CHAPTER 16

Changing Dynamics of Financial Risk Related to Investments in Low Carbon Technologies

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Introduction

The international discourse on climate change has thus far placed greater emphasis on each nation's best effort to mitigate and adapt to the effects of climate change. A synthesis of the Nationally Determined Contributions (NDC) submitted by signatory countries to the Paris Agreement indicates that, for developing countries, financing is still a key issue that impedes the diffusion of climate change responses (Zhang and Pan 2016). In mitigating climate change, the focus has been on increasing low carbon energy sources while reducing the negative contribution of fossil fuels in the atmosphere. Low carbon technologies are commonly referred to as technologies that release a low amount of greenhouse gas (GHG) emissions,

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with renewable energy (RE) technologies being the most common as they derive from natural sources such as the sun (solar), biomass, biogas, rivers (hydro), and wind. In contrast, high carbon technologies derive from fossil fuels/conventional fuels and use resources such as coal, natural gas, and oil. Nuclear technology, with plutonium or uranium as feedstock, is also considered low carbon as it emits close to zero carbon dioxide. However, due to its operational complexity and scale, it is usually analyzed separately from renewable energy (Edenhofer 2014; Grubler et al. 2012).

The first part of this chapter briefly looks at the effect of divesting investment from fossil fuels such as coal to low carbon (Section "Climate Change Investment Landscape") and the risks associated with climate change for coal technology and low carbon technologies (Section "Climate Change and Financial Risks"). Despite a growing interest in low carbon technologies (RE specifically), financing still remains an issue. As such, this part discusses how policies help to alleviate some of the investment risks in renewable energy while also highlighting how increased interest in low carbon policies has led financial institutions to view fossil fuel investment as increasing in risks with investors potentially facing "stranded assets" issues.

The second part of this chapter reviews measures taken by regulatory and institutional bodies to accompany the shift into the low carbon era (Section "Shifting to Low Carbon Technologies") before discussing a variety of measures and instruments employed by financial institutions to cope with these risks and avoid stranded assets issues. These measures and instruments are taken by international financial institutions, including banks, credit agencies, development finance institutions, and private financial institutions. In addition, this part discusses potential measures to reduce risks in the implementation of low carbon technologies.

The changing dynamics of policies is addressed next with a focus on how the development of low carbon technologies impacts the coal industry and how companies can manage these risks (Section "Opportunities for the Financial Sector and the Management of Low Carbon Technologies Risks"). Despite the existence of various mechanisms aiming to address market failures, unfavorable views due to the perceived risks associated with low carbon technologies remain in many countries. In addition, limited evaluating capabilities by financial institutions also act as a barrier. Low carbon policies provide the opportunity to reduce investment risks, but in turn it could increase risks for coal technology in the form of reduced development of coal mines and increasing pressures from investors to divest from fossil fuels. Both these issues have increasingly contributed to "stranded assets" that may lead to disastrous consequences and potential asset misallocation for the financial sector in the future. In addition, the depreciating coal prices and increasing competitiveness of renewable energy are presently making many coal and coal-related industries struggle financially. From the perspectives of financial institutions, diversifying their portfolios by turning their attention to low carbon technologies might prove to alleviate some of the effects of what is projected to be less support for fossil fuels (especially coal).

Climate Change Investment Landscape

As humankind develops, more energy sources are burned resulting in increased greenhouse gas (GHG) concentration in the atmosphere. Scientific studies have shown that the concentration of GHG, especially carbon dioxide, has resulted in heat being trapped in the atmosphere and to an increase in the average global temperature as seen in Fig. 16.1 (NASA's GISS 2018). Increased average global temperatures are known to alter the climate, which presents various types of risk to human beings and to the natural ecosystem.

Although emissions are released locally, climate change transcends geographical boundaries, requiring global efforts to combat its effect. The scientific community and policymakers are aware of this fact, but coming

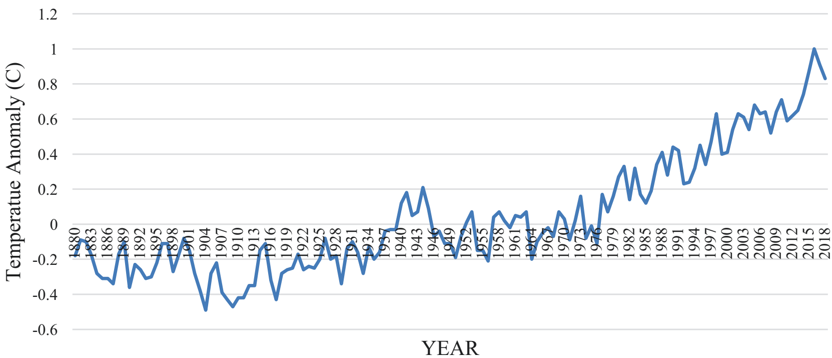

Fig. 16.1 Global land-ocean temperature index (Adapted from NASA's Goddard Institute for Space Studies (GISS) 2018)

to an agreement on the mechanics to reduce GHG emissions has seen decades of disappointments. At the 21st Conference of Parties (COP 21) held in Paris in 2015, a significant step was finally made to limit global average temperature increase below 2 °C with the burden of responsibility shifting from developed countries to all countries (UNFCCC 2016).

To attain this target, the focus is to limit GHG emissions and transition to clean energy. To limit GHG, and in particular carbon dioxide emissions, scientists have calculated the carbon budget which specifies the amount of anthropogenic carbon dioxide that can be released into the atmosphere to keep the global average temperature below 2 °C. The calculations reveal that 65 per cent, or 1900 $GTCO_{2,}$ of the "budget" has been utilized in the period from 1870 to 2011, with 35 per cent, or 1000 $GTCO_{2,}$ still remaining underground (IPCC 2014).

The disconnect between the value of energy firms and their commercialization rests within this concept of "unburnable carbon" (the portion of fossil fuel that must be left underground to stay within the carbon budget) (Carbon Tracker Initiative 2011). According to the United Nations Environment Report (2018), at least three-quarters of existing reserves must remain underground.

The emphasis to move away from carbon-intensive technologies is partially one aspect of mitigation. To complement this measure, the increased use of low carbon technologies to curb emissions while meeting the growing energy demand is needed. Herein lies the problem: despite this fact and various efforts to reduce emissions, CO_2 emissions from burning fossil fuel has dramatically increased as shown in Fig. 16.2 (Carbon Dioxide Information Analysis Center 2012). Coal is currently the main source of CO_2 emissions, accounting for 42 per cent of global CO_2 emissions, followed by oil (33 per cent), and natural gases (19 per cent) (Buckley 2019). With the demand for power is expected to increase, low carbon technologies are important elements to reduce the effect of climate change. Yet, most developing countries argue that a lack of resources to counter social, economic, and environmental issues limits the investment in low carbon technologies. In general, the cost to produce a unit of electricity from low carbon technologies is relatively higher compared to a unit of electricity from conventional fossil fuel power plants such as coal. Although the production cost for certain technologies, such as solar energy, has drastically decreased, overall costs still remain the main barrier for widespread deployment of these technologies (Edenhofer 2014).

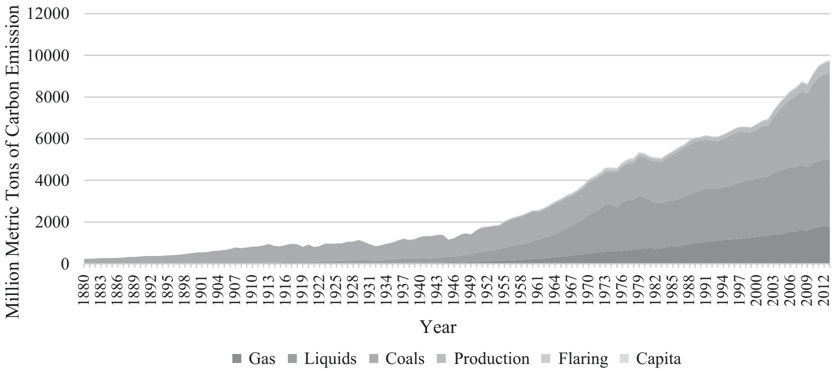

Fig. 16.2 CO_2 emission from fossil fuel consumptions (Adapted from: Carbon Dioxide Information Analysis Center 2012)

Selecting fossil fuels reveal the necessity for cost-effective energy supply and presents a challenge for low carbon technologies. Financing issues are expressed as a major hindrance to promote renewable energy by many developing countries (Zhang and Pan 2016). Globally, US$343 to 385 billion was estimated to have been invested in GHG reduction initiatives per year for 2010/2011. From the figure, however, public financing for developing countries constituted only US$35 to 49 billion from 2011 to 2012, highlighting the importance of private financing (Edenhofer 2014).

From the financial institution's point of view, uncertainties regarding the technologies and a lack of information give rise to multiple risks. Therefore, policy interventions reducing uncertainties and risks can be effective in attracting private financial institutions (Polzin et al. 2019). With more constrained policies to curb CO_2 emissions, especially in the power sector, large capital inflows to fund low carbon technologies and renewable resources are making a significant impact in curtailing CO_2 emissions. In 2017 alone, US$ 279.8 billion was invested in new renewables projects globally (REN21 2018).

With the push for low carbon technologies, conventional technologies such as coal are facing a different kind of challenge. Some developers would still opt to invest in a fossil fuel power plant with relatively lesser carbon emissions (such as natural gas) instead of coal or renewables (REN21 2018). Thus, coal technology is now facing "stranded assets" issues, which have become one of the heated research topics in the energy realm. Stranded assets are assets suffering a sudden change in valuation under certain situations, such as a change in regulations and/or policies or unexpected disasters. When stranded assets occur, they negatively impact investors' portfolios (Silver 2017). Scholars argue that unburnable carbon will contribute to stranded assets and threaten the development of the fossil fuel industry. They may also lead to a financial crisis that could threaten economies that are dependent on it (Silver 2017).

As discussed, the increasing physical and financial impacts of climate changes pose immediate and unexpected threats that are likely to affect the whole economic cycle. Therefore, without an accurate understanding of risks related to climate change, making strategic investments for either technology will become increasingly difficult.

Climate Change and Financial Risks

To understand how the financial sector reacts to the current regulations and policies toward conventional and low carbon technologies, this chapter first addresses the broad implications of risks on these technologies and the financial sector.

Climate Change Risks Associated with Coal Technology

At present, many economic activities are increasingly impacted by extreme weather events due to climate change. For example, Honda incurred a total loss of 150,000 car units when one of its automobile manufacturing plants was severely affected by the Thai floods of 2011. Financially, the floods have caused Honda losses in term of net profits amounting to approximately US$12 million (Haraguchi and Lall 2015). Huge financial losses because of natural disasters brought about unexpected negative consequences for firms and institutions. Therefore, climate risks need to be integrated into the overall risks management of the manufacturing sectors as well as the financial sector.

Financially, investors assess their capital holding and make predictions on their future returns while taking into account the risks taken. Identifying and recognizing potential risks is perhaps one of the key functions of the financial market. Although the concept of climate risks is clear from the scientific perspective, the deliberation on climate risks in financial terms is considered at its infancy. The Task Force on Climate-related Financial Disclosures (TFCD), aiming at helping policymakers and the financial industry to identify all forms of risks, divided climate risks into three categories: physical risk, transition risk, and liability risk. Their brief descriptions are as follows (TCFD 2017):

Physical Risk is defined as risks related to climate change, which impact the valuations of financial assets. This category includes extreme weather that damage properties and could even affect employment opportunities.

Transition Risk is a type of financial risk that occurs during the passage to a low carbon economy. The key element of transition risks is stranded assets, which mainly affect fossil fuel industries. The issues of stranded assets can be viewed in the following context:

- Prospective companies interested in investing in fossil-related business need to consider current fossil fuel reserves and the company's future valuations in view of the transition taking place;
- Even though numerous researches have revealed the loss of value as a result of the transition, capital that has already been invested into fossil-related businesses can still be salvaged as fossil fuel remains the preferred option and the main economic driver of the world.

Liability Risks refer to negative outcomes that arise as a result of mismanagement of climate risks. For example, exposure to liability rests on insurance companies or manufacturers who fail to ensure that the infrastructures could perform or withstand extreme weather.

Despite these risks, coal technology still has its importance in the world and divesting from it would require serious analysis to assess its cost and benefit. Indeed, approximately 1.2 billion people still lack access to electricity in the world (Roberts 2017), and coal could be one solution to reduce this number because of its relatively cheap price and availability. Coal is still the most popular energy source in the world, and it is unsurprising that 30 per cent of the world's primary energy, 40 per cent of global electricity, and 68 per cent of steel is provided by coal (Standard and Poor's 2015). In fact, various top commercial banks continue to invest by lending and underwriting service to companies planning to establish new coal power plants in some developing countries (Banktrack 2018a). Over the last three years, seven banks in China and Japan have provided half of their funding to the coal power plant business (Banktrack 2018a).

However, a shift in investment also seems to be taking place. Although some top banks such as the Royal Bank of Canada, JP Morgan Chase, Toronto-Dominion Bank, and HSBC have increased their funds in the fossil fuel industries, other banks that finance fossil fuels, including tar sands oil, ultra-deepwater oil, LNG, coal mining, and coal-fired power, chose to decrease their funding for fossil fuels in order to achieve one of the goals of the Paris Agreement—"*making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development*" (Article 2,1.(c) in UNFCCC 2015, p. 3). This goal includes China Construction Bank, ranked first in the list of funders for extreme fossil fuels (2015 to 2017) with funding reduced from US$10.3 billion in 2015 to US$6.9 billion in 2017 (Banktrack 2018a). Other notable banks to complete the ranks include the Industrial and Commercial Bank of China, the Bank of China, the Agricultural Bank of China, the Citi Group, and the Bank of America (Banktrack 2018a).

As such, banks can be forced to base their investing decisions on tightened carbon regulations and could advance their financial decisions for non-fossil fuel-based energy. Allocating capital could present a challenge with the apparent enthusiasm in fossil fuel from the industry.

Financial Risks Associated with Low Carbon Technologies

Although low carbon technologies are perceived as the energy source of the future, many risks still plague their development. Risks associated with low carbon technologies are largely due to uncertainties especially the "randomness, volatility and intermittency" of the technology and its resource (Liu and Zeng 2017). Uncertainties can also be extended to their acceptance in society, business model, and market behaviour. They not only affect the overall implementation of a project, but also result in a longer return on investments, uncertain future profits, and possible losses due to unforeseen changes in policy. To convince financial institutions, companies need to demonstrate a strong capability to execute the project, possess a viable business model, and create a realistic project design (Liu and Zeng 2017). With renewable energy as an example, these uncertainties are briefly described below:

Maturity of technology and industry. The infrastructure for fossil fuel technologies is better developed compared to low carbon technologies. Since revenue depends on the reliability of the chosen technology, the maturity of the technology and the industry for low carbon technologies are regarded as ones of the main risks in the project development (Liu and Zeng 2017). Technology risks include the possibility of being outdated and whether it could adapt to local conditions (Liu and Zeng 2017). Apart from operational reliability, the maturity and availability of various support services (maintenance, spare parts, etc.) would not only ensure smooth operation, but also provide prompt action in case of unplanned stoppages (Gatzert and Kosub 2016). With unique technology requiring special parts and components, the ability to access these items should also be included as a risk (Gatzert and Kosub 2016; Liu and Zeng 2017). The upstream component of the industry also presents various uncertainties for technology that requires procuring or harvesting feedstock from a third party, such as from biomass-based power plants. A special agreement should be in place to avoid feedstock shortages (MEGTW 2009).

Power Purchase Agreement (PPA). The off-taker for the electricity generated from conventional power plants or RE plants is typically the grid operator. The grid operator refers to the entities responsible in distributing electricity and commonly maintaining the grid infrastructure such as transmission and distribution lines. The grid operator also purchases the electricity generated before distributing it to consumers at a tariff (price) according to consumption. For renewable energy, a willing buyer-willing seller concept could most likely favor grid operators if negotiations on power purchase agreement (PPA) are left ungoverned or without any oversight, especially in a relatively new investing environment (MEGTW 2009). Delay tactics could also be employed to pressure investors into agreeing on the terms of the PPA. With a lack of proper governance structure, investors are left with no choice but to absorb the increased cost or withdraw from the agreement (MEGTW 2009). In a fairly new industry, poor information dissemination and a lack of experience result in the unwillingness of financial institutions to provide financing due to the many uncertainties associated with new technology like renewable energy. Financial risk issues might include grid operators intentionally offering a price that does not commensurate with the cost of production, demanding stringent non-negotiable technical requirement and including unrealistic performance clauses (MEGTW 2009). Financing issues could also be related to the poor terms spelled out in the PPA and the viability of the renewable energy industry as a whole (Sovacool and Drupady 2011).

Project Design. Karneyeva and Wüstenhagen (2017) highlight the issue of scale, which depends on the investor's business model and technical design. Larger-scale installations typically adopt a high capital model, with higher installed capacity and reliance on electricity sales as revenue. This model is typically adopted by fossil power plants. Smaller-scale projects usually refer to installations with relatively lower capital and installed capacity, such as rooftop solar panels that also rely on electricity sales as revenue. Another business model for smaller-scale installations involves off-setting the electricity produced with the electricity purchased from electricity utility companies to save electricity bill. Either business model could be adopted depending on the existing policy, the costs, and the complexity of exchanges with the grid operator (Karneyeva and Wüstenhagen 2017). However, some projects require an economy of scale to be viable. Capacity caps imposed by an authority or geographical limitation threaten investors to commit to a suboptimum scaled project, making it not worthwhile to be developed and presenting a greater risk if pursued (Karneyeva and Wüstenhagen 2017; Gatzert and Kosub 2016). A grid operator's reaction to oversupply and mandated caps by authorities should also be considered well ahead to account for its impact.

Project Logistics. Some installations are situated in remote areas with a difficult access to the site. This situation increases risks during the construction phase and poses problems for suppliers or service providers to access the project site, hence causing delays and ultimately increasing the cost for repairs and maintenance (Gatzert and Kosub 2016). Some sites with vast potential could also contain natural or technical features that are incompatible with the technology proposed. These site-specific projects may be located away from the grid interconnection point which makes transmitting power to these points difficult (Sovacool and Drupady 2011). Some technologies, such as solar rooftops, do well in this area, though they present new problems for grid operators to plan their operation. Solar panels can be installed modularly, thus making the presence of cumulative renewable energy installations in the grid relatively quicker (similar with wind technology) compared to a single conventional power plant, which can take years and more careful planning to build (Gatzert and Kosub 2016). Concentrated installations around areas with low demand would require operators to limit access to renewable energy installations to avoid oversupply (Gatzert and Kosub 2016). This effect is uncertain, and risks can only be seen over time as the industry develops.

Operational Uncertainties. Revenue could also vary as some renewable energy technology depends on nature as its feedstock (e.g., solar, wind, hydro), which is somewhat difficult to accurately predict. In view of these variations, adopting measures to ensure a stable revenue should be considered even in the planning stages (Gatzert and Kosub 2016). Operational uncertainties include frequent natural events such as extreme weather and harsh conditions, which pose access issues to staff and service providers (Gatzert and Kosub 2016). During construction, some of the concerns involve delay risks like getting the necessary permits (Gatzert and Kosub 2016; Liu and Zeng 2017) and damage risks to goods during the installation or construction (Gatzert and Kosub 2016). By far, the most important stage of the development are the testing and commissioning stage. In this stage, investors and grid operators verify that the electricity production and connection to the grid adhere to agreed specifications. Unplanned delays and unforeseen technical issues due to poor planning between both parties would present a risk of delay (Gatzert and Kosub 2016). Typically, investors are already expected to service their debt in this phase, and delays would only increase financial burden. On top of the aforementioned issues, new technologies could result in unexpected component failures and produce unreliable performance (Gatzert and Kosub 2016; Liu and Zeng 2017). Although issues such as component wear and tear could be managed, operational uncertainties as described still loom.

Policy Uncertainties. There is little doubt that the drivers for renewable energy growth have been through policy intervention to provide incentives and relevant regulatory measure (Edenhofer 2014). Financially, revenue stability hinges on policy decisions, and investors may find that profitability can be negatively affected when policy risks are taken into account (Karneyeva and Wüstenhagen 2017). Therefore, investors need to be aware of political stability, which could result in support being scaled down, changed, or removed altogether due to cost issues, pressure from the public, or even political instability (war, etc.) (Gatzert and Kosub 2016; Liu and Zeng 2017). Policy risks also encompass caps on installation capacity or access to the grid, administrative delays, and the determination of the length of the PPA (Karneyeva and Wüstenhagen 2017). With developing countries implementing various policies to spur the development of renewable energy, investors need to be aware that new policies take time, as some cannot be easily adapted to local conditions. Governance structure and other local conditions can also impact policy decisions and need to be carefully assessed as part of the overall risk components (Gatzert and Kosub 2016; Liu and Zeng 2017). As such, controversy, perception of the public, or unknown reasons could alter decisions and favor certain technologies (Sovacool and Drupady 2011). In some instances where permit or license authority deals with policy formulation, approval issues due to political reasons could arise (Liu and Zeng 2017).

Shifting to Low Carbon Technologies

Shifting to low carbon usually involves a shift in a low carbon power supply by introducing a mix of regulatory measures and incentives. Some of the main policy instruments include (REN21 2018):

- *Feed-in tariff*. A system where renewable energy companies generate revenue through the premium price for each unit of electricity generated. The price is usually higher (premium) than the price to supply a unit of electricity from fossil sources.
- *Tenders*. A similar process to procure bids for conventional (fossil) power plants. It is typically reserved for large scale projects where a tender is opened for bids by interested companies and projects are awarded to the successful bidder. Bids that fulfill the project's technical requirement and can do so at a lower cost compared to other bidders are usually selected.
- *Net metering*. The electricity consumed from the grid is being offset with self-generated electricity produced from renewable energy sources.
- *Renewable Portfolio Standards*. A mandate by authorities for the grid operator to distribute a certain share of electricity from renewables.

In 2017, 179 countries had set a renewable target with most focusing on the power sector with 113 countries favouring feed-in tariff as the mechanism to realize this target (REN21 2018). Low carbon policies, such as the feed-in tariff, can be expected to solve the economic issues related to the technology. In addition, policies could also address institutional issues that hinders the promotion of renewable energy. The introduction of multiple instruments, especially laws, generally produces the intended results mainly due to its "instrumentality" and "coercive effect." It also significantly reduces the cost of exchange for all parties by providing information and obligations that are clearly specified and enforceable by law (North 1990).

With regulatory measures and various instruments working together, compliance can be directed at various players in the energy market and is achieved through provisions on enforcement and penalties that when executed, negate problematic behavior (North 1990; Scott 2008).

Apart from providing economic incentives, government institutions also play a vital role in formulating and executing instruments that facilitate low carbon development through regulations, rules, and guidelines. The benefit of having an instrument coercive by nature is that it reduces policy risks by providing financial institutions with the element of certainty. With the Malaysian feed-in tariff, for example, negotiation time is reduced with the introduction of a Standardized Renewable Energy Power Purchase Agreement (REPPA), which standardizes key negotiation terms such as price, duration, and access to the grid (MEGTW 2009). Other instruments that facilitate the growth of renewable energy include:

The certainty of the source to finance incentives. Typically, the feed-in tariff system needs to be simultaneously established with a funding mechanism because the system subsidizes the cost of distributing the relatively more expensive renewable energy which the grid operator would otherwise not incur by distributing fossil fuel-based electricity. Funds to subsidize this cost are sourced from a levy on consumer's electricity bill or any other source deemed suitable by the government (MEGTW 2009).

Information and guidelines. Connecting various independent installations to the main electricity grid could pose problems. Therefore, safeguarding the grid's assets is a legitimate concern raised by grid operators. Though valid, it can sometimes be taken to extremes by placing stringent requirements to protect the grid and thus incurring unnecessary costs to companies (MEGTW 2009). The availability of these types of information beforehand would enable every player in the industry, especially investors, to perform a different type of risk assessment since information on payments, approval time, technical and license requirement would be clearly spelled out.

In certain situations, any attempt on the part of the companies to contest or independently assess the situation can be futile as the information pertaining to the grid is within the grid operator's rights and control. Having this information also means that the grid operator has the upper hand during negotiations (MEGTW 2009). Thus, transparent technical requirements and an opportunity for the companies to perform their own connection check can greatly reduce asymmetrical information by both parties (North 1990).

Due Diligence. Irregular supply poses concerns to financial institutions and the grid operator. It is difficult, especially for financial institutions, to ascertain whether these irregularities could affect the performance of the plant. These difficulties are down to their own logical determination of the project's credibility (Karneyeva and Wüstenhagen 2017) compounded by a lack of any credible certification (MEGTW 2009). With a system like the feed-in tariff, fulfilling some minimal requirement is required and can serve as due diligence to financial institutions.

With various policies and instruments promoting low carbon technologies as described above, the global coal mining industry could face pressures from analysts and researchers to restructure its business model. China and EU countries, for example, plan to become coal-free. South Korea, the fourth largest coal importer in the world, claims to have reduced its coal power in 2017, which illustrates that the coal mining industry could go into a much more critical situation (Banktrack 2018a). This trend has led investors to reallocate their capitals to renewable resources.

In some developing countries such as India and China, solar and wind technologies are economically competitive to the extent that governments had to cancel plans to develop a new coal power project and shift to renewable energy sources. China leads the world in renewable energy capacity with 334 Gigawatts installed in 2017. For comparison, the total installed capacity for the entire world, BRICS countries (Brazil, Russia, India, China, and South Africa) and the 28 European Union countries (EU-28) was 1,081, 429, and 320 Gigawatts respectively (REN21 2018).

Another factor affecting the global coal industry is the widespread divestment campaigns in Europe and Australia. People are calling for a "non-coal world," which contributes to the surge of restructuring and bankruptcies of coal miners. With the tightening of coal regulations in recent years, banks are forced to reconsider and change their strategies for the coal mining sector. As millions of dollars are collected through general corporate finance, reducing corporate finance for coal mining companies is emerging as one of the key agendas for the banking sector.

The impacts of these changes to coal mining and the coal power industry have already been felt. Since the Paris Agreement in 2015, the UNEP has called for the closure of the new coal power plants and a fastened retirement of current plants to achieve the goals of the agreement. A U.K. and Canada-leading organization, the Powering Past Coal Alliance, also established a union encompassing more than 50 countries, regions, and businesses that have declared their restrictions on financing for coal power.

Concerned about financial risks, several institutional investors are divesting from fossil fuel companies. Large sums have been invested in renewable resources instead of fossil fuel industries. This energy transformation has significant implications for the fossil fuel industry. During

COP21 in Paris, research revealed that more than US$3.4 trillion has been diverted away from fossil fuels (Schueneman 2015). As such, the coal industry is expected to experience the greatest reduction in financial returns. According to the report from the Institute for Energy Economics and Financial Analysis (IEEFA), over 100 financial institutions in the world have already restricted and/or divested from coal in response to the carbon reduction targets as envisaged under the Paris Agreement (Buckley 2019).

Opportunities for the Financial Sector and the Management of Low Carbon Technologies Risks

Climate change has been addressed from the scientific and political fronts and has seen many developments. Yet, the financial sector is still considerably behind in recognizing the link between climate change and its impacts on the wider economy, or the potential risks associated with financial returns on investment. Until recently, the financial world was still outside of the discussions and decisions made by UNFCCC (Miller and Swann 2016).

The next section describes how financial institutions, especially in the banking and insurance sectors, view fossil fuel–related policy goals, guidance, and instruments to overcome the increased investment risk or stranded assets for investors. It also addresses ways to manage financial risks for low carbon projects.

Insurance Companies

Due to the unpredictability of extreme weather events, the rapid increase in global economic losses results in insurers viewing climate change as a threat rather than an opportunity. In a major disaster, evidence reveals that countries with lower levels of insurance coverage record more fiscal losses (Golnaraghi 2018). The rapid increase in global economic losses from extreme weather events has become the impetus for government investments to reduce existing risks and prevent new ones. Impacts of climate change on the insurance sector can be deep and broad, affecting insurers' profits and investments. The impacts can extend to other insurance products such as life insurance and health insurance.

To date, property insurers do not have a full understanding of how extreme weather events will drive higher claims, and what kind of unexpected risks should be deemed uninsurable. At present, in response to concerns over climate change and fossil fuel investments, insurance companies are trying to integrate climate change scenarios into their models, but this effort is still in its early stage.

As one of the largest institutional investors in the world, insurance companies manage more than US$31 trillion (Simons and De Wilde 2017) and take essential roles as underwriters in coal projects. Without the necessary coverage of these projects' risks, major coal mines or plants would not be funded, built, or operated. By continuously underwriting and investing in the coal industry, the business models of the insurance companies are indirectly contributing to climate change, and their roles are expected to be highlighted when the Paris Agreement is operationalized.

A recent Standard and Poor's Rating Services report (2015) summarizes climate change as a greater threat to insurers than has been previously recognized. The rating agency believes that insurers' earnings would be affected by weather-related losses and lower investment returns. Therefore, as part of their efforts to work on the Paris Agreement, insurance companies have begun to invest in renewable energy. According to research conducted by CERES, if 55 insurers in the U.S. hypothetically shifted US$590 billion holdings in fossil fuel to renewable energy, investments in renewable resources would triple (Mchale and Spivey 2016). Allianz, the largest insurance company in the world, became one of the first insurers to divest from the coal industry (accounting for 30 per cent of its revenue) in 2015 (CERES 2016). Also, in 2017, AXA became the first major insurer to discontinue underwriting for coal companies (CERES 2016). It is becoming a trend for top insurance companies to divest from the fossil fuel industry with most of them having done so in the late 2017 or 2018 (Buckley 2019). As data shows, shifting to renewable resources is one method to reduce financial risk for insurance companies.

Simultaneously, insurance companies have conducted research to develop insurance products and instruments for the low carbon market to complement the method mentioned above. For example, to satisfy investors' demand for risk-mitigating tools, Austrian Garant Insurance, French Global Sustainable Development Project (GSDP), and Swiss Re Greenhouse Gas Risk Solution launched the Carbon Delivery Guarantee (CDG) insurance, an insurance for which the insurer acts as the guarantor for future carbon credit delivery to sell the unused carbon credits to the businesses that need more carbon credits. The insurance covers all carbon delivery guarantee, political risk insurance, and business interruption (Carney 2015).

Banking Sector

In adjusting to climate change, banks play a very important role in the financial sector through financing and investing. By closing the finance supply and demand gap, banks do not only ensure financing for the whole economic activity, but also play a role in managing risks. The banking sector involves a wide range of financing and investment activities through capital allocations, such as mortgage lending, business lending, project finance, assets management, and investment banking. These activities span to all aspects of the society, including climate change, thereby becoming an indispensable part in adjusting to the effects of climate change.

Policies to reduce GHG emissions and the uncertainty of future weather patterns may transfer new liabilities and produce new business risks to the economy. In view of climate change issues, credit risks are the main risks presently for banks. Under the European Union Emissions Trading Scheme (EU ETS) and Kyoto Protocol, the policy regarding risks was to transfer liabilities risks or other new business risks to banks (Allianz Group and WWF 2005). These risks are likely to influence the credit quality of borrowers and therefore increase risks for banks. The ETS is one of the examples that have increased the cost of compliance on the industry sectors covered by the EU ETS.

In view of the current development in the international climate policy arena, the EU ETS and Kyoto Protocol could be modelled for future global climate policies, which has deep implications for banks. The following chart (Miller and Swann 2016) summarizes the current risks and opportunities for banks (Table 16.1).

Despite the number of new coal plants across the world being halved between 2015 to 2016, data from the Global Coal Plant Tracker shows that there are still over 1600 coal plants under construction, predominantly in developing countries (Banktrack 2018b). If these plants materialize, the power capacity would expand by more than 40 per cent (Banktrack 2018b). These plants will pose a serious threat in achieving the goals set under the Paris Agreement and various international conferences. As seen from Fig. 16.3 (Banktrack 2018b), banks in Asian countries, especially in China, are the big sponsors of coal plant developers.

Table 16.1 Potential risks and new opportunities for banks (Adapted from: Miller and Swann 2016)

Banking types	*Risks*	*Opportunities*
Corporate banking	• Increasing costs for consumers • Losing competitiveness in carbon-intensive industries • Price uncertainty toward carbon prices • Reputational risks	• Enhancing the services toward risk management, carbon trust, and carbon projects
Investment banking	• Immature technologies • Increasing insurance costs for unexpected weather	• Chances to establish the carbon funds • Offering high-leverage products such as financial derivatives
Retail banking	• Financial losses • Uncertain policies risks	• Microfinance for climate-friendly activities • Advisory services

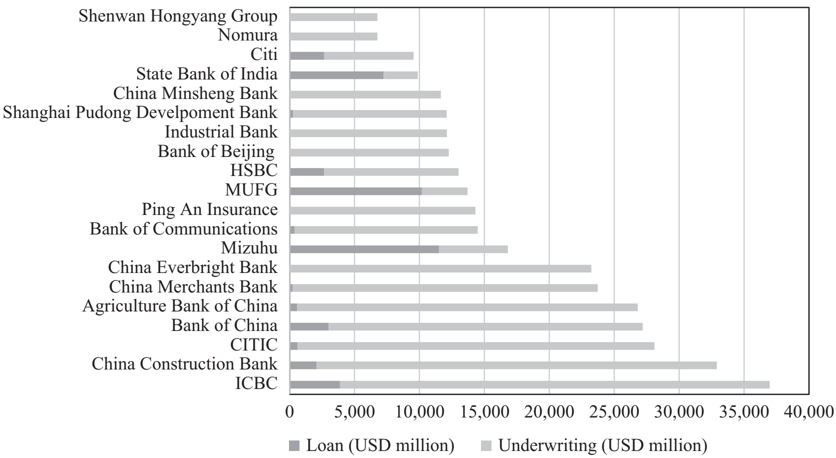

Fig. 16.3 Top 20 banks for coal plant developing banks (Data Period: 2014–2017) (Reprinted from: Banktrack 2018b)

Management of Risks by Renewable Energy Companies

A company's financial strength and competency to execute a project are assessed by its current financial situation, its access to funds, and its track record (Liu and Zeng 2017). However, uncertainties generate serious questions outside of the company's financial capability, especially issues on policy risks, the viability of the low carbon industry, and the multitude of factors that could influence revenue. Companies could address these uncertainties by taking proactive measures, though policy intervention would eventually be required to significantly address these risks in the final analysis. Nevertheless, there are some measures that the investors and the company could adopt to mitigate these risks. They are briefly explained below:

Identification of Risks. Liu and Zeng (2017) list "policy, technology, economic, security and market" as some of the risk sources, but their study focuses on policy, technology, and market risks as they are considered significant in a renewable energy project. An honest attempt to identify all the risks and their consequences in the planning stages is therefore crucial in ensuring a successful renewable project (Gatzert and Kosub 2016). The main purpose is essentially to allow investors to identify risks involved during the planning stages and facilitate informed decision making at all stages of the project lifetime (Liu and Zeng 2017).

Risk Assessment. In assessing the risks involved in an offshore wind project, Gatzert and Kosub (2016) list "strategic/business, transport, operation and maintenance, liability/legal, market and sales, counterparty, political and regulatory" as their risks assessment typology. Liu and Zeng (2017) highlight that risks should not be assessed independently as they are interlinked and contain unique feedback that influences the impact of these risks. Risks also change over time and may not be relevant until it reaches a certain stage of the project development. The authors propose an assessment method which involves identifying risks, their consequences, and attaching a score to quantify the impact of those risks. The quantification can be modelled and simulated to determine how the system will behave, the significant effect of the risks involved, and the financial returns across various scenarios. The authors also highlight that most evaluation methods are qualitative in nature, which implies that risks are determined without some relevant form of measurement to indicate the severity of the impact (Liu and Zeng 2017).

Risk Management. Gatzert and Kosub (2016) categorize risk management instruments into three categories: risk transfer, mitigation, and avoidance. Insurance is the main instrument to transfer risks while diversification can be useful to transfer risks. Diversification involves relying on various technologies to normalize revenue over time, subscribing to various insurances covering different risks, applying various government support schemes, and having multiple service providers. Mitigation of risks involve:

a. Forecasting resources availability, political stability, curtailment, natural hazards, etc.;
b. Monitoring of various technical components of the project;
c. Incorporating a minimum or fixed revenue clause, longer-term contracts, maintenance needs in contracts, etc.

Risk mitigation methods can be reflected through guarantees and warranties specified in contracts between investors and service providers. In terms of avoidance, investing in proven technology or existing facility could alleviate some of the risks discussed above (Gatzert and Kosub 2016).

Conclusion

The definitions of climate risks are more complex than expected, and yet extremely important for investors and business managers. There is a need for further understanding of what climate risks mean in investments (Miller and Swann 2016). In December 2016, the TFCD elaborated on the climate change risks in its report (TCFD 2017):

> *There is a growing demand for decision-useful, climate-related information by a range of participants in the financial markets. Creditors and investors are increasingly demanding access to risk information that is consistent, comparable, reliable, and clear. There has also been increased focus, especially since the financial crisis of 2007–2008, on the negative impact that weak corporate governance can have on shareholder value, resulting in increased demand for transparency from organizations on their risks and risk management practices, including those related to climate change.*

The need to take climate risks into account in the decision-making process is vital in ensuring informed decisions based on recent and relevant issues. This, along with the focus to strengthen governance and transparency in climate risks, may facilitate in avoiding the negative impacts of the shareholder's value.

The TFCD also states in the report that institutions should disclose climate-related risks and potential opportunities in their public report, especially in the financial sector and more specifically for banks, insurance companies, and private institutions (TCFD 2017). In addition, the organization notes that revealing information associated with climate change could improve the investors' ability to identify and price climate risks and future opportunities properly (TCFD 2017).

For low carbon technologies, the absence of clear information has created a lot of uncertainties. Policies are important to establish and maintain a growing industry but as illustrated, implementation can be far more effective with specific instruments. These instruments are interlinked to provide clear specific information, a structure for players to perform exchanges, create level-playing field, and provide a governance structure to achieve the intended outcome. For low carbon technologies, as the industry grows, feedback from understanding the mechanics and structure of the RE industry can help financial institutions to better perform risk assessments. With these instruments in place providing knowledge and certainty, financial institutions are expected to further grow and provide financing products/packages that are attractive and conducive for the benefit of the low carbon technologies.

The feed-in tariff (FIT) system and other various instruments have the potential to increase the number of renewable energy projects. The FIT essentially allows independent renewable power producers to sell the electricity produced to the grid at a specified rate (tariff). However, the FIT system was mostly developed with the assumption that the cost of production for renewable energy would be on par with that of fossil fuel. Consequently, the government could decide to withdraw or adjust the feed-in tariff system to match the current market situation. Although the cost of production for both types of resource could match or reach "grid parity" (Karneyeva and Wüstenhagen 2017), institutional issues could still raise concerns and uncertainties. Policies address institutional issues by shaping the behaviour and driving the exchanges of all parties involved, including the financial sector. As such, the need for policy support to reduce risks should remain in place until renewable energy competes with fossil fuel and reaches widespread diffusion (Karneyeva and Wüstenhagen 2017).

The interests of stakeholders in society have influenced investments in both the industries promoting low carbon technologies and the coal and coal-related industries. In particular, the investments in low carbon technologies highlight shifting trends of the interests among various stakeholders toward a low carbon society. They illustrate how the financial decisions among financial institutions are being shaped differently over time under different sets of opportunities, norms, and regulative pressures in society (Scott 2008; North 1990). Despite coal technology's proven track record, investment in low carbon technologies addresses opportunities to generate income while fulfilling environmental and social obligations for developing countries. However, it could come at the expense of coal technology.

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