Chapter 5

Fragmentation in clean energy investment and financing

This chapter reviews how policy and market fragmentation is constraining financing of, and investment in, renewable electricity projects. Scaling-up investment in renewable electricity is critical for reducing greenhouse gas emissions from the power sector, and is therefore important for implementing the 2015 Paris Agreement on climate change. Despite increasing cost-competitiveness of renewable electricity technologies, overall investment in renewables projects remains constrained by policy and market obstacles. These hinder development of a sufficient pipeline of bankable projects and affect the risk-return profile of renewable electricity projects. This chapter reviews recent trends in renewable electricity investment and financing and identifies policy misalignments and market barriers constraining investment in renewable electricity, with a focus on fragmentation issues.

Main findings

- An increase in the scale and pace of climate change mitigation efforts, including mobilising investment and financing for renewable electricity generation, is necessary to successfully implement the 2015 Paris Agreement concluded by the 21st Conference of the Parties (COP21) of the United Nations Framework Convention on Climate Change (UNFCCC).
- Global new investment in renewable energy has rebounded since its decline in 2012-13 to an all-time record of USD 286 billion in 2015, with a shift in geographic focus towards Asia. The growth in investment flows has been sustained by an evolution in financing models and financial stakeholders for renewable electricity projects, coupled with significant policy support to renewable energy.
- The struggling finances of many utilities have contributed to new ownership and financing models in certain renewable electricity technologies such as wind energy. Traditionally, utilities and project developers have provided the majority of equity in large renewable projects through their balance sheet. In the past five years, other types of investors have increased their commitments to renewable electricity. A large number of institutional investors have notably recognised infrastructure investments through debt and equity finance as a source of inflation-linked, long-term and stable cash flows.
- Partnerships between financial actors are increasingly used to recycle capital from the balance sheets of utilities through the sales of project stakes or refinancing. Institutional investors have an important role in freeing up debt and equity capital in operating-stage renewable electricity projects. Banks, private equity funds, project developers and utilities can then redeploy the proceeds into the development and construction of new projects. Innovative financing structures are now being used during construction and operational stages of renewable electricity projects. Since 2013, some utilities and other corporate entities have notably launched "yieldcos",[1] publicly traded companies whose growth is one of the main trends affecting renewables investment.
- Even though technology costs are falling fast, policy and market obstacles still constrain overall growth in investment in renewable electricity, limiting the pipeline of bankable projects and affecting the risk-return profile of renewable electricity investments. As well as insufficiently ambitious climate mitigation policies, the misalignment of other policies and regulations with respect to climate goals can act to hinder investment in renewable electricity. Misalignments can occur across the general investment environment, such as in the areas of investment policy, competition policy and electricity market design, trade and financial markets policy.
- Trade and investment policies that are inconsistent with climate change goals can create barriers to cross-border trade and investment in renewable electricity generation. The increasing use of local-content requirements in solar photovoltaic (PV) and wind energy since 2008 threatens to fragment rather than optimise global renewable electricity value

chains. Other outstanding trade and investment barriers in solar PV and wind energy include trade remedies and divergent national technical standards.

- Fragmentation in electricity markets, including in the development of transmission and distribution infrastructure, can favour fossil-fuel incumbency in the power sector and increase the cost of further integration of renewables. Factors include insufficient cross-border interconnection of transmission networks, which limits the flexibility of electricity systems and hinders integration of renewables, and heterogeneous design of capacity mechanisms with insufficient regional planning.[2]
- In order to unlock investment in renewable electricity, policy makers need to consider options to address existing obstacles to investment, especially concerning existing fragmentation in electricity markets and policy misalignments with climate change goals. Additional research is needed to help G20 and OECD policy makers address key policy priorities to overcome barriers to renewable energy investment and financing.

Introduction

Implementing the 2015 Paris Agreement concluded by the 21st Conference of the Parties (COP21) of the United Nations Framework Convention on Climate Change (UNFCCC) will require increasing the scale and pace of climate change mitigation efforts. At COP21, parties agreed to transition to “aggregate emission pathways consistent with holding the increase in the global average temperature to well below 2°C above preindustrial levels”, going further than the previous agreement at Cancun in 2010.[3]

Yet a large gap remains between the action pledged by countries and the emission pathways consistent with the “well-below-2°C” target. As the OECD Secretary-General has emphasised, meeting the climate challenge requires achieving zero net greenhouse gas (GHG) emissions globally by the end of this century. The power sector will be crucial for these efforts (accounting for around 40% of global primary energy use and carbon dioxide (CO_2) emissions in 2012). Fortunately, though, it offers high potential for “decarbonisation” (IEA, 2015b).

Mobilising investment and financing in low-carbon energy technologies, and especially in renewable electricity, is therefore central to implementing the Paris Agreement. Although investment in renewable electricity generation has increased significantly over the past decade, achieving the energy transition will require considerable new private investment in both mature and early-stage clean energy technologies in the power sector. In addition to renewable electricity generation, this will include carbon capture and storage, electricity storage and demand-side management technologies such as smart grids.

The costs of many renewable electricity technologies are falling fast and some are becoming increasingly cost-competitive against fossil-fuel-based alternatives in a number of countries. So why is renewable electricity investment not growing faster? There is no shortage of available capital globally. The problem is the absence of a sufficient pipeline of bankable projects in renewable electricity. This is because renewable electricity investment and finance remain constrained by serious barriers linked to market and policy failures, along with country-specific impediments, market conditions (including fossil fuel prices)[4] and technical challenges. Such barriers can inhibit the development of renewable electricity-generating projects vis-à-vis fossil fuel-based infrastructure projects.

A key cause of the problem of insufficient investment opportunities in renewable electricity is a misalignment between climate goals, investment policies and the underlying economic conditions. The complexity of policy packages used around the world both to address climate change and to stimulate investment in renewable electricity has led to a web of different policies, resulting in a fragmented business environment. Furthermore, the layer of broader business regulations on which climate and renewables policies are overlaid can create conflicting incentives, increasing overall risk and constraining investment. Policy makers therefore have a role in setting coherent and predictable policies to send consistent signals to investors and financiers in renewable electricity. Future regulatory uncertainty makes it difficult for investors to formulate risk and return expectations, causing hesitation and preventing capital inflows.

This chapter reviews recent trends in renewable electricity investment and financing. It then focuses on key trends and policy misalignments that contribute to the fragmentation problem hindering renewable electricity development. These include:

- lack of coherent and sufficiently ambitious climate mitigation policies, such as insufficient carbon prices, inefficient fossil-fuel subsidies and policy uncertainty about renewable-energy incentives;
- misalignment of broader policies with climate change goals, e.g. within the general investment environment;
- inconsistent trade and investment policies that create barriers to cross-border trade and investment in renewable electricity and threaten to fragment rather than optimise global clean-energy value chains, especially in solar PV and wind energy;
- fragmentation in electricity markets and the development of electricity infrastructure, favouring fossil-fuel incumbency in the power sector and restricting further integration of renewable electricity.

Annex 5.A1 provides more information on the dataset used in the equity investment section. A glossary of technical terms used in this chapter can also be found in the annex.

The challenges ahead

The scale of greenhouse gas emissions reductions needed is large

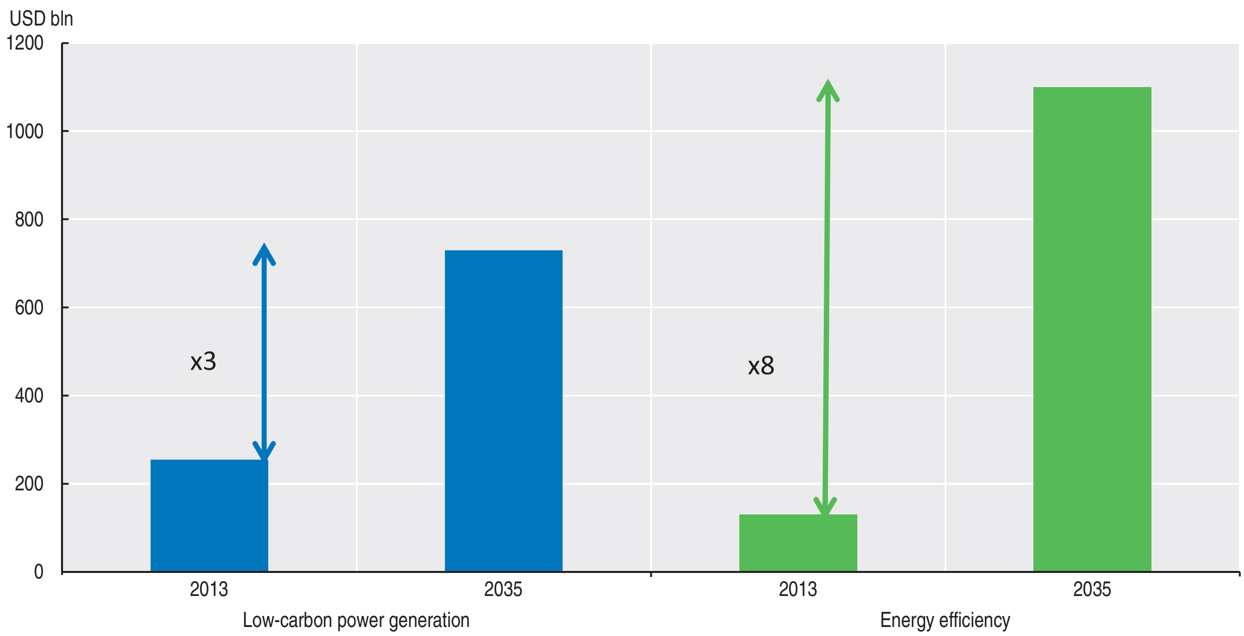
The intended nationally determined contributions (INDCs) submitted prior to COP21, outlining countries' mitigation targets and actions starting in 2020, remain insufficient to achieve the agreed global climate change goals. By some estimates full implementation of all the INDCs would lead to a global temperature rise of around 3°C by 2100 (UNEP, 2015). In particular, energy-sector investment implied by the INDCs would remain insufficient to get the world on a path to achieve the 2°C target.

Given the scale of the climate challenge, recent emissions trends and developments relating to climate change mitigation policies in OECD countries and partner economies[5] suggest that enhanced action and co-ordination are required between all actors, including businesses, investors and governments. As highlighted by the recent OECD report *Climate Change Mitigation: Policies and Progress*, aggregate GHG emissions from OECD countries and partner economies have been increasing since the 1990s. In addition, although the use of renewable electricity is increasing, most countries still rely on fossil fuels and support the production and consumption of fossil fuels through subsidies and other budgetary measures. In particular, coal (the most carbon-intensive fuel) still accounted for 45% of electricity generation in OECD countries and partner economies in 2012 (OECD, 2015k). The share of total emissions covered by energy and carbon taxes also remains too low to spur technological change and shift investment decisions away from fossil fuels and towards renewable electricity.

The scale of the investment gap is also large but technology costs are falling

Despite recent growth, private sector investment in renewable electricity needs to be scaled up significantly to meet climate change goals. According to the International Energy Agency (IEA), to limit the temperature increase to 2°C, investment in "low-carbon power generation"[6] would need to triple between 2013 and 2035, and investment for energy efficiency across energy sectors would have to rise by a factor of eight (Figure 5.1).

Figure 5.1. **Growth in investment needs in low-carbon power generation and energy efficiency**



Note: All figures are expressed in USD billion.
Source: IEA (2014a).

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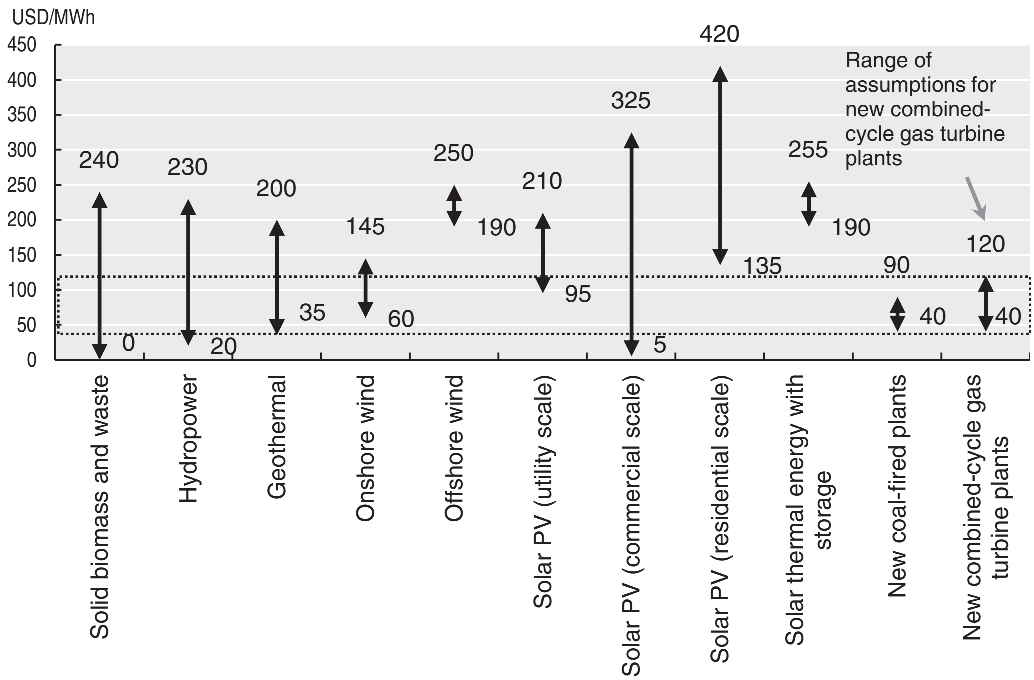
The good news is that, on aggregate, scaling-up renewable electricity investments should not cost much more than the investment that would be required in energy infrastructure under business-as-usual assumptions. The IEA estimates that cumulative investment in energy supply and energy efficiency will need to reach USD 53 trillion by 2035. This is only 10% more than investment needs in the energy sector that are likely under current policies (IEA, 2014a).

These projections of modest incremental costs are driven in part by rapidly falling technology costs. From 2010-15, average costs for new onshore wind plants fell by 30% and average costs for new utility-scale solar PV installations declined by two-thirds (IEA, 2015c). The cost of solar components has halved since 2010, making current solar PV module costs just 1% of the price prevailing 35 years ago, while wind turbines can now generate 100 times more power than 30 years ago (Global Commission on the Economy and Climate, 2014). Utility-scale solar PV projects are now competitive against peaking gas generation in several countries in terms of costs to generate electricity.[7] Figure 5.2 presents recent IEA estimates of levelised costs of electricity for various renewable electricity technologies in the power sector, and shows that several of these technologies can now be competitive against fossil-fuel-based alternatives under certain conditions.

Figure 5.2. **Levelised cost of electricity using various technologies, 2015**



Note: The grey band represents the range of IEA assumptions for new combined cycle gas turbine (CCGT) plants.
Source: OECD calculations based on IEA (2015c).

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Increased deployment of renewable electricity projects will also yield major economic and climate benefits, such as better health and reduced local air pollution, improved energy security and reduced traffic congestion, in addition to substantial fuel savings (OECD, 2015c; IEA, 2015d). The economic cost of damage to health from poor air quality, for instance, amounts to about 4% of GDP on average in the 15 countries with the highest GHG emissions; in the People's Republic of China, this value exceeds 10% of GDP (Global Commission on the Economy and Climate, 2014).

Key trends in renewable electricity investment and financing

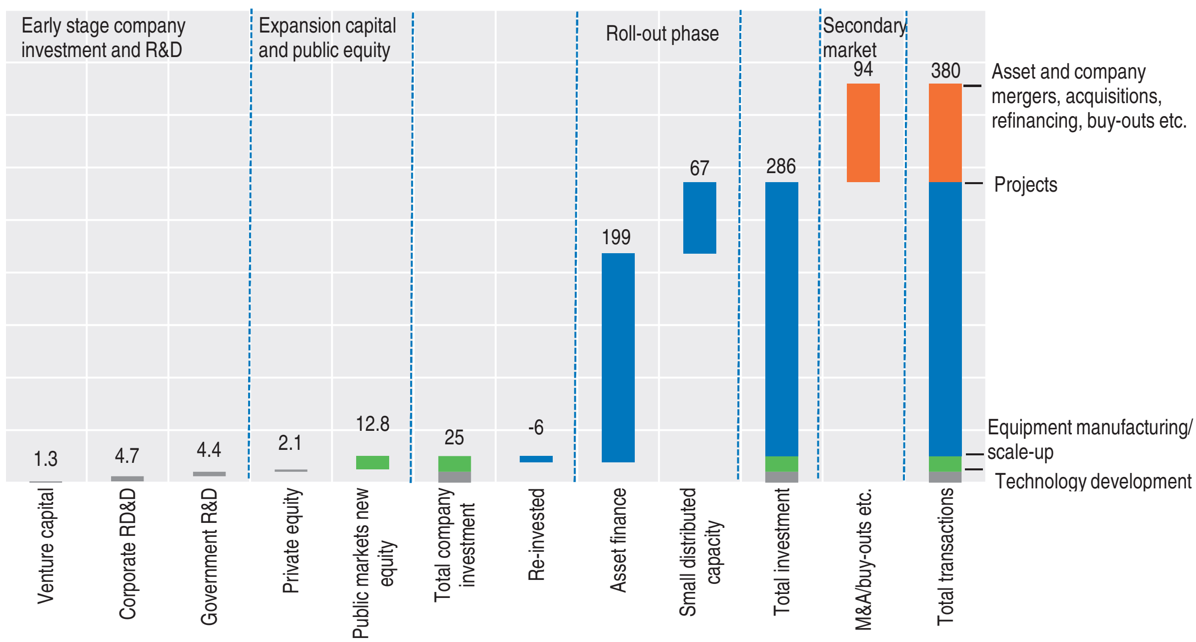
This section provides a brief background overview of renewable electricity investment financing. It then describes the main trends and innovations occurring financing of renewable electricity projects. Subsequent sections of the chapter then turn to policy and market barriers related to fragmentation constraining overall investment and financing.

Overview: the shifting base of investment financing for renewable electricity

The United Nations Environment Programme (UNEP), based on Bloomberg New Energy Finance (BNEF) data, reports global new investment in renewable electricity and biofuels has reached a new record of USD 286 billion in 2015, an increase of 5% on 2014.[8] A major contributor was the installation of 118 Gigawatts (GW) of solar PV and wind capacity. Growth was largely driven by the Asian region where more than half of the total investment took place, with over one third of total investment in China alone. For the first time, developing countries accounted for more than half of global new investment in renewable electricity and biofuels (54.5%) (McCrone et al., 2016).

Figure 5.3 shows the full range of investment activity in renewable electricity and biofuels by asset class. It runs from the early stages of financing for companies and investment in research and development (R&D) at the left and moves to the roll-out phase on financing of new build assets (projects) in the middle. The right-hand side covers secondary market activities not associated with new activity, including investment projects that do not contribute directly to new assets or company financing, such as corporate mergers and acquisitions (M&As), private equity buyouts, investor exits and asset refinancing and acquisitions.

Figure 5.3. **Renewable electricity and biofuels investment financing, 2015**



Note: All figures are expressed in USD billion. RD&D: research, development and demonstration. Total values include estimates for undisclosed deals. Figures may not add up exactly to totals, due to rounding.
Source: OECD calculations based on McCrone et al. (2016) and BNEF data.

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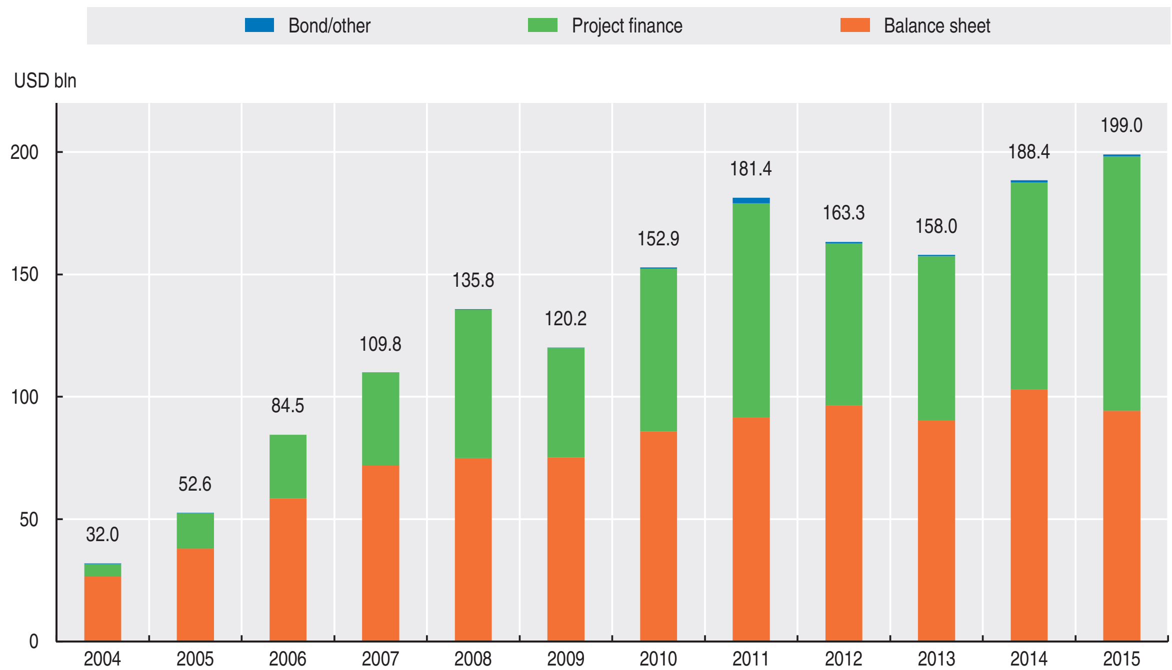
Asset finance[9] of utility-scale[10] renewable electricity projects accounts for the largest share of new (or "greenfield") investment in renewable electricity and biofuels (i.e. in primary markets), accounting for USD 199 billion in 2015 (Figure 5.4). This is up from USD 188 billion in 2014.

In 2015, wind energy was the largest sector in terms of new utility-scale asset finance, rising 9% to USD 107 billion. Driven by growth in Europe and China, offshore wind energy rose 40% in 2015, accounting for USD 23.2 billion. The next largest sector, solar power, grew faster and advanced by 13% to USD 80.9 billion. Other sectors were much smaller, the next largest being biomass and waste-to-power, with USD 5.2 billion (down 46% from the previous year).

Financial markets support the renewable electricity sector through a variety of investors (e.g. utilities, banks or institutional investors) and financial structures (such as debt, equity or mezzanine). Figure 5.4 shows the split in global asset financing by type of

Figure 5.4. **Asset financing of new investment in renewable energy by type of financing, 2004-15**



Note: All figures are expressed in USD billion. Total values include estimates for undisclosed deals. "Bond" refers to project bonds, and does not include corporate bonds and public bonds. In this graph, "renewable energy" refers to renewable electricity generation and biofuels.
Source: McCrone et al. (2016), based on BNEF data.

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arrangement.[11] Renewable electricity projects can be financed in three ways (OECD 2015b, j, 2016c forthcoming):

- **Project finance,** involving a mixture of debt (mainly banks) and equity capital. Based on available equity and debt data from BNEF, 2015 marked the first year in which project finance represented more than half of total asset finance in renewable electricity and biofuels McCrone et al., 2016). Project financing of renewable projects has been growing strongly in the last few years, reflecting preference for term loans structures in developing countries such as China and South Africa. In 2015, non-recourse project finance[12] made up 52% of total asset financing, at USD 104 billion, up from 45% in 2014.
- **On-balance-sheet corporate financing,** by utilities, independent power producers, project developers and other corporates. In 2015, on-balance-sheet financing of projects by utilities, corporate actors (non-energy corporations and manufacturers), independent power producers and developers made up approximately USD 94 billion, representing about 47% of total asset finance in renewable electricity and biofuels.
- **Project bonds and other types of transactions** accounted for a small residual of asset finance flows.

Additional sources of finance and new financial structures are emerging. Utilities and power producers continue to be substantial providers of equity capital in the renewable sector. However, due to the large scale investment and stable income returns, there is greater interest from the financial services industry. As renewable electricity becomes increasingly cost-competitive, and the low-risk and stable-return profile of assets becomes more apparent, the largest institutional infrastructure investors are accessing renewable

Box 5.1. **Drivers of funding and financing models for renewable electricity projects**

What are possible factors influencing the funding and financing models such as corporate, project finance or bond structures? Possible drivers and parameters may include:

- *The financing profile of the investment*: a large initial investment followed by significant operating and maintenance costs could for instance indicate advantages from bundling the construction, operation and maintenance of the assets in a single contract. In the wind- and solar-power sectors, most of the costs are incurred upfront, so concessions are often used by governments to procure projects. Project finance structures matching the long term nature of the concessions and relying on the cash flows during the operation period then become the preferred route for financing renewable projects.
- *The potential for cost recovery from users*: for investments in sectors that have a non-excludable nature for example, user fees will not be practicable and the project will need to be funded via government spending.
- *The extent to which quality is contractible*: When quality is difficult to specify and monitor for instance, contracts are likely to be costly and time consuming to develop, and will be highly vulnerable to renegotiation.
- *The level of uncertainty, especially within broader enabling conditions, and attractiveness of domestic policy frameworks:* projects may face significant speculative risks that are difficult for the private sector to quantify and mitigate, linked notably to unstable and unpredictable legal and regulatory frameworks, high political risk and construction risk. In the offshore wind-power sector for example, as projects scale up and move into deeper water, newer technologies also add to construction risk, which may discourage some investors from participating. The political and regulatory regime, and the risk that support will erode over time, are key considerations for investors when investing in renewable electricity projects.
- *Financial market conditions*, such as difficulties in securing project finance debt, development of capital markets and corporate constraints (i.e. deleveraging, impact of oil prices), high costs of capital.
- *Optimal allocation of risks*: the ability to identify, assess and allocate risk appropriately is an important consideration driving the decision about funding and financing structures.

Source: OECD (2016c, forthcoming), *Infrastructure Financing: Partnering with the Private Sector*, OECD Publishing, Paris; and the OECD Public Investment Framework.

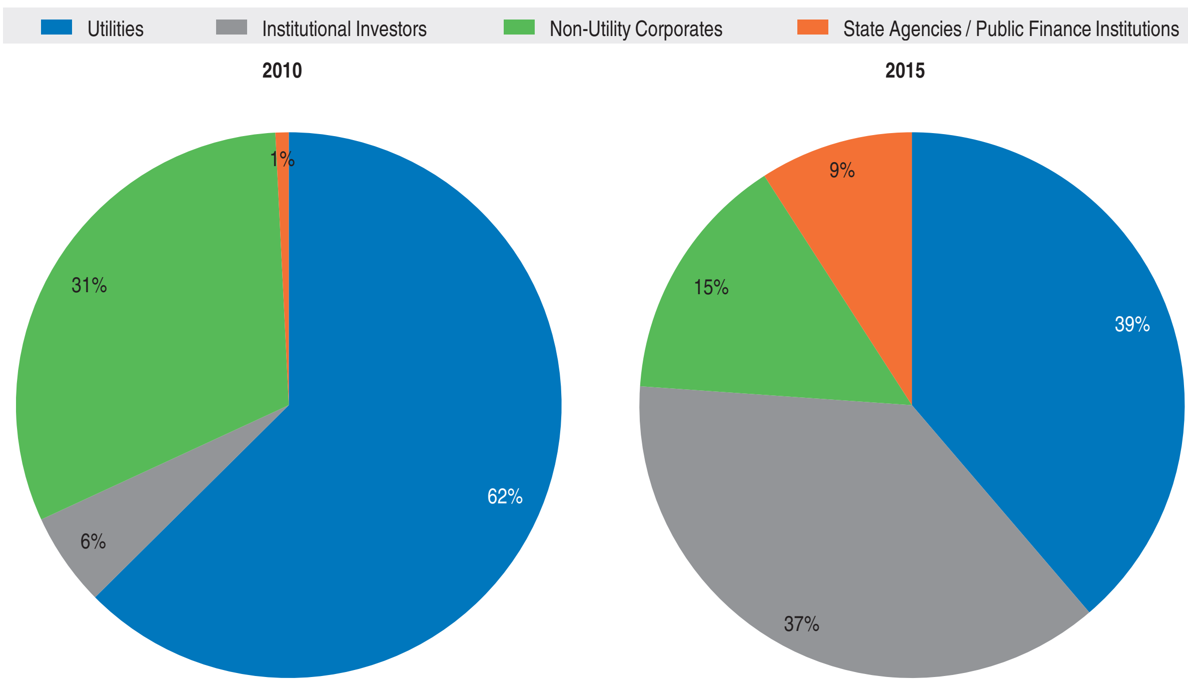
projects through direct investment (OECD, 2015b, j, 2016c, forthcoming). In some cases, project bonds are another emerging way to raise debt financing compared to more established sources of corporate debt or project finance (OECD, 2016b). As recently surveyed by the OECD (2015j), investment is also channelled through public-market vehicles such as "yieldcos", real estate investment trusts (REITs) and other publicly listed vehicles (see Annex 5.A2). Finally, investment growth and recent trends, such as divesting of assets from utilities, are contributing to the development of a secondary market for renewable electricity.

The equity mix in wind energy is changing

This section analyses the evolution of the equity mix in ownership and financing models for both onshore and offshore wind energy in Europe.[13] The equity mix for renewable electricity projects has changed vastly in the last five years. Recent developments in the wind energy sector in Europe between 2010 and 2015 are illustrative.

The first offshore wind-power farms were typically financed on the balance sheets of the utilities that conceived, built, and operated them. Now banks, private equity funds, pension funds, state-backed "green" banks and insurance companies have all invested in these projects. Figure 5.5 highlights changes to the equity mix of wind energy deals, comparing deals which reached financial closure in Europe in 2010 and 2015.[14]

Figure 5.5. **Change in equity mix in wind energy projects in Europe, 2010 and 2015**



Note: Figures correspond to shares of total equity in sample.
Source: BNEF (2016), OECD calculations.

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The share of total equity provided by utilities (state-owned and private) decreased from 62% in 2010 to 39% in 2015, that of non-utility corporates from 31% to 15%. In other words, the combined share of the two traditional equity investors in the wind energy sector decreased substantially, from 93% in 2010 to 54% in 2015. Accordingly, other investors have stepped up their activities. Further research is needed to understand the decreased role of utilities beyond deleveraging as a consequence of the crisis.

Institutional investors[15] drive this development, at least for brownfield projects; pension funds, insurance companies, private equity and infrastructure funds have become major equity investors in the European wind sector. Their share in total equity provision increased from 6% in 2010 to 37% in 2015, making them the second most important equity providers in the 2015 sample, just 1% behind utilities. The increase of equity provision by institutional investors in the sample can be traced mainly to the acquisition of brownfield assets or portfolios for onshore wind deals. Pension funds and insurers were not involved in any greenfield onshore wind-power transactions included in the 2015 sample. This suggests that institutional investors look to the onshore wind sector mainly for the acquisition of existing projects.

Equity investment in wind energy assets by state agencies and public finance institutions grew significantly from a marginal share in 2010 to 9% of total equity invested in 2015.

In the sample, this increase can be attributed mostly to the activities of the UK Green Investment Bank. This institution was created by the UK government in 2012 to attract private sector financing for green infrastructure projects. The creation or expansion of similar institutions is a trend observable at the global level, and is important for risk sharing with newer technologies. In the offshore wind sector, for example, as projects scale up and move into deeper water, newer technologies also add to construction risk. This may discourage some investors from participating. In Europe, commercial banks have invested in partnership with government supported banks (e.g. United Kingdom's Green Investment Bank, Germany's KfW Development Bank), export credit agencies (e.g. Denmark's EKF and Belgium's Delcredere – Ducroire), and multilateral banks (e.g. the European Investment Bank; see OECD, 2016a forthcoming).

On the project level, large offshore wind deals illustrate the diversifying equity mix. The largest wind energy deal in Europe to reach financial closure in 2015, the Galloper Offshore Wind Farm, provides an example of a project in which equity investors include a utility (the German company RWE), a public finance institution (the UK Green Investment Bank) and institutional investors (Macquarie Capital). The equity part of the second largest deal, the Veja Mate Offshore Wind Farm, was provided by two institutional investors, while mezzanine finance was provided by another. Finally, the UK Green investment Bank and the utility E.ON collaborated for the financing of the Rampion Offshore Wind Farm. All three deals were greenfield projects (albeit offshore) with a transaction value of over USD 2 billion each.

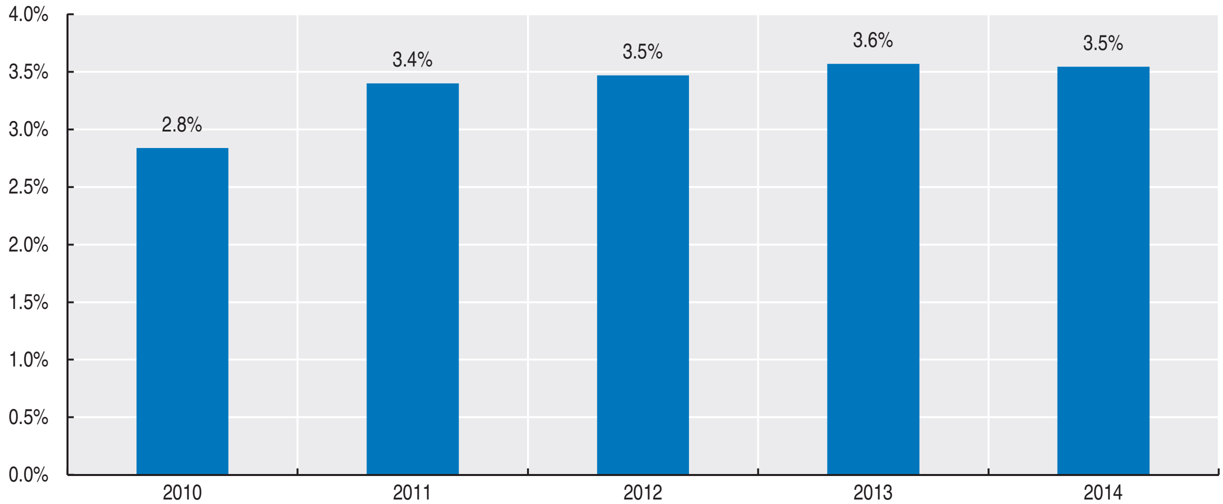
Renewable electricity infrastructure can offer an attractive return profile for long-term investors

Many institutional investors, notably pension funds, have long-dated liabilities and may not necessarily face short-term liquidity needs. These investors are increasingly seeking to invest in lower beta assets where risk-return trade-offs may be better than in public equity markets. Indeed, the recent OECD Survey of Large Pension Funds (LPFs) and Public Pension Reserve Funds (PPRFs) (OECD, 2016d) indicates that allocations to listed equities declined from 2010-14, confirming that large pension funds are shifting return-seeking assets to alternative investments.

As part of the overall trends in alternative investments and demand for higher-yielding assets, pension fund demand for investment in illiquid unlisted infrastructure equity markets has increased over the past five years. Despite this strong demand, the funds that reported their unlisted infrastructure equity allocation have only increased this allocation slowly over the past five years, occupying around 3.5% of portfolios, on average, in 2014 (Figure 5.6). At the same time, many funds reported that they were below their investment targets for infrastructure. This suggests that funds have some capacity to increase their investment in unlisted infrastructure equity. By investing directly in renewable electricity projects or through funds that invest in renewable electricity assets, some pension funds have included renewable electricity as part of their illiquid infrastructure allocation. These findings confirm the above analysis on the changing sources of finance in renewable electricity sectors, particularly in pension fund investment in onshore wind.

Additionally, renewable electricity has potential to contribute to meeting institutions' liability-driven investment objectives. A 25-year power purchase agreement on a solar project, for example, creates a predictable stream of future cash flows, providing a bond-like return profile. Renewable electricity projects with a strong yield component and

Figure 5.6. **Historical unlisted infrastructure equity allocation of selected pension funds, 2010-14**



Note: Pension funds refer to large pension funds (LPFs) and public pension reserve funds (PPRFs). Values are a simple average invested in unlisted infrastructure equity for those LPFs and PPRFs that reported unlisted infrastructure equity exposure in Part B of the 2015 survey, independently of their size in terms of assets. The data track a total of 24 LPFs and PPRFs over the period 2010-14.
Source: OECD (2016d).

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suitable risk profiles may diversify liability-driven investment portfolios and benchmarks of pension funds, which tend to be dominated by fixed income.

Despite the increasing interest, renewable electricity is still a small component of the total infrastructure allocation by pension funds. This reflects the overall investment environment for renewables: market barriers and policy risks (described later in this chapter) mean that opportunities are fewer than in more traditional infrastructure sectors such as transport or conventional energy.[16] Of the 26 pensions and reserve funds that reported sector allocations in their infrastructure portfolios, only nine reported exposure to renewable electricity. The largest allocation of an infrastructure portfolio to renewables was 19% (PFA Pension, Denmark), while the smallest was less than 1% of total infrastructure investment (OMERS, Canada). It is noteworthy that OMERS, the fund with the largest allocation to infrastructure in absolute terms in the survey population, had a very small weight in renewable electricity, given the long history of the fund's investment in infrastructure and expertise in due diligence and deal sourcing. Most funds reported exposure to renewables in unlisted infrastructure equity, either through private equity-style funds or through direct investment and co-investment in renewable electricity projects.

Public equity markets have provided innovative finance for renewable electricity

While pension funds and other institutional investors have been active in financing renewable electricity projects in illiquid private markets, some new equity instruments have become available through public equity markets. This trend has increased competition for renewable electricity assets in some regions, especially in the United Kingdom and the United States. Different investor bases can have differing costs of equity. Competition amongst equity sources of capital that minimise the cost of equity has been a driving source of these financing trends and has spurred innovations to create new vehicles to access renewable electricity investment.

Over the past few years, a handful of exchange-listed closed-end funds have emerged in the United Kingdom. These funds raise capital by issuing shares and debt to acquire wind and solar assets. The funds are designed to pay a significant amount of earnings as dividends to shareholders. Closed-end funds have been used for a number of years in infrastructure finance, particularly in Australia where some funds have lengthy track records.

In the United States, yieldcos have emerged as a new form of public equity market finance for renewable electricity. Yieldcos differ from closed-end funds in that they are essentially publicly listed companies that hold renewable electricity assets. Most often these assets are acquired directly from a sponsoring parent such as a utility. But yieldcos are similar to closed-end funds in that they are designed to pay out a significant amount of earnings in the form of dividends.

Recent developments in the United States yieldco market have tested their structures and raised questions about their future. Since yieldcos were established to hold cash-flow generating assets and are committed to distribute all, or substantially all, of available cash to investors as dividends,[17] this would imply that much of the expected return to investors would be in the form of income instead of capital growth. Yet many yieldcos included aggressive dividend growth policies as part of their earnings guidance. This strong growth had been fuelled through direct acquisitions of assets and drop-downs from the sponsoring entity. Such growth through investment required a strong pipeline of projects and near continuous access to capital markets – both in debt markets, and the ability to tap equity markets through new share issues.

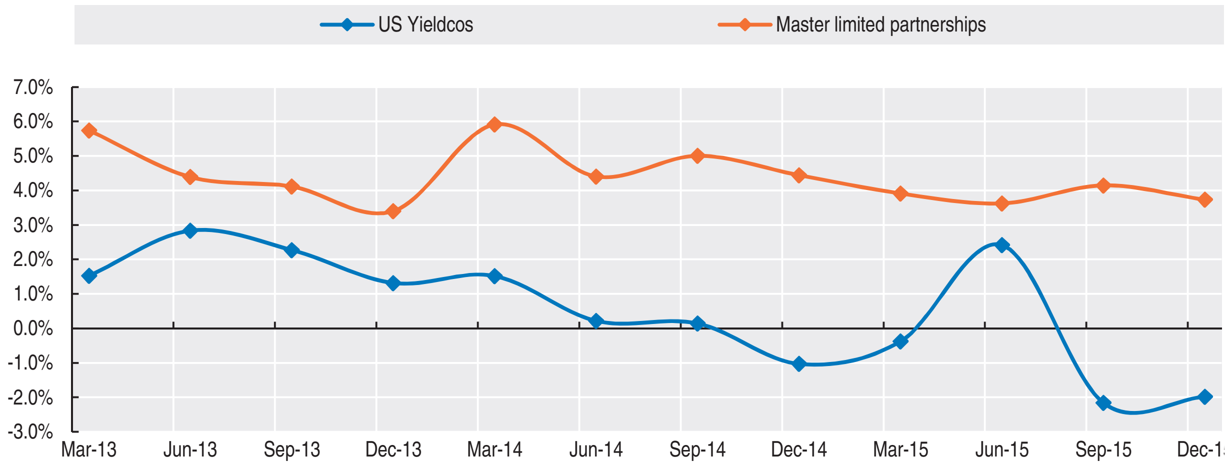
A steep drop in yieldco equity prices in 2015, prompted by flaws in the business model and also contagion from falling fossil fuel prices, closed off access to capital markets and brought the yieldco machine to a halt. While falling stock prices lead to rising dividend yields, they made growth through new acquisitions unfeasible due to depressed stock prices. As a result, investors are re-evaluating the yieldco model.

Investors may also be hesitant with the yieldco model due to lacklustre performance. Comparing yieldco performance to that of master limited partnerships (MLPs),[18] the return on equity for the five largest yieldcos was consistently below that of the five largest MLPs (Figure 5.7). An unproven yieldco business model combined with a relatively short operational history and weak performance leaves many investors on the side-lines.

In order to build confidence in the yieldco model, greater transparency of asset transactions (drop-downs from sponsor) is necessary, along with stronger and more responsible corporate governance. Additionally, reforms such as higher carbon prices and stronger climate mitigation policies (described in detail in further sections) could make investment in renewable energy, through public equity markets, more attractive by making returns more competitive with conventional energy.

Further innovation is afoot in public equity markets for the finance of renewable electricity. Proposed legislation in the United States seeks to include projects in wind and solar as qualifying assets under securities laws that govern MLPs, potentially expanding the field of listed equity finance for renewable electricity. The growth of closed-end funds, such as in the United Kingdom, shows signs of attracting higher levels of investment. Public equity markets have the potential to meet the growing financing needs of renewable energy, yet the market is still in a state of development where new business models seek greater acceptance from investors, combined with the need for mitigating policies, that make renewable energy assets more attractive for investment.

Figure 5.7. **Average ROE of largest yieldcos and master limited partnerships in the United States, 2013-15**



Note: ROE: return on equity.
Source: Reuters, OECD calculations.

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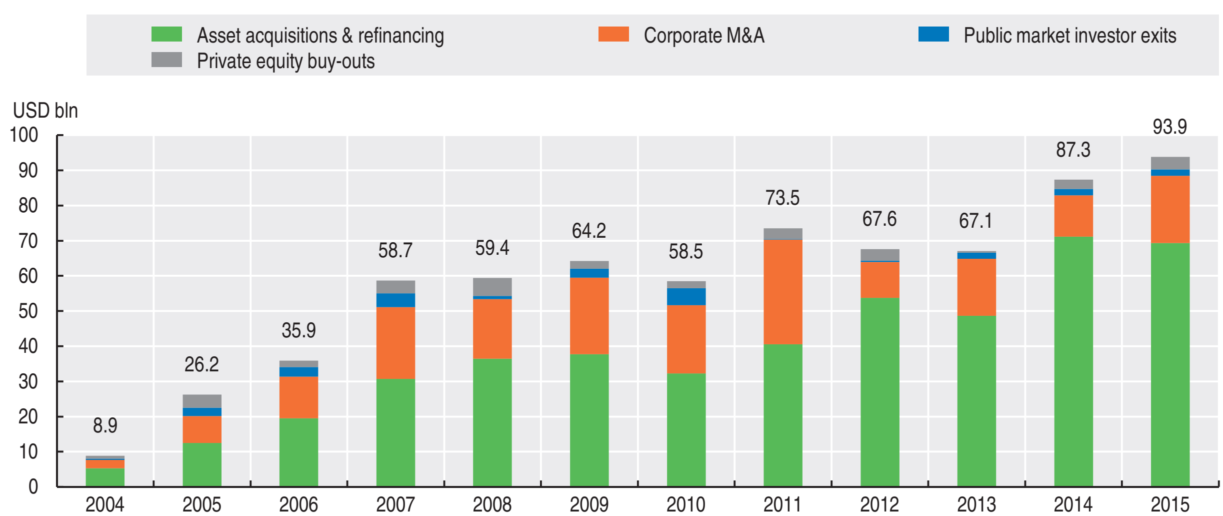
A secondary market for renewable electricity projects has developed

Corporate asset disposals from utilities and refinancing of projects in operation, coupled with a strong appetite from investors, are contributing to the increase in global secondary market acquisition transactions in the renewable sector. Figure 5.8 shows corporate M&A, private equity buy-outs and public market investor exits, as well as the refinancing and acquisition of renewable assets.

Figure 5.8. **Acquisition transactions in renewable energy by type, 2004-15**



Note: All figures are expressed in USD billion. Total values include estimates for undisclosed deals.
Source: McCrone et al. (2016), based on BNEF data.

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In the United States and the European Union, competition from renewable electricity and lower demand for energy are putting pressure on utilities and developers. In order to preserve the balance sheet or undertake new projects, many utilities are now seeking to recycle capital through sales of equity stakes. In December 2015, for example, the yieldco TerraForm Power acquired more than 90% of the North American wind energy portfolio from the developer Invenergy, for USD 2 billion. Almost USD 300 million was financed via commercial debt, while TerraForm financed the remaining amount through its balance sheet. Three of the seven wind farms included were under construction at the time, and the acquisition will be completed upon operation, providing an example of secondary market transaction at the construction stage.

A range of financial institutions has provided capital for the refinancing of operating offshore wind projects on a project finance basis, including banks, export credit agencies, multilateral development banks, pension funds and sovereign wealth funds. In December 2015, the investor Blackstone issued USD 1.067 billion in bonds to refinance Phase I of the MeerWind Sud und Ost Offshore Wind Farm (OECD 2015a, 2016b). Table 5.1 summarises other recent prominent examples in the secondary market.

Table 5.1. **Top transactions in secondary markets in Q4 2015**

Organisation	Country	Sector	Type of transaction	Acquirer	Value (USD mln)
Invenergy North American Wind Portfolio TerraForm Acquisition	Canada	Wind	Term loan	Terraform Power	2 000
Meerwind Sud und Ost Offshore Wind Farm Phase I Refinancing	Germany	Wind	Bond	Blackstone Group	1 067
Benedict First State Investment Portugal Wind Farm Portfolio Acquisition	Portugal	Wind	Bond	First State Wind Energy	1 012
Finerge-Gestao de Projectos Energeticos	Portugal	Wind	Equity (company)	First State Wind Energy	956
GDF Suez Mitsui Axium Infrastructure Canadian Wind/Solar Portfolio Refinancing	Canada	Wind	Term loan	Fiera Axium, IPR-GDF, Mitsui & Co	464

Source: BNEF (2016).

Given these trends in the renewable electricity market, it is not surprising to see increased co-operation between utilities and other market participants. This can be observed at the project level, as highlighted in Table 5.1, but also at the institutional level, where formal partnerships have been emerging. In particular, utilities have recently established joint ventures with financial companies to invest in renewable electricity. The aim is to combine the operational expertise of energy companies with the financing know-how and long-term capital fundraising of established investment companies. For example:

- The French utility EDF and Amundi partnered in 2014 to create a joint asset management company that will finance energy-related projects. This partnership initially plans to raise EUR 1.5 billion for the financing of renewable electricity generation and energy efficiency projects.
- In Italy, EDF and Edison, two utilities, and the infrastructure fund F2i established the third-largest operator in the Italian renewable energy sector in 2014. EDF is responsible for the operation of the facilities while Edison is in charge of the marketing.
- In Germany, the utility RWE, along with 29 municipal utilities, established Green GECCO in 2010, a joint-venture company for renewable projects which operates five wind farms to date.

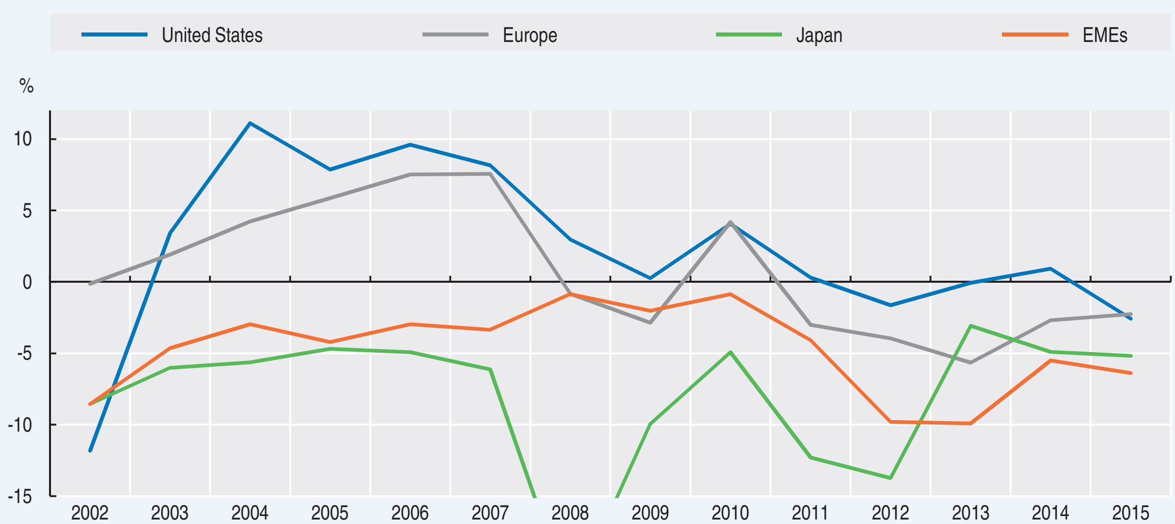
Policy misalignment and fragmentation: implications for renewable electricity investment

The evolution and innovation in financing models described above have led to a return to growth in total investment in renewable electricity. Nevertheless, investment remains constrained by policy and market obstacles that either hinder the development of a sufficient pipeline of bankable clean-energy projects or affect the risk-return profile of renewable projects. These barriers include policy stability and alignment, market design issues, technology risk and prevailing fossil-fuel energy prices. Taken together they can lead to weaker returns for renewables investments, as reflected, for example, in the returns on equity for clean energy companies (Box 5.1).

Box 5.1. **Returns on renewables investments: The case of equity for large listed companies**

As noted in the *OECD Business and Finance Outlook, 2015*, returns on equity have tended to be insufficient to cover costs of capital for large listed companies specialised in clean energy, at least since 2008. (Figure 5.9 considers a group of large publicly-listed clean-energy companies cited within the Bloomberg "Clean Energy" index.) The discrepancy between falling technology costs and poor returns on equity can be explained by a number of market and policy factors.

Figure 5.9. **ROE on clean energy investments minus COE, public companies 2002-15**



Note: ROE: return on equity. COE: cost of equity. Europe refers to the European Union and Switzerland.

Source: Bloomberg, *OECD Business and Finance Outlook 2015*.

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This section discusses the key role policy makers can play to remove outstanding investment barriers and scale up attractive investment opportunities in renewable electricity. A broad approach is necessary, combining strong climate change policies with efforts to ensure that policies affecting the broader investment environment for renewable electricity (such as investment policy or the design of electricity markets) are coherent and aligned with climate goals. A more aligned policy landscape can strengthen the confidence of private financiers in renewable electricity investments.

Set stronger climate mitigation policies

As highlighted by the report *Aligning Policies for a Low-carbon Economy* (OECD/IEA/NEA/ITF, 2015), economy-wide shifts in investment away from fossil-fuel-based options remain constrained by the absence of coherent and strong climate mitigation policies**.** These policies are needed to internalise climate change costs and to create incentives for the private sector to shift investment away from fossil-fuel-based technologies towards "low-carbon" technologies, including renewable electricity. When developing climate change policies aimed at the electricity sector, priorities for policy makers include:

- Setting a robust, credible long-term price on GHG emissions. Putting a price on carbon is critical to send long-term signals to investors. OECD analysis shows that explicit carbon-pricing tools, such as carbon taxes and emissions-trading schemes, are more effective than other policy instruments (such as mandates) in abating GHG emissions (OECD, 2013c). In the electricity sector, carbon pricing acts to increase wholesale prices due to the extra cost levied on carbon-intensive generation. Currently however, carbon prices generally remain too low to encourage investment in renewable electricity technologies. Supporting climate policies are thus needed to achieve GHG emissions reductions in the electricity sector without compromising other policy goals such as energy security and energy access.
- Developing targeted investment incentives, designed to complement carbon pricing policies and help deploy renewable electricity projects. In addition to carbon pricing, policy makers have provided significant support in the past decade to help deploy renewable electricity technologies at commercial-scale through targeted incentives. For renewable electricity, some of these measures offer a fixed tariff to generators and so operate largely independently of the electricity market (e.g. feed-in tariffs). Others, such as feed-in premiums, offer a premium to wholesale electricity prices. Globally, government support for renewable energy amounted to USD 121 billion in 2013 – of which 80% went to renewable electricity generation and 20% to biofuels. As of early 2015, 145 countries had implemented renewable-energy incentives, including feed-in tariffs, renewable electricity certificates, public auctions and tax incentives (REN21, 2015).
- Eliminating inefficient subsidies and other forms of support to fossil fuels, which create disincentives to renewable investment, including in the electricity sector. Such support undermines global efforts to achieve zero net emissions in the second half of this century. Although government support for fossil fuels seems to have peaked in 2011-12, such support in OECD countries and the BRIICS[19] still amounted to USD 160-200 billion annually (OECD, 2015m).
- Providing targeted technology support to innovation, e.g. through targeted, technology-neutral public support for research, development and demonstration.

Aligning the broader investment environment

Adopting a portfolio of climate policies is critical to address the gap between current and desired GHG emissions trends, but is not in itself sufficient. The overall investment environment still collectively favours investment in fossil-fuel-based options. Achieving the desired emissions reductions – including scaling up investment in renewable electricity – also requires that broader policies affecting investment are not misaligned with climate goals (OECD/IEA/ITF/NEA, 2015). Such misalignment of policies increases the public cost of climate-specific policies and can even lead to retroactive policy changes, for example retrospective changes to solar PV feed-in tariff contracts in several countries. These changes can increase investors' risk and increase market fragmentation. Policy misalignment can also unnecessarily add to the cost of renewable electricity investments.

In accordance with the OECD *Policy Framework for Investment*, the investment environment or business climate can be defined as the range of policy fields that form a country's enabling environment for all types of investment (OECD, 2015e). Potential misalignments with climate goals can be identified in many different policy areas, including trade and investment policies affecting manufacturing, electricity market design features and financial and banking regulations. Some of these are considered in the following sections.

However, more empirical evidence is needed to help policy makers improve the effectiveness of policy support to investment in renewable electricity, including through aligning the broader investment environment and addressing fragmented business conditions. Ongoing OECD work is undertaking new econometric analysis to estimate the impact of climate mitigation policies and investment conditions – and their interactions – on investment flows in renewable electricity generation in OECD and G20 countries (OECD, 2017a forthcoming). The report seeks to build on qualitative conclusions in the *Aligning Policies for a Low-Carbon Economy* report and assess empirically how the investment environment influences the "effectiveness"[20] of climate mitigation policies in mobilising investment flows in renewable electricity generation in OECD and G20 countries. Based on this analysis, the report will seek to identify which climate mitigation policies are more effective in driving investment flows and encouraging patent activity in renewable electricity generation in OECD and G20 countries. It will also consider the hypothesis that the effectiveness of such policies depends on the broader investment environment.

Avoid fragmenting global renewable electricity value chains

Over the past decade, governments have provided substantial support to the deployment of renewable electricity, and both international and domestic investors have benefited. Applied import tariffs on solar PV and wind energy equipment are relatively low across OECD and emerging economies, and *de jure* restrictions to foreign direct investment (such as limits on foreign ownership) in clean electricity generation remain limited, especially in OECD countries.

Since the 2008 financial crisis, however, the perceived potential of renewable electricity to promote growth and employment has led several governments to implement trade and investment measures protecting domestic solar panel and wind turbine manufacturers, with a view to creating local jobs and promoting exports (OECD, 2015a; Bahar et al., 2013). In particular, the OECD report *Overcoming Barriers to International Investment in Clean Energy* (OECD, 2015a) highlights that:

- Policy makers have increasingly used local-content requirements in solar PV and wind energy since 2009. Local-content requirements typically require project developers or investors to source a specific share of manufactured components or equipment locally to be eligible for policy support or public tenders. Such requirements have been planned or implemented in solar and wind energy sectors in at least 21 countries, including 16 OECD countries and emerging economies, mostly since 2009.[21]
- The alleged use of dumping or actionable subsidies has resulted in an escalation in the use of trade remedies in solar PV energy, and to a lesser extent, in wind energy. Between

January 2010 and September 2014, OECD countries and emerging economies have imposed nine anti-dumping duties and seven countervailing duties on products and components associated with solar PV and wind energy, and launched 24 WTO investigations for anti-dumping or countervailing duties.

- There are outstanding non-tariff barriers to trade and investment in solar and wind energy, such as divergent domestic technical standards in wind energy.

Such measures can seriously disrupt global value chains. They are misaligned with climate goals. In particular, according to recent OECD work (OECD, 2015a):

- The increasing use of local-content requirements in solar PV and wind energy in OECD and emerging economies since 2008 has had a detrimental effect on global international investment flows in solar and wind energy. Midstream manufacturing and downstream activities (such as power plant project development) in solar PV and wind energy sectors are increasingly global, i.e. solar and wind-power generation relies on an increasing share of imported intermediate products. This means that by raising the cost of inputs for downstream businesses, local-content requirements can hinder the profitability of downstream investors and lead to increased overall costs, weakened price competitiveness, reduced international investment flows and higher electricity prices. The rise of green industrial policies, especially through local-content requirements, threatens to fragment solar PV and wind energy value chains into regional and domestic markets. This may prevent supply chain optimisation and cost reductions.
- Analysis of the solar PV and wind energy value chains suggests that local content requirements may have limited or even negative impacts on value added and job creation. This is because downstream activities represent the largest share of job creation and value added potential in solar PV and wind energy. In the solar PV sector in particular, manufacturing activities represent only 18%-24 % of total jobs, according to recent estimates. At least 50% of solar PV jobs and value-added are located in downstream activities. This means that policies targeting manufacturing activities may not be effective in creating domestic jobs and value across the entire value chains.
- In addition, the increasing use of trade remedies against imports of solar PV and wind turbine components has led to large reductions in global trade, especially for solar PV, amounting to around USD 14 billion annually (Cimino and Hufbauer, 2014).

Reduce the fragmentation of electricity networks and markets

The characteristics of electricity markets and systems may themselves be constraining investment in renewables. Liberalised electricity markets, as they are designed today, can be considered misaligned with climate change objectives. Indeed, "current designs of wholesale electricity markets in many OECD countries are not strategically aligned with the low-carbon transition. They do not deliver the long-term price signal that investment in high capital cost, low-carbon technologies […] would require" (OECD/IEA/ITF/NEA, 2015). Given that renewables have often been supported by "out-of-market" incentives in parallel with wholesale markets, the integration of renewables into existing market designs has contributed to downward pressure on electricity prices (along with reduced overall demand in many OECD countries and reduced running hours for conventional power plants; see Box 5.2). Wholesale electricity prices are now at their lowest level since 2002, squeezing profit margins of conventional electricity utilities. As a result, in 2015 more than one-quarter of Standard & Poors' rated universe of Europe, Middle-East and Africa (EMEA) utilities has been subject to negative rating actions (downgrade or negative outlook revision). Combined with the policy uncertainties described above, the result is that many utilities may limit investments – including in renewables – for cash flow preservation and balance sheet protection.

Box 5.2. **Electricity market design and renewable electricity**

Several analyses have noted that the current designs of wholesale liberalised electricity markets are often not strategically aligned with the low-carbon transition (OECD/IEA/NEA/ITF, 2015; IEA, 2014c). "Energy-only" wholesale electricity markets would not attract investment in low-carbon technologies unless there was a high CO_2 price, periods of very high electricity prices and even risks of rolling brown-outs (because electricity demand remains fairly inflexible in most countries). Even if these conditions were to occur, the high risks involved would lead to higher cost of capital which would in itself hinder low-carbon investment, given that most low-carbon generation options have high upfront capital costs and low (or near-zero) variable running costs.

To stimulate investment in renewable electricity, many governments have turned to "out of market" measures that offer a fixed tariff to generators, such as feed-in tariffs. While feed-in tariffs can be effective at providing revenue certainty for investors, the challenge of setting appropriate tariff levels is important. Also, as the proportion of low-marginal-cost renewables rises due to these out-of-market agreements, the result is downward pressure on wholesale prices, especially when overall electricity demand is also falling, as has been the case in some OECD countries. This exacerbates the well-known "missing money" problem in electricity markets, whereby short-run marginal cost pricing does not guarantee full recovery of capital costs for all plants, including renewables (OECD/IEA/NEA/ITF, 2015; IEA, 2014c).

New market arrangements are needed to ensure competitive investment in low-carbon capacity, and to ensure that renewable electricity is generated when it is of most value to the overall system. Mechanisms involving price discovery are a promising step forward. Auctions for procurement of specific new capacity at new locations appear to provide a strong incentive for investment while delivering low electricity prices even for renewables, provided that the purchase agreements are for a sufficiently long duration (IEA, 2016). Some countries have also required renewable generators to sell their electricity on the wholesale market, while guaranteeing a supplementary premium payment (feed-in premiums). Further, market design issues will also be different in fast-growing regulated markets that do not rely on spot markets, such as in China.

The investment profile of renewable electricity projects can also be affected by elements of fragmentation in the development of transmission and distribution infrastructure for electricity and in some elements of electricity market design. These include:

- a lack of investment in transmission networks, including cross-border interconnections, reducing the flexibility of electricity systems;
- the design of capacity mechanisms used to ensure that sufficient generating capacity will always be available in systems based on wholesale electricity markets.

Investing in the flexibility of electricity systems

The variability of renewable electricity generation means that, to integrate high proportions of renewables into existing electricity networks at lowest cost, significant investment will be required to improve the overall flexibility of electricity systems. While technical solutions do exist, the flexibility of the whole system needs to be considered – including the demand side, transmission and distribution management, storage availability and generating patterns of both conventional generators and the renewables themselves (IEA 2014c; IEA, 2016). This includes, notably, investment in network infrastructure in two ways:

- investments and improvements in transmission and distribution networks locally;
- broadening the geographic spread of electricity systems by increasing levels of interconnection between neighbouring electricity grids (including policy harmonisation to optimise the cross-border flow of electricity).

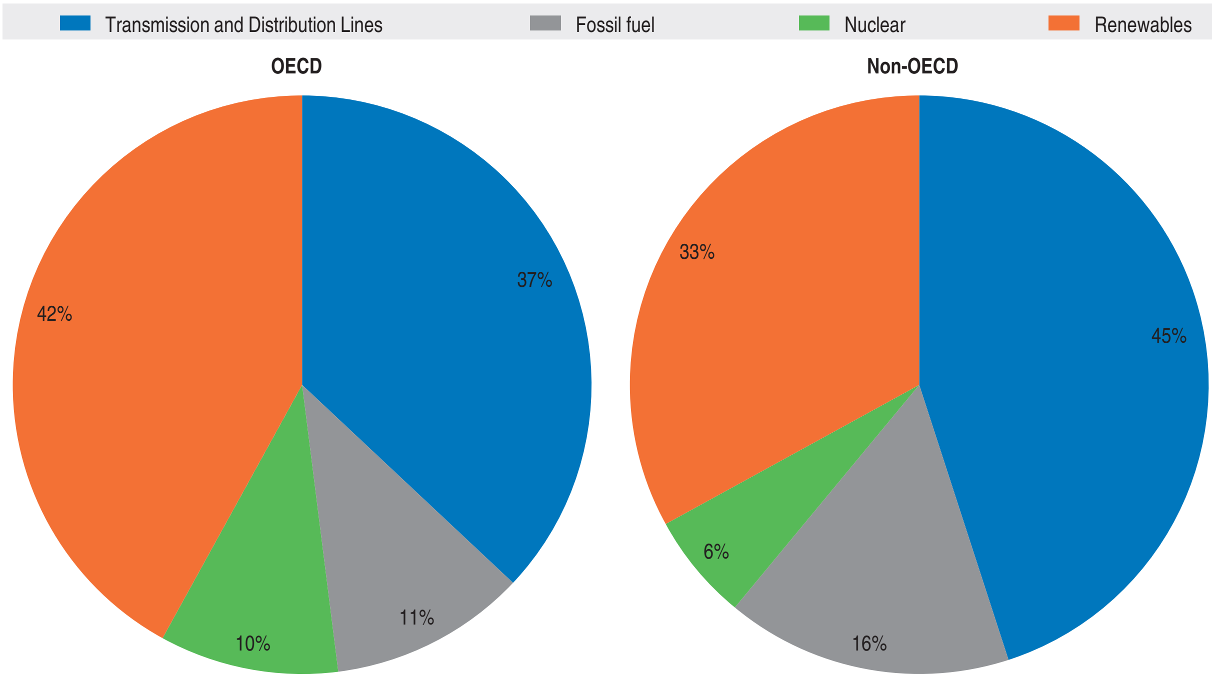
Variable renewable electricity technologies are essential to address climate change but their integration into existing grid systems can be challenging. Weather-dependent technologies such as wind and solar PV do not generate electricity constantly, and although energy storage technologies are developing fast, cost-effective storage options do not yet exist. Recent improvements in weather forecasting have dramatically improved the predictability of wind and solar generation on a day-ahead timeframe (IEA, 2014c). However, wind and solar plants are still not fully dispatchable, meaning that the system operator cannot rely on being able to call upon them at times of high demand. Other dispatchable capacity needs to be available to allow for system balancing. The location of renewable generating sites can also pose an integration challenge as the renewable resources (such as wind and water) are often far from demand centres. This adds to pressures on the electricity transmission grid, requiring new lines extending to generating sites and increasing congestion on pre-existing trunk lines.

Significant investments in transmission and distribution infrastructure are needed, both to address local problems and to increase the geographic spread of the grid systems that renewable sources serve. It is notable that the IEA expects considerable investment in transmission and distribution infrastructure in its "New Policies Scenario" (Figure 5.10), of a similar magnitude to investment in renewable generation itself (and even more in non-OECD countries).

To date, private investment in electricity transmission and distribution infrastructure has been limited. The sector is not open to private investment in many countries, and even where it is open, attracting merchant investment has not always been easy. Nevertheless, some experience is now building up globally. In Brazil, all transmission expansion projects are put to tender and, since 1999, 50 000 km of new lines have been financed by USD 28 billion of private investment (IEA, 2016). In Europe, private investment in transmission infrastructure has been limited, partly because system operators are also owners of the infrastructure in many cases. However, the United Kingdom has begun to open up the transmission sector for investment in the particular case of offshore transmission lines connecting offshore wind farms.

The integration of renewables can also be facilitated by increasing the geographic spread of the electricity grid and encouraging trading of electricity across a broader area. National transmission grids (and in larger countries, sub-national grids) are often interconnected to neighbouring grids. Interconnectors allow for cross-border trading and, overall, a better matching of renewable electricity supply with demand centres. Nevertheless, the capacity of interconnections is still limited in many countries. For example, in Western Europe, most countries have grid interconnection of less than 10% of their total capacity, with only a few countries exceeding 15% (IEA, 2015). Low levels of

Figure 5.10. **Investment in transmission and distribution relative to power generation based on IEA New Policy Scenario 2015-40**



Note: Figures are expressed in percentage of total.
Source: OECD calculations based on IEA (2014d), World Energy Outlook, OECD/IEA Publishing, Paris.

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interconnection make variable renewables harder to integrate and can affect the risk-return profile for potential wind and solar investors.

According to IEA analysis, interconnectors are the most cost-efficient way to integrate a high share of variable renewable electricity while maintaining a secure supply of electricity (cheaper, for example, than current options for large-scale storage or investments in extra baseload capacity). In the European Union, a better interconnected European energy grid would bring notable market benefits, with some estimates foreseeing consumer savings of between EUR 12 billion and EUR 40 billion annually by 2030 (IEA, 2016). Interconnection is particularly important for renewables because the generation patterns of weather-related technologies will be different across larger geographic areas. If the wind drops in western France, it may still be blowing in eastern Poland. Similarly, demand patterns are likely to be less synchronised across broader geographic areas. While peak demand in northern Europe may occur in the winter due to electric heating, in southern Europe it may be in summer when the demand for air-conditioning increases. Models suggest that with more than 3% penetration of wind, there are significant benefits to increasing cross-border trade through interconnection (Benatia et al., 2013).

Interconnectors, as with all transmission infrastructure, require substantial investment. Such investment is only economically justifiable when the benefits of increased power flows exceed the costs of new lines, yet elucidating the real benefits and costs can be challenging (IEA, 2016). Interconnectors pose particular opportunities and risks for investors. In theory, long-term price differences in neighbouring (but insufficiently connected) power grids can provide attractive revenue possibilities. However, the cross-border nature of interconnectors can complicate the planning and approval process, worsening the investment case. Cost-benefit analyses can be difficult due to benefits being heterogeneous across jurisdictions (e.g. interconnection can actually increase wholesale prices in isolated grids that enjoy abundant low-cost power, such as cheap hydro). Some regulators have sought to overcome these barriers by offering higher returns on capital for interconnectors (e.g. in Italy and by the Federal Energy Regulatory Commission in the United States, IEA, 2016).

Physical interconnection is not enough to guarantee cross-border trading. A range of market integration issues and administrative barriers can prevent trading even where sufficient physical interconnection capacity exists. These include different gate closure times, auction procedures and tax situations as well as conventional barriers such as language differences (Bahar and Sauvage, 2014; IEA, 2014b, 2016). Increased international co-ordination on network planning and market design could therefore facilitate increased interconnection and increased cross-border trading of electricity.

Design and use of capacity mechanisms

A further challenge for liberalised electricity markets is the need to maintain electricity generation capacity margins for security purposes at times of scarcity. While electricity markets based on wholesale marginal cost pricing can deliver reliable electricity supply over the short-term, they may not provide sufficient incentives to deliver investment in the capacity margins necessary to guarantee supply over the medium and longer term. Countries have introduced different mechanisms to tackle this problem, and the resulting policy fragmentation in regional markets, including within Europe, can distort electricity markets regionally, affecting the investment attractiveness of renewable electricity projects. Different mechanisms include:

- Market-wide capacity markets, providing payments for generating capacity or reduced demand that is guaranteed to be available at times of stress, with the price set through auctions. These provide additional revenue to generators, on top of year-round sales via the wholesale market.
- Targeted volume-specific strategic reserves, which are used to maintain strategic reserves and tend to provide payments for existing baseload capacity.

While capacity markets are important complements to wholesale markets, they should not be seen as a means to prop up revenues of otherwise unprofitable generators; in other words, capacity mechanisms should not replace good market design in the first place (IEA, 2016). Further, the design and role of capacity markets should be carefully considered in the context of a transition to low-carbon power generation. Capacity markets can provide incentives to maintain existing generation units open for longer than they would be economic in an energy-only market. While such incentives are good for security of supply, they may be misaligned with climate change objectives. This is especially likely in the absence of a robust carbon price.

Differences in the design and operation of capacity markets can, therefore, hinder cross-border trade of electricity, creating further barriers to integration of renewable electricity. The IEA identifies principles for efficient co-ordination of capacity markets to support private sector investment in renewable electricity projects (IEA, 2016). These include:

- addressing capacity adequacy requirements on a regional level (aiding both capacity market design and interconnector planning);

- aligning capacity product definitions to facilitate cross-border trade;
- ensuring that capacity markets do not interfere with forward pricing of electricity.

Conclusions

Helping policy makers mobilise private investment in renewable electricity requires addressing outstanding policy and market obstacles to such investment. The OECD has an important role to play in providing policy analysis to help countries strengthen the enabling conditions for renewable electricity investment and financing. Policy priorities for addressing fragmentation issues in renewable electricity markets and suggested ways for the OECD to continue to provide support include:

- overcoming financing challenges and mobilising private finance for renewable electricity;
- setting coherent and strong climate mitigation policies and aligning the investment environment;
- supporting electricity market integration and regional co-ordination;
- improving data collection.

Overcoming financing challenges and mobilising private finance for renewable electricity

Given the considerable need for long-term infrastructure investment, including for renewable electricity and power transmission and distribution, countries need to improve the efficiency of public investment while mobilising private investment at scale and at pace. Diversifying the types of financial stakeholders and sources of finance for such investment through new financing and funding structures, and innovative financial tools, can help align public and private sector interest in infrastructure provision and management, while optimising the capital structure and reducing the cost of capital for the public sector.

This chapter has emphasised the rising appetite from both equity and debt investors for renewable electricity projects, in various activities associated with project development, and using different financial structures employed across the spectrum of investment opportunities. Increasing numbers of institutional investors are recognising the potential for infrastructure investment to deliver inflation-linked, long-term and stable cash flows. Despite these encouraging trends, total amounts of institutional investment in renewable electricity remain relatively limited, considering the large pool of available capital from long-term investors. Various financing instruments can allow investors to tailor cash-flows to their needs. In addition, governments currently have a key role in fostering institutional investment not only by the direct use of funds, but also by playing an important catalytic role with respect to the mobilisation of private financing in renewable electricity, and other clean-energy technologies, beyond working on enhancing the macroeconomic and legal environments.

Further research and policy dialogue with regulators and investors (such as the B20) are also needed to better understand issues such as: factors driving the changing nature of banks and declining share of utilities and banks in financing renewable projects; the risk appetite of different types of investors, given the risk profile of renewable electricity projects; and new models and instruments for private sector financing of renewable projects, including through financial instruments offered by governments and multilateral development banks (MDBs). As different types of private investors are willing to take on different types of risks, risk allocation is a crucial factor in determining the pool of willing investors (i.e. the "right-siting" of capital). Attracting institutional investment may require new financial instruments and forms of collaboration beyond traditional instruments, such as direct equity stakes and bank loans. This can make infrastructure as an asset class more accessible to a broader group of investors and help diversify the large risks of infrastructure projects – currently shouldered to a large extent by the banking sector and the public sector through guarantees – across many groups of investors through capital markets.

Setting coherent and strong climate mitigation policies and aligning the investment environment

Stronger and coherent climate mitigation policies are needed to align incentives for the private sector to shift investment away from fossil-fuel-based technologies towards renewable electricity technologies and other "low-carbon" investments (in the power sector and other emissions-intensive sectors). Such policies can include a policy package of explicit carbon pricing (e.g. carbon taxes and emission rights trading), targeted investment incentives (e.g. feed-in tariffs and public tenders), reform of fossil-fuel subsidies; and targeted support to innovation, e.g. through public R&D expenditures.

Beyond the need to set strong and coherent climate policies, investment and financing in renewable electricity remains constrained when other policies and regulations are misaligned with climate goals (OECD/IEA/ITF/NEA, 2015). Such misalignments can create an unsupportive investment environment for low-carbon investment such as renewable electricity.

Further research is needed to help policy makers improve the effectiveness of policy support to investment in renewable electricity, including through aligning the investment environment. Ongoing OECD work is empirically assessing the impact of climate policies and broader investment conditions on investment in renewable electricity, as mentioned previously (OECD, 2017a forthcoming). Related work is also underway on investigating the effects of competition policy and the role of state-owned enterprises in influencing investment in renewable electricity (OECD, 2017b forthcoming). Subsequent research steps could usefully develop country-specific indicators on countries' attractiveness for renewable electricity investment, depending on domestic policies and investment conditions.

In addition, continued research is needed to further assess implications of the possible fragmentation of solar PV and wind energy value chains into regional markets, as a result of policy misalignments such as local-content requirements and trade remedies. This would build on recent OECD work (OECD, 2015a; Bahar et al., 2013).

Supporting electricity market integration and regional co-ordination

Integrating renewable electricity technologies at least cost requires flexible electricity systems and electricity markets covering large geographic areas. However, many countries are not sufficiently interconnected with their neighbours and some regions face internal congestion in domestic transmission grids, meaning that electricity cannot flow freely to where it is of most value. In addition, market arrangements are often not integrated between neighbouring systems, preventing international electricity trades and leading to inefficient use of interconnectors where they exist. These fragmented arrangements can hinder investment in renewable electricity.

To create a market design and regulatory framework fit for the low carbon transformation of the electricity system, additional research and policy efforts are needed to foster regional co-ordination for the planning and use of interconnections. While some countries have encouraged private investment in transmission capacity, including interconnectors, cross-border issues can complicate the planning and approval process. Governments and regulators need to take more regional and holistic approaches to network planning, both within countries and across borders. Finally, public financial institutions such as MDBs can play an active role in addressing obstacles encountered by projects, ranging from overseeing compliance with permit granting procedures to facilitating access to finance.

Another element of fragmentation in electricity markets is the development of diverse mechanisms for ensuring sufficient availability of capacity at times of scarcity. Again a more regional approach is desirable, such as addressing capacity adequacy requirements on a regional level (aiding both capacity market design and interconnector planning) and aligning capacity product definitions to facilitate cross-border trade.

In co-operation with the IEA, further research could focus on the investment implications of the design of electricity markets and systems, both to increase investment in renewable electricity and to stimulate private sector participation in other electricity infrastructure such as transmission and distribution (including interconnectors).

Improving data collection

To better assess the impact of fragmented climate policies and misaligned business conditions on investment and financing in renewable electricity, improved data collection and tracking is needed. The OECD is undertaking new data gathering on renewable electricity investment (OECD, 2017a forthcoming, 2017b forthcoming). It is also administering the *2016 Survey on Improving the Investment Environment for Renewable Energy*. This new survey will supplement empirical work by gaining insight into what key stakeholders consider to be the key policy barriers and drivers to private decisions to invest and innovate in renewable electricity technologies in OECD and G20 countries. The survey also includes a section on financing practices, including expected returns and risk perception.[22]

Other recent research has focused on infrastructure investment, looking at the "productivity" of capital and the determinants of investment and its financing, whether public or private (IMF, 2014; OECD, 2015). More evidence is needed about the impact and benefits of infrastructure investment on policy goals such as: economic development and wealth creation; and the investment characteristics of infrastructure.

In addition, future work could usefully gather data on the costs as well as new capacity of low-carbon technologies, and especially renewable electricity, in order to better assess the "quality" of investment flows, as well as the cost-effectiveness of policy support to the deployment of such technologies. It could also help assess how policies, such as feed-in tariffs and tenders, have contributed to driving technology cost-reductions through "learning-by-doing".

More clarity is also needed on future investment needs for infrastructure and the estimated contribution of private sector capital, by sector, region and type of financing, building on existing work (Global Commission on the Economy and Climate, 2014; Kennedy and Corfee-Morlot, 2012).

Notes

1. A publicly-traded company that is formed to hold renewable energy assets such as wind and solar power generation facilities. Most yieldcos are formed through a sponsoring entity, such as a utility, where operational assets may be sold from the sponsor to the yieldco entity. Yieldcos are designed to pay earnings as dividends to shareholders; OECD, 2015j; Annex 5.A2.

2. Capacity mechanisms are used to ensure that sufficient generating capacity will always be available in systems based on wholesale electricity markets.
3. "[…] and pursuing efforts to limit the temperature increase to 1.5°C above preindustrial levels"; UNFCCC (2015a).
4. In particular, the drop in oil prices globally since 2014 – and to a lesser extent, gas and coal prices – may create challenges for clean-energy technologies such as biofuels in the transport sector and renewable heating. At the same time, the decline of oil prices creates opportunities to reform fossil-fuel subsidies; IEA (2015b).
5. Brazil, the People's Republic of China, Colombia, Costa Rica, Indonesia, India, Latvia, Lithuania, the Russian Federation and South Africa.
6. Including in renewable electricity generation, nuclear power and carbon capture and storage (CCS).
7. Using levelised costs of electricity (LCOE) to estimate the cost of generating electricity; the LCOE calculations are based on a levelised average lifetime cost approach, using the discounted cash flow method; costs are calculated at the plant level, excluding transmission and distribution costs; IEA (2015c).
8. This is remarkable given also the shifting exchange rate and the sharp fall in oil prices.
9. As defined by the BNEF database, asset finance for renewable energy investment includes electricity generation and biofuels production assets that meet the following size criteria: one megawatt (MW) or larger for biomass and waste, geothermal, solar and wind energy generation; 1-50 MW for hydroelectric power projects; any size for marine-energy projects; and one million litres per year or greater for biofuel projects. The financing of carbon capture and storage and energy-smart technologies, along with mergers and acquisitions and refinancing deals are excluded.
10. As defined by the BNEF database, utility-scale projects refer to projects greater than 1 MW.
11. Figure 5.4 also reflects the quality of data available, which can be affected by incomplete financial disclosures for many transactions. There are major issues with data. Measuring investment flows or understanding the risk/return trade-offs in the renewables sector is challenging – the industry is young, track records are short, and a significant amount of investment has occurred in private markets. For example, the BNEF methodology regarding the accounting of Chinese asset finance deals with no disclosed financing type is an important caveat. A recent change in methodology has significantly reduced the share of balance-sheet finance for 2015 and previous years in BNEF statistics.
12. Where recovery in case of default is limited only to the collateral.
13. Based on the BNEF database (2016), including onshore wind generation as well as offshore wind-power generation and offshore wind-power transmission.
14. The data on investment, including new build and acquisition transactions, is compiled from the BNEFdatabase. The sample for 2010 includes 70 projects (57 new builds; 13 acquisitions), and the sample for 2015 includes 44 projects (29 new builds; 15 acquisitions). The total disclosed transaction value of the deals included in the sample was USD11.7billion in 2010 and USD14.9billion in 2015. The aggregated transaction value of greenfield projects stood at USD10.8billion in 2010 and USD11billion in 2015. The volume of total equity invested has decreased from USD6.6billion in 2010 to USD6.1billion in 2015. The institutional investor category includes pension funds, insurance companies, private equity and infrastructure funds; for more information on the data sample, please see Annexes 5.A1 and Table 5.A1.1.
15. Institutional investors are defined in this section as pension funds, insurance companies, asset managers, private equity funds, infrastructure funds, yieldcos, other listed vehicles and investment funds.
16. For a detailed description of infrastructure investment channels see OECD (2015b). As surveyed in detail by the OECD (2015j), institutional investors can invest in renewable electricity through a number of available channels. These include debt investments made in companies or projects, on a listed or private basis, and intermediated approaches such as fund structures.
17. NRG Yield Inc., Prospectus, Form S-1 Registration Statement Under the Securities Act of 1933.
18. Master Limited Partnerships are a type of limited partnership that is publicly traded, and is representative of the midstream conventional energy sector. Since securities law in the United States does not currently include wind and solar projects as qualifying assets, yieldcos were launched starting in 2012 as an attempt to mimic the MLP model for renewable electricity assets.

19. BRIICS stands for Brazil, Russia, India, Indonesia, China and South Africa.
20. For the purpose of this forthcoming report, the “effectiveness” of a given climate policy is determined by the fact that this policy variable has a statistically significant effect on investment flows in renewable electricity generation (or on patenting activity in renewable electricity sources); OECD (2017a, forthcoming). The analysis covers the period 2000-13.
21. Updated as of September 2014; OECD (2015b).
22. The results of the Survey will feed into the work of the OECD project on “Improving the Investment Climate to Achieve the Clean-Energy Transition” (OECD, 2017a forthcoming; 2017b forthcoming), as well as the OECD Long-Term Investment project, which aims to facilitate long-term investment by institutional investors such as pension funds, insurance companies, and sovereign wealth funds.

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ANNEX 5.A1

Complementary information on the dataset of Figure 5.5

To study the development of the equity mix of wind energy deals, we analysed the structure of deals having reached financial closure in Europe in 2010 and 2015. The data on investment is compiled from the Bloomberg New Energy Finance asset finance database (BNEF, 2016). The database distinguishes between three types of transactions: new build, acquisition and refinancing. For the purpose of this analysis, refinancing transactions has been disregarded. New build and acquisition transactions have been included. Furthermore, only transactions in the wind sector (onshore generation, offshore generation and transmission) in Europe have been included. The BNEF database is limited to wind projects of over 1 MW capacity. Additional criteria of selection are the availability of a disclosed total transaction value and availability of sufficiently granular data to ensure consistent classification of equity investors. This could introduce a bias towards projects in countries with stronger disclosure guidelines or better coverage of BNEF data.

Some important assumptions have been made: short term debt and mezzanine debt have been included in the debt total; investment reported as balance sheet financing has been assumed to be equity financing from the sponsors; if the disclosed total transaction values differed from the sum of reported debt and equity, the discrepancy has been assumed to be balance sheet financing (sponsor equity); in the case of multiple equity sponsors, where no ownership split was available the assumption of equal ownership stakes has been made. For the classification of equity investors, the BNEF databases of organisations as well as outside sources have been used. Please refer to Table 5.A1.1 for the complete list of investors included.

The investor categories are defined as follows:

- Utilities: companies that sell and distribute electricity, gas or water to customers. It may also be the producer/energy generator and can be private or state-owned.
- Institutional Investors: investors in energy assets. The distinction between sole investors and managers/operators of the assets in the portfolio is sometimes difficult to make. Includes pension funds, insurance companies asset managers, private equity firms, yieldcos and other listed vehicles, and investment funds.
- Non-Utility Corporates: All companies involved in the energy sector which are neither financial companies nor utilities. The majority are power plant operators, electricity generators, project developers, construction companies or manufacturers of technical components. Bloomberg defines them as the sponsors of the project, the company that

has the idea for the project and carries it out. They might sell the energy they produce to utilities and can be private or state-owned.

- State Agencies/Public Finance Institutions: government institutions, such as ministries, and public finance institutions, such as the Green Investment Bank in the United Kingdom or the European Investment Bank.
- Banks.

Table 5.A1.1. **Equity investors included in the deal sample**

Category used	Included in 2010	Included in 2015
Utilities	Alpiq Holding AG DONG Energy A/S EDF Energy Renewables Ltd Fortum OYJ GDF SUEZ Energia Polska SA Good Energy Group PLC Iberdrola Renovables SA Skellefteaa Kraft AB SSE PLC SSE Renewables Holdings UK Ltd Transpower Stromuebertragungs GmbH Trianel Goup	E.ON SE E.ON Thueringer Energie AG EDP Renovaveis SA Enel Green Power SpA Energie AG Oberoesterreich RWE Innogy GmbH RWE NPower Renewables Ltd ScottishPower Renewables Ltd SSE Renewables Ireland Ltd Statkraft AS Vattenfall AB
Non-Utility Corporates	ABO Wind AG Agaoglu Group C-Power NV Elektrani na Makedonija AD Element Power US LLC Energia y Recursos Ambientales SA Energiekontor AG Eolica Bulgaria EAD Eolicas de Portugal Eunice Energy Group SA Eurowatt SCA Faik Celic Holding Falck Renewables Wind Ltd Fersa Energias Renovables SA Fornax Sp zoo Gamesa Energia SAU Gamesa Eolica SL Gecal SA Gemba UAB Gestamp Eolica SL Gestamp Wind Greentech Energy Systems AS Inversiones Empresariales Tersina SL Inversiones Empresariales Tersina SL Jaeren Energi AS Krzemien i Wspolnicy Spzoo Ostwind Group Petrom SA PROKON Entrepreneurial Group REG Windpower Ltd Renewable Development Co Ltd Renewable electricity Systems Ltd Renovalia Energy SA Umweltgerechte Kraftanlagen GmbH Ventinveste SA Windvision Belgium SA Windway SGPS SA Wpd AG	Balfour Beatty Coillte Teoranta Coillte Teoranta Energix-Renewable Energies Ltd Enlight Renewable electricity Ltd Iberwind Desenvolvimento e Projectos SA ImWind Elements GmbH Invenergy LLC Momentum Renewables GmbH Raedthuys Groep BV Raedthuys Groep BV Raedthuys Groep BV Statoil ASA Sumitomo Corp Windkraft Simonsfeld AG Yard Energy Group BV

Table 5.A1.1. **Equity investors included in the deal sample** *(cont.)*

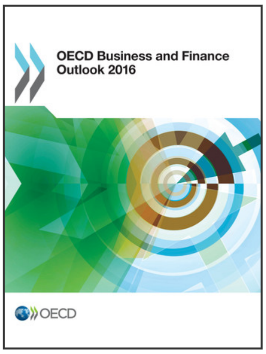
Category used	Included in 2010	Included in 2015
Institutional Investors	Allianz Renewable electricity Management GmbH Energia UK Ltd Eolia Renovables de Inversion SCR SA HgCapital LLP Infinis PLC Inveravante Inversiones Universales SL Island Of Hoy Development Trust/The Kallista France Novera Energy Services UK Ltd PensionDanmark A/S PGGM NV Platina Partners LLP Viridian Group Ltd Wind Works Power Corp	4P Envest GmbH Allianz Global Investors Fund Management LLC AMF Fonder AB Brookfield Asset Management Inc Brookfield Renewable electricity Partners LP/CA ; Capital Stage AG Equitix Equitix Ltd First State Wind Energy Investments SA Greencoat UK Wind PLC John Laing Environmental Assets Group Ltd Laidlaw Capital Group Macquarie Capital Ltd MEAG MUNICH ERGO KAG mbH Meewind NV Parkwind NV Siemens Financial Services Inc Siemens Project Ventures GmbH
State Agencies, Public Finance Institutions	EU (European Energy Programme for Recovery (EEPR)) Polish Ministry of Economy Polish Ministry of Energy	Green Investment Bank Ltd

ANNEX 5.A2

Glossary of clean energy investment and financing terminology

Asset finance	The new-build financing of renewable electricity generating projects. As defined by Bloomberg New Energy Finance (BNEF) database, asset finance for renewable energy investment includes electricity generation and biofuels production assets that meet the following size criteria: one megawatt (MW) or larger for biomass and waste, geothermal, solar and wind energy generation; 1-50 MW for hydroelectric power projects; any size for marine-energy projects; and one million litres per year or greater for biofuel projects. The financing of carbon capture and storage and energy-smart technologies, along with mergers and acquisitions and refinancing deals are excluded. Projects may be financed via the balance sheets of the project owners, or through financing mechanisms such as syndicated equity from institutional investors, or project debt from banks. *Source:* BNEF.
Brownfield projects	Brownfield or secondary projects are already operational and/or have a predecessor of some form at the same location. These projects may involve the reconstruction, renovation or expansion of existing assets. *Source:* Weber and Alfen, 2010.
Clean energy	According to BNEF definition and classification, "clean energy" includes the following sectors: renewable electricity generation (solar, wind, small and large hydroelectric, geothermal, marine, biomass and waste-to-energy power plants); carbon capture and storage (CCS) technologies; energy-efficient technologies (digital energy and smart grids, power storage, hydrogen and fuel cells, advanced transportation and energy efficiency on both the demand and supply side); low-carbon service providers (consultants, government agencies, policy makers, NGOs, financial service providers, investors and clean energy information providers); *Source:* BNEF.
Greenfield projects	Greenfield or primary projects are assets generally constructed for the first time at a specific site. They may be in the planning, development, financing or construction stage. *Source:* Weber and Alfen, 2010.
Institutional investor	Entities which mainly provide financing for clean energy projects. Includes pension funds, insurance companies, asset managers, private equity firms, yieldcos and other listed vehicles, and investment funds. The distinction between sole investors and managers/operators of the assets in the portfolio is sometimes difficult to make.
Liability Driven Investment (LDI) and Asset Liability Management (ALM)	The task of managing the funds of a financial institution to accomplish two goals: i) to earn an adequate return on funds invested and ii) to maintain a comfortable surplus of assets beyond liabilities. *Source*: OECD 2015j.
Non-utility corporates	All companies involved in the energy sector which are neither financial companies nor utilities. The majority are power plant operators, electricity generators, project developers, construction companies or manufacturers of technical components.
On-balance-sheet financing	Where a renewable electricity project is financed entirely by a utility or developer, using money from their internal resources. *Source*: McCrone et al., 2016.
Project bond	Project bonds are standardised securities that finance individual stand-alone infrastructure projects. They can be issued in public markets, or placed privately. Projects bonds are issued by a project company (distinct legal entity). *Source*: OECD 2015b.
Project finance	Project finance is the financing of long-term infrastructure, industrial, extractive, environmental and other projects / public services (including social, sports and entertainment PPPs) based upon a limited recourse financial structure where project debt and equity used to finance the project are paid back from the cash flow generated by the project (typically, a special purpose entity (SPE) or vehicle (SPV)). *Source*: OECD 2015b.

Renewable electricity	Assets generating energy from renewable sources. Includes: Wind, solar, small hydro, marine, geothermal, biomass & waste, offshore wind transmission. *Source*: BNEF.
State agencies and public finance institutions	Government institutions, such as ministries, and public finance institutions, such as the UK Green Investment Bank or the EIB.
Utility	A company that sells and distributes electricity, gas or water to customers. It may also be the producer/generator of energy.
Yieldco	A publicly-traded company that is formed to hold renewable energy assets such as wind and solar power generation facilities. Most yieldcos are formed through a sponsoring entity, such as a utility, where operational assets may be sold from the sponsor to the yieldco entity. Yieldcos are designed to pay earnings as dividends to shareholders. *Source*: OECD 2015j.



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