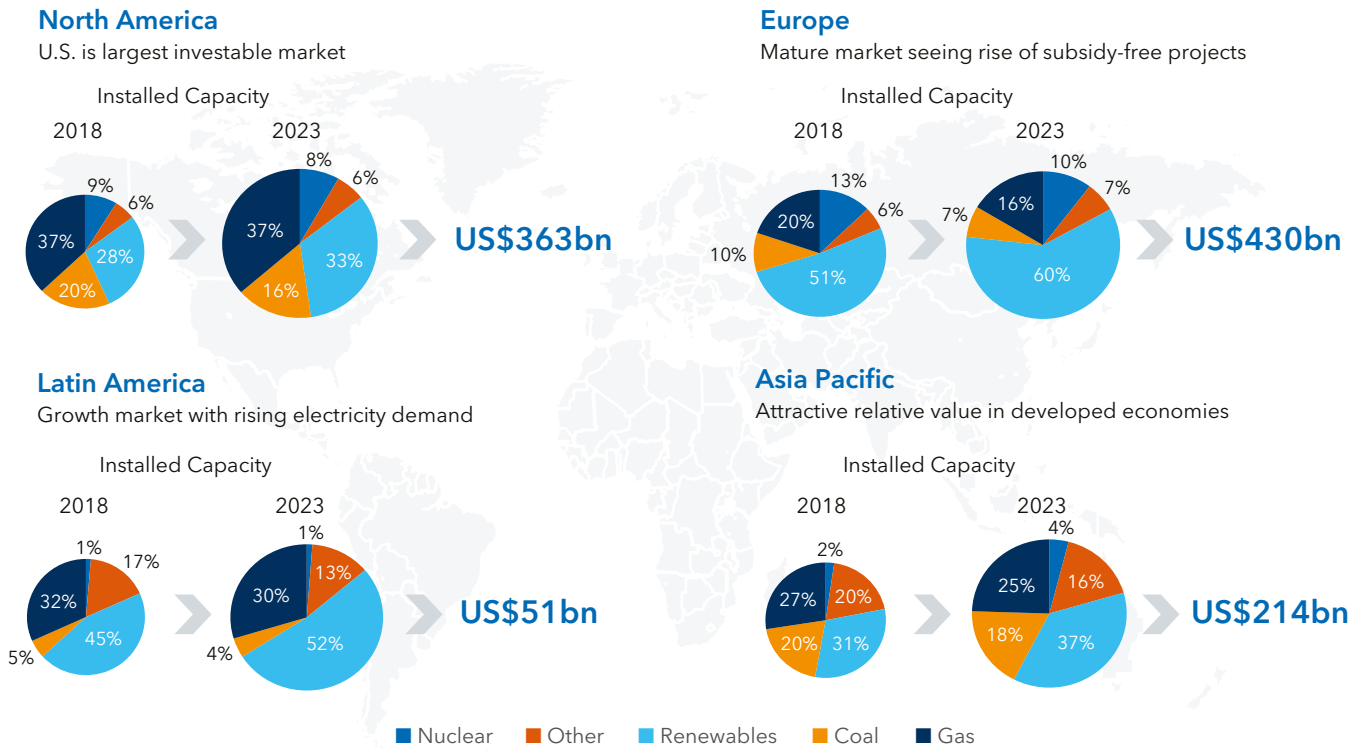
Views from around the globe

Electricity markets vary considerably from country to country. A threshold question for global renewables investors, of course, is the extent to which outside capital is needed to finance local development. Beyond that, investors need to consider the unique profiles of local systems, shaped by available resources, government policies, macroeconomic conditions, business culture, demographics and other factors, with renewables buildouts adding further complexity. Policy tools—whether feed-in tariffs, tax incentives, mandated targets or other mechanisms—matter less amid wind and solar efficiency gains, but still must be factored into many investment decisions. The flexibility of local grids is another important differentiator.

Despite the complexity, we think the fundamental job of a global renewables investor today can be summed up fairly simply, as a task of calibrating risks (now mainly power price and resource) and balancing them against potential returns in the context of the addressable market opportunity. In the chart below and the text that follows, we present highlights from those global markets we consider most addressable by institutional investors.

Mapping the renewables buildout

Capacity growth and five-year financing need in selected markets[7]



Source: BlackRock using data from BNEF, February 2019. Installed Capacity is Cumulative.

7 The dollar figures are BNEF's expected investment need from 2018 to 2023 in countries BlackRock considers suitable for institutional investors. Our list includes 30 countries in Europe, North America, Latin America and Asia Pacific and excludes China and India. Criteria: OECD membership or equivalent regulatory regime; market size; and availability of contracted cash-flows for generation assets via feed-in tariffs, corporate and utility PPAs and other mechanisms. "Other" sector includes oil, demand response, other flexible capacity. **Important Information:** Any opinions or forecasts represent an assessment of the market environment at a specific time and are not intended to be a forecast of future events or a guarantee of future results. There is no guarantee that any forecasts made will come to pass.

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North America

The U.S. is the most active renewables market after China and the largest investable market, with strong demand for renewable power from individuals, cities, states and corporations. Development is slower in Canada, thanks mainly to abundant hydropower.

United States

- The U.S. is the largest global market for corporate power purchase agreements, accord to IRENA, with 241 companies actively sourcing renewable electricity as of 2018. The number of states where deals are located expanded from seven in 2013 to 25 in 2018. Greater experience in structuring PPAs, improved storage systems and other new tools are supporting further expansion in PPAs.

- Commercial & Industrial (C&I) solar, which typically constitutes portfolios of rooftop and ground-mount solar on industrial warehouses, offices, car parks and other public and private properties, is one of the fastest growing renewables subsectors in the U.S. C&I solar capacity in the U.S. has grown 18-fold in the past decade, and is expected to represent 36% of all U.S. solar capacity installations over the next three years, according to BNEF. Increased adoption of behind-the-meter storage is likely to smooth integration into the grid.

- Offshore wind is moving ahead. The first farm was commissioned off Rhode Island in 2016, and contracts are expected to have been signed in seven more eastern states by the end of this year, according to a 2019 report by the Special Initiative on Offshore Wind. The country's total offshore wind potential is estimated to exceed its total current generating capacity.

Canada

- With hydropower representing almost 60% of the current power generation mix, new wind and solar additions will remain relatively flat over the next five years, with strong domestic infrastructure investors likely to dominate investment activity.

- New government policy offers tax benefits for businesses procuring clean energy or storage solutions, which should support roll-out of corporate power purchase agreements.

Europe

Europe is the world's most mature renewables market, with a diverse opportunity set across onshore and offshore wind, solar and storage. The EU gets more than 30% of its electricity from renewable sources and has significant additional growth potential. But the market is competitive, making differentiation, selectivity and the ability to invest in a range of countries and sectors important. Certain markets may get overheated, and the pace of new-build projects varies across markets and sectors.

Nordic countries

- Sweden, Norway and Finland are prime locations for large-scale wind projects, with strong resource and stable grids supported by flexible hydro production. It's now possible to build onshore wind without subsidies, despite power prices that are the lowest in Europe.

- The presence of energy-intensive industry and data centers has helped make the region home to 81% of European corporate renewables procurement, according to BNEF.

UK and Ireland

- With good wind resource and a growing contribution from solar, the UK aims to meet a legally binding 15% renewables target in final energy consumption by 2020. Plans include a 31% renewable share in electricity and 10% in transport. After significant investment in offshore wind, prices are cheaper than the cost of new-build gas generation and significantly cheaper than nuclear.

- Ireland has ambitious plans for a 55% renewables contribution to total electricity generation by 2030, which will require the equivalent of an additional 4,500 MW of onshore wind capacity.

France and Iberia

- The French government released an aggressive draft plan early this year aimed at doubling renewable energy capacity in ten years. It calls for onshore wind to potentially triple, solar PV to quintuple and offshore wind to go from nothing today to about 6 GW by 2028. An active energy storage market is another objective. Closing as many as six nuclear reactors in the period will help reach a goal of reducing nuclear to 50% of the power mix by 2035.

- In Spain, the 2013 withdrawal of subsidies by a new government temporarily turned a booming market into a case study in regulatory risk. But the market has revived, and the party that won the most seats in the April 2019 elections ran partly on a pledge to target a 74% contribution from renewables in the electricity mix by 2030. Spain's solar power potential, perhaps the highest on the continent, should play a key role. PPAs, now dominated by utilities, are expected to extend to corporates.

- Portugal has already achieved its 2020 target for renewable generation of 31%, and authorities are now working toward being carbon neutral by 2050. New solar capacity should contribute significantly, benefitting from the sunny climate and land availability.

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Asia Pacific

The huge and diverse Asia Pacific region has a central role in the development of renewable power. China and India in particular are key to global efforts to reduce emissions, and countries such as Thailand are also moving ahead, especially in solar. Current opportunities for global investors are concentrated in the more developed countries, where we see strong similarities to the state of play in Europe a decade ago: rapid growth in projects with long-term contracted revenues, and attractive relative values compared to other regions.

Australia

- The world's largest coal exporter produces 65% of its power from coal, according to a 2019 report from Platt's, but that is changing as coal plants age and wind and solar generation become more attractive on a cost basis. State-level emission targets and incentives support the transition, as does the fact that Australia has ample land and the highest solar radiation of any continent. Storage is gaining momentum as well.

Japan, South Korea and Taiwan

- Japan's renewable power sector has grown rapidly since the 2011 Fukushima disaster spurred a retreat from nuclear power and the introduction of a feed-in-tariff regime. Growth has been mainly in solar PV, and as of 2017, Japan was second in the world for solar capacity, behind China, according to IRENA. Solar will continue to dominate in the near term, with offshore wind expected to ramp up over time.

- Although South Korea's government has been taking steps to promote renewables since 2010, their contribution stood at only 6% of the power mix as of 2017, according to BNEF. But momentum is now building, thanks in part to ambitious 2030 targets to be supported by an injection of $101 billion into the renewables sector. Storage is a particular focus.

- Taiwan has set a target for 20% of its power to come from renewables by 2025, increasing generation capacity to 25 GW, up from 5 GW today, according to BNEF. Most of the new capacity is expected to be in solar, backed by attractive 20-year fixed feed-in-tariffs.

Latin America

The power markets in Latin America are characterized by growing demand for electricity, abundant hydropower in many countries, and strong government support across the region for the addition of solar and wind generation. A 2019 report from S&P Global ratings described electricity regulation across the region as largely predictable and transparent.

Mexico

- Multinational developers and equipment suppliers have been drawn to Mexico by an ambitious 2012 law targeting 35% clean energy (including nuclear) by 2024. The largest chunk of new solar and wind capacity is expected to be generated by businesses, which under a self-supply law can buy electricity directly from power plants. Walmart, for example, supplies its stores in Mexico from a 67 MW wind farm in Oaxaca.

Chile, Peru and Argentina

- Chile offers political and economic stability, and as the country's economy expands, demand for power is forecast to grow 3% to 4% annually. With the government targeting a 20% renewables contribution to the power mix by 2025, much of this demand will be met by wind and solar. The energy sector has had the country's highest investment rate in recent years.

- Peru began a push in renewables more than a decade ago, welcoming international capital and attracting $2.3 billion in clean energy investment from 2011 to 2017. Activity has slowed more recently. Over the past 3 years, new-build renewable finance has totaled $690 million, with 39% of the investment going to small hydro, 37% to solar and 24% to onshore wind.

- Argentina's adoption of renewables is being hampered by the country's current macroeconomic problems, but a series of renewables auctions in recent years has helped spur development. Rule changes are expected to facilitate the growth of the corporate PPA market, according to IRENA.

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Resilience and sustainability

For investors, change on the scale mapped out here can seem attractive but difficult to act upon. Investments grounded in deep, durable trends have a strong intuitive appeal, but forming a view on the price of electricity in multiple dynamic markets ten years hence is not a trivial task. The question for most will be twofold: Given this complexity, how does one assemble a renewables portfolio with the resilience to support financial objectives, plus the measurable impact on climate change necessary to support sustainability objectives? Fortunately, the two are mutually supportive.

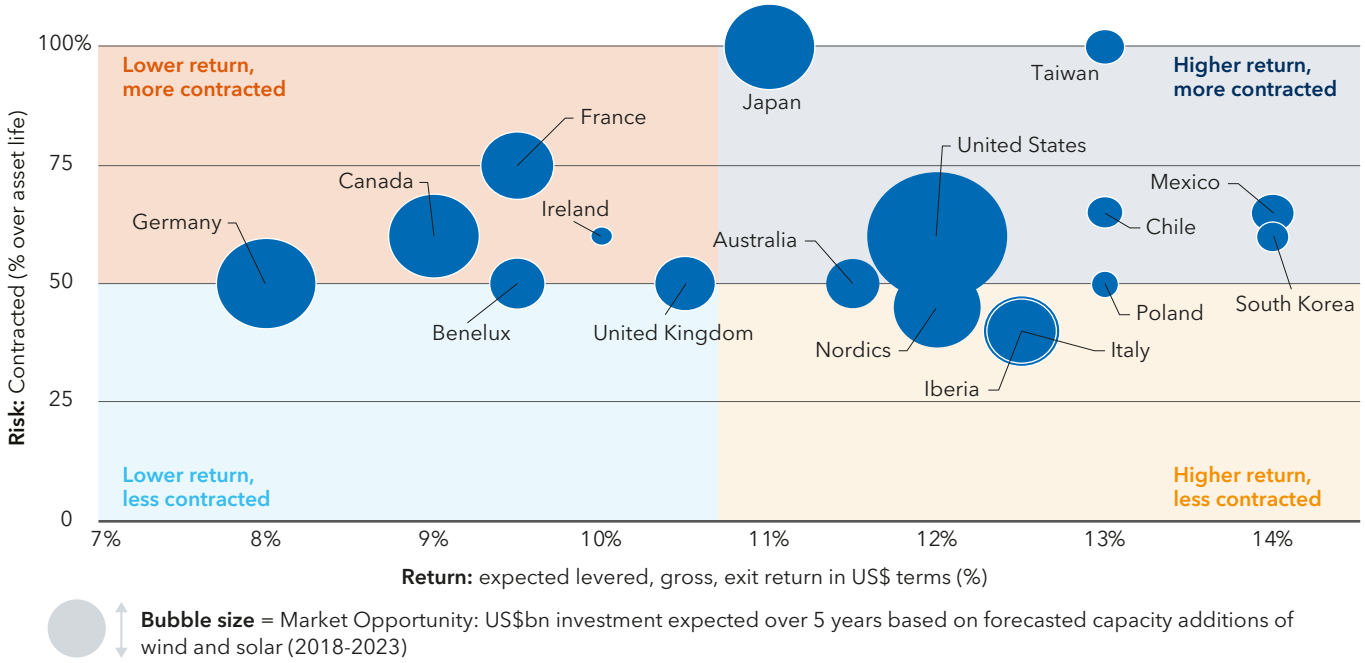
Building resilient portfolios, we believe, is a matter of determining how some evergreen tenets—regarding deal sourcing and due diligence, risk awareness, diversification and hands-on management—are best applied in the renewables sector. The ideas we emphasize include the following:

Partnerships are powerful, and innovation is essential. In an industry defined by networks—and with roles and business models in flux within those networks—connections and collaboration are vital for deal sourcing and accessing new growth sectors. Corporate power purchase agreements, for example, can bring investors into partnerships with highly rated counterparties who have long-term commitments to the renewable power transition and an interest in innovative structures.

Take a comprehensive and calibrated view of risk. One key determinant of risk is whether the power being produced is contracted with an offtaker, and if so, the duration of the contract and the credit quality of the counterparty. As shown in the pricing chart below, the degree of exposure to merchant power prices in competitive wholesale markets is an important driver of potential returns and a key dimension for relative value comparisons. The stage of the project is another important basis for risk-return comparisons. Today, valuations for operating assets have been pushed so high in some markets that we believe development- or construction-stage assets may have a better risk-return profile.

Global renewables pricing environment

Risk/return profiles of selected markets



Source: BlackRock, proprietary analysis performed by BlackRock's Global Renewable Power Team, as at March 2019. Capacity market data is taken from Bloomberg New Energy Finance, March 2019. This material is not intended to be relied upon as a forecast, research or investment advice, and is not a recommendation, offer or solicitation to buy or sell any financial instrument or product or to adopt any investment strategy.

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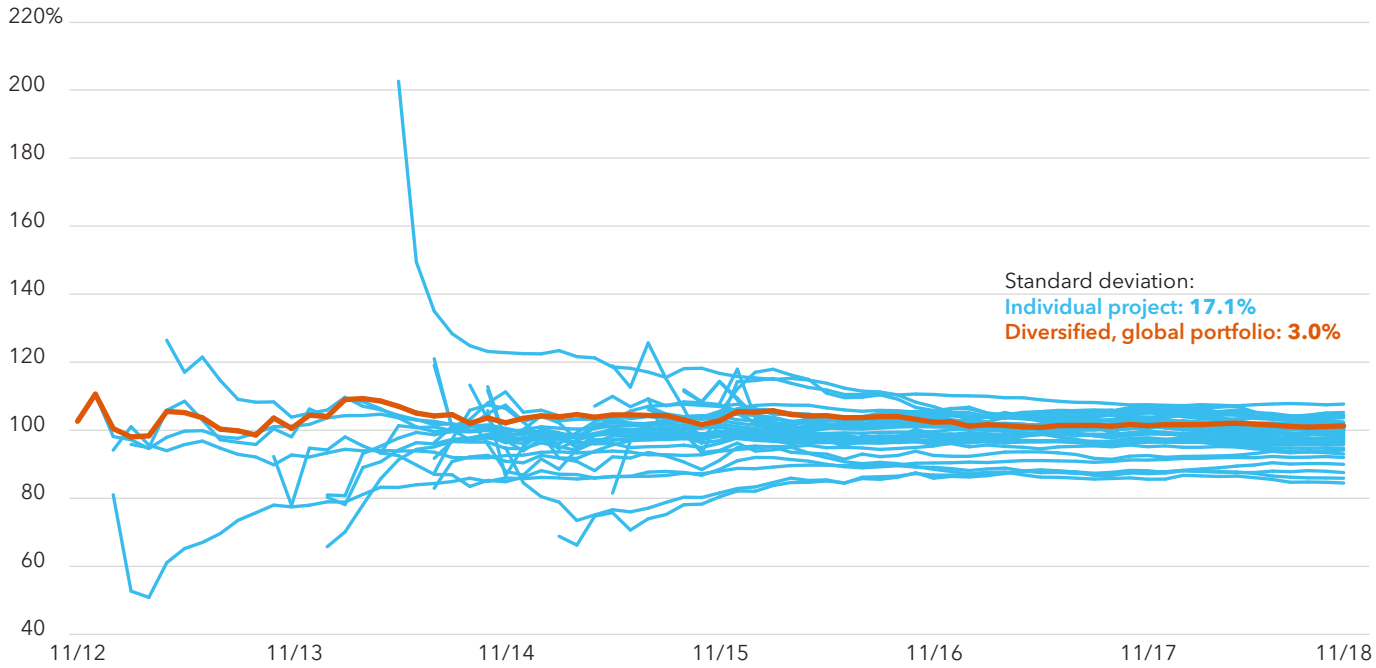
Pursue diversification in multiple dimensions. Global diversification is a basic building block of portfolio resilience. It enables investors to take advantage of the myriad differences in global markets, from regulatory regimes to economic conditions to weather patterns and the types of resources available for power generation. Diversification by resource type—a balance of onshore wind, offshore wind and solar—makes a further contribution to resilience and introduces the broad spectrum of tier-one equipment manufacturers. As the diversification chart below shows, a globally diversified portfolio is an effective potential mitigator of resource variability.

Active management extends through the life of the assets. The initial investment in a solar park, wind farm or other renewable power asset is just the first of many active decisions needed to improve the potential outcome. Owners need to take an active approach across the long lifespan of these real assets, monitoring and adjusting as needed on three fronts. The first is financial: Is the capital structure still optimal? Are cashflows secure? Is it time to sell? Next is operations and maintenance: Can these arrangements be improved by reducing costs, lengthening the term or increasing alignment of incentives? Can the useful life of the project be extended? The third is technical: Could a technology update enable more power production? Does rigorous testing reveal performance shortfalls? Can a repowering of the existing site lead to improved economics?

Global diversification helps mitigate resource risk

Actual resource performance vs. investment case at project and portfolio level



Source: BlackRock, as at October 31, 2018. The information presented above represents a global portfolio of renewable power investments. Variation is based on 20 year implied uncertainty at the project level.

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Impact on sustainability goals

Integrating environmental, social and governance (ESG) criteria into investment programs is a growing priority among investors. Our views on the topic draw on BlackRock's considerable work in the field. Referring again to *Sustainability: The future of investing*, we note that for asset owners with large, highly diversified portfolios, there is no one-size-fits all approach. Looking across all asset classes, each investor needs to decide upon a mix of the available approaches, which include screening out specific companies or industries; crafting broad exposures based on ESG scores or issue-specific themes; and impact investments that target specific non-financial outcomes along with financial returns. All must be data-driven to be effective, and while the availability and quality of data are still uneven, rapid improvements are making robust measurement increasingly feasible.

Renewable power is a quintessential impact investment category, backed by a particularly robust data set on the effectiveness of the sector in improving the environmental outlook. In the IEA's most-optimistic Sustainable Development Scenario, the use of low-carbon technologies (mainly renewables) for 85% of the power sector's generation needs in 2040 is the biggest contributor to a 45% reduction in energy-related CO2 emissions.

But even though it's clear that renewable energy is a good place to look for impact investments, investors still need to measure the effects of the specific assets they put their capital into. This can be achieved by tracking the investments within the framework of the UN's Sustainable Development Goals and deriving a score in the form of an impact multiple per dollar invested. Along with the avoidance of greenhouse gas emissions, the goals potentially advanced—and trackable—include job creation, water preservation, and adding to the supply of clean energy. These scores can also validate the renewable investment's role in improving the sustainability profile of the portfolio as a whole—an important consideration for many investors.

So how are the twin objectives of portfolio resilience and sustainability connected? We go back to the long lives of these assets and the scenario analysis investors are increasingly employing to assess the sustainability of their portfolios. These what-if exercises come in various types, but many are policy-based: What would be the impact on our portfolio if the world's governments followed a given set of policy recommendations, with the goal of achieving a given level of greenhouse gas emissions within a given timeframe? Conversely, what would be the impact on the portfolio of inaction on climate change?

We believe such lenses can inform judgements about both the sustainability contribution and return potential of investments in renewable power. Our view of the future is that investments that create value in the first dimension have a better chance of doing so in the second one.

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