Project Finance in Renewable Energy: Sensitivity Analysis and Valuation

by

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Submitted to the Department of Electrical Engineering, Electronics, Computers and Systems
In partial fulfillment of the requirements for the degree of Erasmus Mundus
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Abstract

Project finance in renewable energy remains complex regarding the risk allocation between parties and sophisticated financial modeling of the renewable energy power plants. This paper aims to address and evaluate these risks quantitatively by building a financial model of renewable energy projects and performing sensitivity analysis on key risk and success factors and demonstrate how investors value and decide to invest in renewable energy projects and/or companies. We mainly find that the effects of macroeconomics such as (interest rates and inflation) and lender's (such as loan margins and the debt-service-coverage-ratio "DSCR") factors on project's prospect are relatively smaller when compared to those of project's characteristics from revenue (such as plant's capacity, energy generation, PPA price, and plant's lifetime) and cost (such as CAPEX and O&M costs) factors. The outcome of this thesis will be useful for project developers and investors. Particularly, on the one hand, this thesis can help the developers identify and manage key risk factors of the project. On the other hand, it can help assist the investors to make a proper investment decision.

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Chapter 1

1 Introduction

1.1 Motivation

In the Paris Agreement in December 2015, the governments worldwide committed to the reduction of CO_2 emissions to address global warming issues. The power sector accounts for 32% of global CO_2 emissions [1]. As a result, one of the driving forces for the transition towards a greener economy to reduce global warming is the development of renewable energy. Resulting from a considerable number of policy measures to support renewable energy adoption, the International Energy Agency (IEA) has observed an unexpectedly rapid growth in the renewable energy industry and projected a global increase in renewable energy investments from $240 billion a year in 2018 to $635 billion a year in 2040 with a 20-year cumulative total of $11.7 trillion to meet the Paris targets [2].

To meet the global expectation of CO_2 emissions reduction, trillions of dollars will be required for the investments in renewable energy through the capital markets as most of the financing of energy infrastructure is usually done by private sectors and not by the governments [3]. In fact, over 90% of capital raised for the new energy infrastructure investments has come from private finances [4], particularly converting from traditional energy such as the oil and gas industry towards renewable energy in recent years [5]. One of the most common methods of financing energy and infrastructure projects has been through project finance due mainly to the separation of high project risks away from the company's balance sheet. The use of project finance in renewable energy has grown from 16% of all projects in 2004 to 52% in 2015 [6].

1.2 Objectives

Although project lenders have become more comfortable in giving the green light (loans) to renewable energy projects from the experience built over the years to deal with the relationship between the unpredictability of renewable energy (wind and solar) resources and project cash flows, project finance in renewable energy remains complex with regard to the risk allocation between parties and sophisticated financial modeling of the renewable energy power plants. This paper aims to address and evaluate these risks quantitatively by building a financial model of renewable energy projects and performing sensitivity analysis on key risk and success factors. and demonstrate how institutional investors, who contribute significant capital to the project (e.g. 59% of investments in renewable energy power plants in 2012 was made by institutional investors [6]), value and decide to invest in renewable energy projects. The outcomes of this paper will be particularly useful for project companies that seek to get their renewable energy power plants off the ground and successfully built as it provides an insight to managing the project risks both qualitatively and quantitatively and guidelines to make the project attractive to investors. Nonetheless, all parties – policymakers, investors, or financial intermediaries - are required to have a clear understanding of the risk environment around financing renewable energy projects.

1.3 Thesis Structure

Chapter 1: Introduction

This chapter introduces the motivation and objectives for the work carried out.

Chapter 2: Background of Project Finance

In this chapter, the concept of project finance and its characteristics are defined. Its structure and risk allocation will also be discussed to demonstrate why project finance is commonly used for renewable energy projects when compared to other financing methods.

Chapter 3: Financial Modeling

This chapter provides an insight into how a renewable energy (wind or solar) project is financially modeled in terms of revenues and costs and how the amount of debt and equity needed to build the project is calculated under certain assumptions.

Chapter 4: Project Valuation

This chapter demonstrates how the project is appraised by investors. Returns and other market data used for some listed companies in Europe are used as proxies for the cost of capital to value renewable energy projects. Then, key decision-making tools to invest in renewable energy projects are identified.

Chapter 5: Title of Chapter 5

This chapter presents the sensitivity analysis is performed on key factors used in Chapters 3 and 4 to observe the potential risks against which the project company might hedge. The results of the sensitivity analysis are discussed and summarized.

Chapter 6: Conclusion

Finally, the conclusion and potential future work of the thesis work are drawn.

Chapter 2

2 Background of Project Finance

2.1 What is Project Finance?

Before a renewable energy power plant is built, the first decision the company has to make is how to finance the project. Two common methods used to finance the project are through the company's balance sheet (using corporate finance) or through a new separate balance sheet created specifically for this project (using project finance). Two generally accepted characteristics of project finance that are different from traditional corporate finance – mentioned in [3][8][9][10] for instance – are first, the project company utilizes a specially created self-contained entity, called special purpose vehicle (SPV), existing only for serving the project and, second, the project lender(s) rely on a non-recourse basis in which the lenders are prohibited from making claims against the project sponsor(s) business where the assets backing the loans are within this specific project and the lenders cannot go after the sponsor's other businesses.

The first feature allows the sponsor to have immunity since the contingent liability from the high-risk project (or portfolio of alike projects) is removed from the sponsor's balance sheet that otherwise might jeopardize the financial health of the sponsor as a whole company. At the expense of this immunity to the project sponsor, the cost of capital in project finance is usually higher than that of corporate finance as the lenders will need guarantees to access idiosyncratic risks associated with the project. This risk assessment in project finance is in nature very complex and time-consuming, leading to relatively higher monitoring costs. The second feature emphasizes the fact that the project sponsor can walk away in case the project fails as the liability is limited only to the equity it has contributed. The lenders, however, are exposed to more risks as the only assets the lenders can depend on are the capital invested in the project and the project's future cash flows.

The distinct characteristics of project finance from corporate finance mentioned above also resonate in the Basel II framework [11]: project finance is "a method of funding in which the lender looks primarily to the revenues generated by a single project, both as the source of repayment and as security for the exposure. In such transactions, the lender is usually paid solely or almost exclusively out of the money generated by the contracts for the facility's output, such as the electricity sold by a power plant. The borrower is usually an SPE that is not permitted to perform any function other than developing, owning, and operating the installation. The consequence is that repayment depends primarily on the project's cash flow and on the collateral value of the project's assets."

Traditionally, corporate finance is a classical way to raise capital for either private or public enterprises, which has made up around 90% of 2004 total capital investments in developed countries [12]. Project finance, on the other hand, has been used for large, highly risky projects where project sponsors need to protect their core firm from a potential project failure, globally accounting for $277 billion in 2015 with the lion's shares in power generation, oil & gas, and transport infrastructure [13]. Recently, however, a rapid increase in less complex, small, low-risk projects funded by project financing in developed countries can be observed with more than 45% of all already such as wind and solar technologies [8].

2.2 Why Use Project Finance?

Project finance has long been used in renewable energy sectors since the 1980s [14]. The motivation of project financing towards renewable energy projects in the early days is firstly developed and introduced by Mills & Taylor [15]. They laid out five driving forces of project financing renewable energy projects: 1) the ability to raise debts "off-balance-sheet" to maintain low debt-to-equity (DE ratio) in the corporate balance sheet; 2) potentially lower cost of debt offered by the lenders; 3) a useful joint venture structure between sponsors with different financial strengths; 4) the capability of allocating and transferring risks between contractual parties associated with the project; 5) the only tool accessible by less financially-sound sponsors.

Later in 1998, the preference for project financing energy technologies is further discussed by Pollio [16]. His key findings based on reviewing existing literature and interviews with project sponsors, lenders (banks), and the government, indicate that "project finance has nothing to do with capital constraints," but rather the "walkaway" option of the non-recourse basis of developers to the lenders is the underlying reason behind project financing energy-related projects. More specifically in renewable energy projects such as onshore wind technology, Enzensberger in 2003 found that a common structure in wind projects in Germany is through project finance which pools together capital from individual households, stressing that capital constraints do matter [17]. This evidence is later emphasized by Kann in 2009 [18] and by Henderson in 2016 [19] that project finance allows small developers to get involved with large wind projects, rejecting Pollio's claim that capital constraints do not have roles in project finance, whereas larger-sized sponsors prefer corporate debt as a cheaper alternative. Alonso in 2015 [20], however, stated that large-scale projects and associated high political risks, perceived as classical drivers for project finance, play no role in the use of project finance but rather the developer's characteristics do.

Recently, Steffen in 2018 extended the discussions as to why project finance is preferred and conducted quantitative analysis on the motivation behind project finance [8]. He outlined eight key potential reasons that have been the backbone of extensive use of project finance in the renewable energy sector under these three pillars: 1) negative financial synergies with existing business under conventional corporate finance; 2) reduction of issues related to market imperfections; and 3) the organizational change of firm's structure brought about by project finance.

The first pillar states that issues of contamination risk, debt overhang, and securitization can arise when utilizing conventional corporate finance that guarantees the project by using assets and cash flows of the existing business. Contamination risk occurs when the project performs poorly and negatively affects the company's balance sheet, increasing the bankruptcy risk of the company especially when the project is relatively risky and takes up a large proportion of the balance sheet. Separating the project from the core business under project finance helps reduce the contamination and bankruptcy risks of the core business. Therefore, the firm can protect its key assets such as intellectual property, key personnel, and investments in other businesses in case the project is foreclosed or in default. This reason is well-aware and well-documented in past literature [21][22]. Debt overhang happens when firms with limitations of high debt ratios or groups of individuals without a balance sheet or ample creditworthiness have to forgo profitable projects. Under project finance, however, highly levered projects are possible with a special purpose vehicle that decouples that project from the sponsor's balance sheet. Hence, the internal rate of return of the sponsors can dramatically increase. Moreover, higher leverage also leads to high tax shields. Securitization refers to a situation when firms protect their core business through project financing the high-risk projects. The opposite can also be true when distressed firms (or utilities) with high default risks want to pursue low-risk projects through project financing as it can bring about lower financing costs resulting from low-risk projects.

The second pillar covers the problems of asymmetric information and agency costs, addressing three pairs of counterparties: sponsors and lenders, owners and contractual parties, and owners and managers. Information asymmetry in the first pair can be reduced via project financing as it requires the sponsors and project company to disclose detailed information and actual performance of the project whether being financial, technical, or regulatory reports to the lenders for the purpose of debt underwriting. This statement reconciles with past literature [23] that project finance can be advantageous when the costs of revealing the entire firm's information that might potentially put the firm in public scrutiny are high and showing only project details is seen as a safer alternative. The conflicts of the second pair between the project owners and contractual parties such as suppliers, off-takers, and host government can arise when parties choose to opportunistically alter their actions to realize a better condition from the project, resulting in a "hold-up problem," commonly perceived as a situation where two parties might defer their efficient cooperation over the concerns that the opposite party might gain more bargaining power from doing so, leading consequently to underinvestment by the company [24]. Confiscation of the project assets from the host government is another example of the conflict over the second-pillar relationship. Using project finance can help mitigate these risks as carefully crafted long-term contracts between parties are well defined and respected [25]. An example where the

World Bank gets involved, providing a "political umbrella" to the potential project expropriation from the host government is seen in [26][27]. Next, the conflict between the owners and managers in the third pair, which is well-defined in [28], can arise when free cash flows in the company are high and managers choose not to pay out dividends to the shareholders and choose instead under their discretion to use resources for less (positive-NPV-wise) sound or empire-building re-investments. Project finance introduces strict corporate governance with the nature of high debt ratio that could discipline the managers and reduce these risks.

The third pillar can be beneficial from the points of view of the strands of strategic management and socially-minded investments. Project finance allows the company to have an opportunity for horizontal joint ventures where tacit knowledge of a group of companies (e.g. utilities) that are in the same general line of business could be acquired among themselves, as opposed to vertical joint ventures where companies in the industry chain are integrated to create more economies of scale. Lastly, renewable energy is seen as another alternative to conventional power plants to improve citizen's welfare. This social investment decision in low-carbon technologies extends beyond the risk-return tradeoffs and is preferred for such political reasons as supporting independent electricity supply within the country and civic ownership of the project. Project finance with a non-recourse basis allows retail, smaller-sized, and local investors to take part, making the renewable energy power plant independent from outside energy players.

With eight potential reasons (contamination risk, debt overhang, securitization, asymmetric information and agency conflicts between three pairs of counterparties, the change of organizational structure for strategic management, and socially-minded investments) under three main pillars (negative financial synergies with existing business, market imperfections, and organizational structure change of the firm) mentioned thus far, project finance has been acting as an important financing option in the renewable energy sector. Nonetheless, some limitations of project finance should be aware and are discussed next.

2.3 Limitations of Project Finance

Although project finance possesses a number of benefits for financing renewable energy power plant projects as discussed above, there are limitations and downsides that hinder the use of project finance and should be considered. The limitations of project finance discussed below are mainly drawn from [3].

First, project finance is a slow process as the financing process requires thorough due diligence and feasibility analysis of the project, let alone the periods for project development and construction, and involves back-and-forth negotiations to reach acceptance of highly complex structured contracts by all contractual counterparties. The longer the time span it takes to reach the financial close, depending upon market conditions, the underlying economies of the project could change and create disputes between contractual parties.

Second, as each project differs in its own way, high transaction costs could arise as the lenders in project finance, when compared to the traditional corporate finance, would typically require a thorough analysis and consultancy of the highly complex project's risks, contracts, insurance, and technicality. Especially with highly complicated documentation that allows risk allocation between contractual counterparties with conflicting objectives, the longer execution timespan and higher transaction expenses of project finance could turn out to be the main hindrance to the project's success.

Third, the fact that the lenders rely only on the project's assets, contributed capital, and future cash flows exposes the lenders to idiosyncratic risks specific to the project where uncertainty (and its default risk) is usually high during the construction and project development period. Therefore, the lenders in project finance will require higher compensation and hence higher cost of debt for the additional risks they underwrite, when compared to conventional corporate finance. In addition to the higher cost of debt resulting from lender's dependency on the project's prospects due to the non-recourse basis of project finance, lenders demand the sponsors to cover their own projects with some insurance policies so that the insurance proceeds can make up the outstanding loan amounts in case of project's failure. Insurance markets are usually less liquid and could drive up the insurance costs and thus the overall cost of capital.

Fourth, on top of such periodic updates as operations reports and financial statements from the project company, as the lenders will need to thoroughly assess the underlying risks of the project due to the nature of the highly complex structure of project finance, stringent reporting requirements demanded by the lenders can increase the overall operation cost. Furthermore, the lenders are concerned with the performance of the projects as they rely heavily on the project prospects that they do not wish to overlook any crucial details of arising issues and generally intervene to have a say in every important decision that could be critical for the overall project's health. The project sponsors under project finance are usually not flexible and subject to operating restrictions when it comes to decision making. Therefore, the lender's assessment of the risks and consents on the important matters could be time-consuming, delay the decision-making process, and potentially create negative financial impacts to the project. This intervention of the lenders in the decision-making process can also prevent the sponsors from pursuing profitable projects as the sponsors have less freedom in making use of the free cash flows from the project.

Fifth, as discussed earlier as one of the limitations of project finance that the lenders usually demand a significant amount of information (and sometimes confidential information) from the project sponsors to ensure successful operation of the project and the capability of the project company's generating expected future cash flows to serve the debt.

Table 2.1 Benefits vs. Limitations of Project Finance.

Benefits of Project Finance (mainly from [8])	Limitations of Project Finance (mainly from [3])
Aviod negative financial synergies	Slow and complex process
Reduce contamination risk	High transaction costs
No debt overhang	Need insurance policy
Securitization	Stringent reporting requirements
Market imperfections (agency conflict)	Need lender's approval on important decisions
Between sponsor and lender	Less freedom for managerial discretion of cash flows
Between owner and contractual parties	Disclosure of confidential proprietary information
Between owners and managers	
Organizational change	
Strategic management	
Socially-minded investment	

If required by the lenders, on a regular basis, the sponsor may have to give up its proprietary information such as business strategies, project technology assessment, internal legal analysis, and financial market assessments, to name a few. Nevertheless, the project sponsor is protected from this business risk by obligating the lenders to abide by confidentiality agreements for a certain period of time.

In short, despite the merits brought about by the main characteristics of project finance of separating the project risks from the sponsor’s core business and reducing agency conflicts, project finance is time-consuming, document-intensive, highly complex in structure, and usually relatively expensive to complete, taking into consideration that all related parties pay for their own consultants and attorneys. Furthermore, the sponsors cannot freely exercise their decisions under project finance, for instance, making investments in other profitable projects or distributing dividends to the equity-holders prior to the payment of operating expenses and debt service, and are requested to pass the approval of the lenders before any important decision that would determine the project prospects is made.

2.4 Corporate Finance vs. Project Finance

This section aims to highlight the difference between the structures of traditional corporate finance and project finance and the potential debt options commonly used in the renewable energy sector. When it comes to raising capital to pursue a new positive-NPV (or profitable) renewable energy project, two alternatives are usually considered: financing at the level of organization funding a project (i.e. using corporate finance) or financing at the level of an individual project with a newly created separate entity (i.e. using project finance). Corporate finance is the classical way to fund investments for private and public enterprises. Project finance comes into play when the project sponsors want to separate high-risk projects from their balance sheets and want to enjoy other benefits discussed earlier. Table 2.2 demonstrates distinct characteristics of corporate finance and project finance.

Table 2.2 Characteristics of Corporate Finance vs. Project Finance.

Characteristics	Corporate Finance	Project Finance
Entity	Multi-purpose firm	Single-purpose vehicle
Recourse	Yes	No, limited recourse
Leverage	Generally low	High (60%-90%)
Underlying assets	Undefined, all assets from firm	Ring-fenced
Investor/lender base	Deep secondary market	Sophisticated thinner market
Transaction costs	Low, standardized	High, complex
Financing costs	Low, deeply liquid market	High, thinner market, highly complex contracts
Time to financial close	Faster to implement (risk based on agency rating)	Slow to implement (detailed project risks and complex contracts)
Control	Firm is free to manage	Lenders take part
Maturity	Shorter (up to 5 years)	Longer (10-15 years)
Payout policy	Management discretion	Pre-defined in contract
Reinvestment	Management discretion	No
Reporting to creditors	Opaque	Transparent
Contamination risk	Yes	No, little
Credit basis	Overall financial health of firm or guarantor	Technical and economic feasibility of project

It can be seen in Table 2.2 that corporate finance differs from project finance in almost every way. For instance, companies using corporate finance can access investors more broadly through the secondary market with high liquidity whereas companies using project finance rely on sophisticated transactions with a thinner market. In addition to market illiquidity, complex transactions based on back-and-forth negotiations of counterparties in project finance drive up the overall financing cost when compared to corporate finance. As more and more parties are involved, project finance with the requirements of detailed analysis of project risks is relatively slower to implement than corporate finance. Companies under project finance are not free to decide where and when to invest and lenders always require stringent reporting and take part in making important decisions that could affect the firm’s prospect to ensure successful project implementation. Finally, credit evaluation under the financing does not depend on the overall financial health of the firm but rather on the feasibility of the project.

2.5 Loan Structure

Fig. 2.1 illustrates the annual global volume of project finance between 2013 and 2016 with different sources of capital. Within project finance, the fact that debt is more dominant than equity improves the internal rate of return to the sponsor as the project is tuned towards high leverage. Equity in project finance is mainly from the capital contributed directly by the project sponsor and particularly in the US from tax-equity investors. Tax equity is usually done by specialized banking institutions partnering with project developers to take advantage of tax credits. For some projects to a lesser extent, equity can also come from private equity

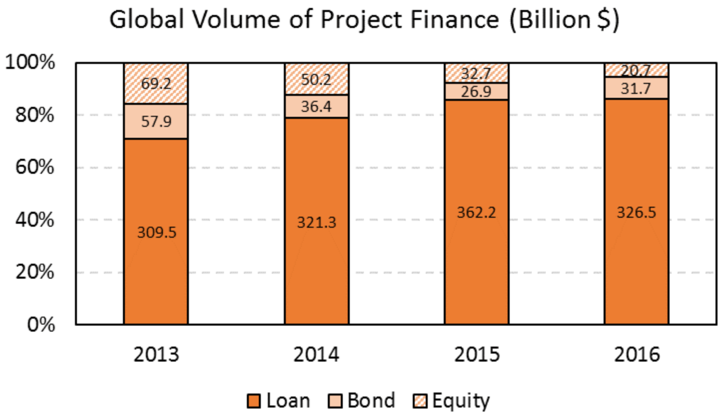

Fig. 2.1 Global Project Finance Volume by Source of Capital [5].

and venture capital funds where the money is raised from wealthy individuals and large investors and managed by experienced financial practitioners [9].

Debt in project finance comes mainly from bank loans and the issuance of project bonds. The dominant source of debt as displayed in Fig 2.1 is from loans. Particularly, these loans are in the form of a syndicated loan or club loan. A syndicated loan is a financing source offered by a group of lenders or banks who provide funds to the borrower and work together to assess the risks of the project [29]. In case of a borrower's default, the participating financial institutions can be prevented from a huge loss as the loans are spread out among lenders. A syndicated loan is managed and led by one or more arranger banks whereas, in club loans, all lenders take equal roles in leading the transactions and the project. Furthermore, different loans can be acquired by the project company depending on the development stage of the project. Construction loans, as the name suggests, are usually taken during the construction period owing to higher interest rates reflecting increased risks during this period. Particularly in the US, late in the construction period when the risks are perceived to be relatively low by the lenders, back-leveraged debt from the sponsors is commonly utilized as a way to increase project leverage and replace a higher cost of equity with a lower cost of debt [9]. Once the project is complete, the construction loan is usually converted to a term loan with a longer amortization period and a lower interest rate than the construction loan with the lenders without having to negotiate the same documents twice. Risks associated with the project during different periods will be discussed in more detail in the next sections. Moreover, the project company occasionally needs more cash flows during the operation period to reserve for servicing its operation and maintenance payments. This money can also be borrowed as working capital loans or revolving credit facilities, which are generally smaller than the construction and term loans, to ensure the smooth and successful operation of the project.

For large projects, project sponsors can upsize the loans and increase the marketability of the loans by dividing debts into tranches or classes to attract more capital from a larger group of investors with different risk-return profiles; thus, higher debt sizing can be obtained from these debt securities combined, especially by small project developers with less financially-sound balance sheets. Debt tranches in project finance are often divided by their prioritization claims to the collateral (contributed equity and project assets and incomes) in case of bankruptcy or liquidation of the project company. First-lien, second-lien, third-lien, and senior unsecured debts are examples of debt tranches ordered from high to low priority. In the event of liquidation, the first-lien debtholders get paid first before paying out to the second-lien debtholders, and so on. Hence, second-lien debtholders are exposed to higher risks and the credit spreads for such lower-ranked debt securities should be priced higher than first-lien debts. Institutional investors such as pension funds, insurance companies, sovereign wealth funds, university endowments, and charitable foundations are particularly attracted by these debt securities with the different payoff and risk schemes to diversify their portfolios. Apart from segregating by their priority like debt tranches, institutional investors can invest in renewable energy projects through another riskier financial instrument called term loan B (TLB) characterized by shorter tenors and lower amortization when compared to direct investing [30].

As will be discussed in the next section, lenders usually contend with renewable energy projects created under a power purchase agreement (PPA) with a long-term contract to sell electricity at a specified price over a period of time to ensure stable cash flows and high capability of the project to service debt repayments. However, higher risks can arise when the maturity of the loan is shorter than that of the PPA, especially in the US where stringent capital requirements are imposed by the Federal Reserve on corporations with long-term debts. Sometimes, this limits the lenders to offer 5-year to 10-year loan maturity. The amortization schedule is set in response to this maturity and with a large payment at the end called a balloon payment. This profile is termed a mini-perm loan. It should be noted that this structure of mini-perm loans introduces refinancing risks because the project company relies heavily only on the expected future cash flows and refinancing is the only way the project company can repay the balloon payment.

Apart from loans in project finance, the project sponsor can issue another debt security – bonds – to raise capital in the forms of investment-grade, high-yield (non-investment-grade), or convertible bonds. Bonds are fixed-rate instruments with pre-defined coupon rates regardless of the market interest rates. Table 2.3 below illustrates different characteristics between bank loans and project bonds. As the risk of the project varies throughout the project lifecycle, starting high during the construction period, then significantly reducing and tapering off afterward. Hence, the borrowing cost of bond issuance might be overpriced due to high risks at the beginning of the project whereas the borrowing cost of taking bank loans can be flexibly adjusted once the project is complete as the construction loan is converted into the term loan. Banks also have accumulated experience of renewable energy and become comfortable around financing renewable energy projects. For this reason, banks tend to rate

Table 2.3 Characteristics of Bank Loans vs. Project Bonds [3].

Characteristics	Bank Loans	Project Bonds
Counterparty	Banks	Private, public investors
Borrowing rate	Varing, subject to interest rate risks	Fixed
Borrowing cost	Can be adjusted	Fixed
Financing mechanism	Flexible	Fixed
Experience in Renewables	Higher experience	Lower, no experience
Rating process	Internal rating model	Rating agencies
Rating view	Reflect project risks	Generally more conservative
Governance	Stringent	More relaxed
Maturity	Relatively shorter	Relatively longer
Ownership	One or a few entities	Diffused

the project fairly while rating agencies hired to assess the credit rating of the project bond tend to be more conservative. As a result, bond financing may lead to raising a lower debt amount. In terms of debt covenants, bond financing may offer more relaxed governance than do bank loans. Since bond investors are not familiar with the renewable energy industry and are more interested in the return, banks that are well experienced in it tend to require more stringent reporting requirements. As discussed earlier, this can essentially affect the decision-making process. Because bond financing tends to offer longer tenors than bank loans, some investors such as pension funds or insurance companies prefer bond financing to match their long-term liabilities with longer-tenor assets. Finally, in case of financial restructurings such as bankruptcy and liquidation, bondholders are diffused with public ownership of the project and generally are more difficult to negotiate terms, while banks usually have a long-term relationship with the sponsor and can be more compromised.

2.6 Support Policies in Renewable Energy

Deployment of renewable energy has expanded rapidly in many jurisdictions around the world due largely to government support policies that help make investments in renewable energy more economically sound when compared to its cheaper alternative – fossil fuels. Investors and lenders usually demand some criteria to be met before they get the go-ahead for the project. In other words, they need to see if the project is feasible and stable enough to confidently honor its debts and generate the expected required rate of return. As discussed in more detail in this section, renewable energy projects are usually initiated with support policies from the public sector. A popular example of the support policy is feed-in-tariff (FIT) under a power purchase agreement (PPA) where, similar to a concession, the price of electricity sold for a considerable period by the renewable energy power plant is fixed, eliminating the possibility of reduction of cash flows from the project that could deter the lenders who look for stable debt repayments.

Public policies that support renewable energy investments are rooted back from some economists realizing the danger of pollution from cheap resources such as fossil fuels on the social welfare and maximizing the wealth of corporations without considerations of environmental consequences to the society can make the society worse off in the long run [31]. Therefore, to put a price on carbon emissions derived from power generation and to make renewable energy more competitive, carbon taxes are introduced. Under the carbon tax system, a tax is levied on carbon emissions, which is equal to the marginal incremental social costs of those emissions [32]. Ideally, a perfect carbon tax should eliminate the need for other renewable energy support policies because the power producers would have the incentive to pursue low-carbon technologies. However, in practice, carbon taxes are not simple to implement the accurate level of tax (which is equal to the marginal incremental social costs) cannot be easily set and estimated. In contrast to fixing the price under carbon taxes, fixing the amount of carbon emissions (e.g. one ton of carbon) that a factory or a power plant is permitted to emit is utilized under a tradable permit system. A tradable permit system allows emission permits to be traded in the market and the price of the permits should economically provide incentives for factories and power plants to emit less carbon at the lowest total social cost [3]. One issue of the tradable permit system is that the price of carbon emissions can be highly volatile, deteriorating the investment environment for investors. Although carbon taxes and tradable permit systems have attractive characteristics in theory, evidence shows that they have not been widely used due to price and policy stability. As Raikar and Adamson put it in [3], other mechanisms such as direct subsidies, quantity-based mechanisms, and price-based mechanisms have, in fact, been more effectively supporting renewable energy development over the years.

One way to make renewable energy cheaper and comparable with conventional energy sources (fossil fuels) is by direct subsidies from the government to the project developers through the tax system. Two common tax-related policy measures employed in the US renewable energy are investment tax credits (ITC) and production tax credits (PTC). The ITC provides a one-off tax credit of up to 30% of the installed costs for such renewable energy technologies as solar and small wind turbines. While the PTC provides an over-time inflation-adjusted tax credit for each unit of electricity produced for 10 years, in addition to the revenues received from selling the electricity. It should be noted that the ITCs and PTCs are complex in terms of implementation as they require that the investors or developers possess some equity with some legal restrictions to ensure that the tax credits are effectively exploited within the renewable energy projects that sometimes the investors incur expensive tax equity strategies to secure these tax benefits. These groups of investors are called tax-equity investors. Some criticisms of the ITCs and PTCs arise, stating that the ITCs do not encourage directly emission reduction and may lead to over-investment by the project company, and the PTCs do not deliver effective renewable energy production and emission reduction as the tax credit is the same regardless of where and when clean energy is most needed to avoid the use of conventional dirty energy resources. Lastly, these tax credits require approval from lawmakers and, like all other taxation systems, are politically difficult.

Another way to support the development of renewable energy is to require the utilities to deliver some proportion of their total energy generation from qualified renewable energy suppliers. This quantity-based mechanism is widely used in the US and is known as renewable portfolio standards (RPS). Under the RPS mechanism, electricity distributors and retailers are required to supply their customers with some proportion (e.g. 30%) of renewable energy resources. It should be noted that there is no general RPS mechanism but rather each state in the US has its own standards. Some states do have more than one standard of RPS for different renewable energy technologies (e.g. wind, solar, or geothermal). Nonetheless, many states have set their targets at 100% renewable energy generation in the foreseeable future. Utilities that fail to comply with the requirement under the RPS can also purchase (tradable) renewable energy credits (REC) from other utilities that exceed the requirement. This REC system is designed to help the utilities to meet the environmental requirements more easily and cheaply. Like the tradable permit systems mentioned earlier, tradable RECs can be highly volatile in nature depending upon the supply and demand of renewable energy as well as state policies. The prices of RECs vary corresponding to specific renewable energy technology and power plant location. Despite the aforementioned issues, the RPS and REC have been widely adopted together with other types of PPAs in the US to support the development and investments in renewable energy. Another type of quantity-based mechanism is a renewable energy auction (or a competitive tender) where the project developers bid to supply a fixed quantity of renewable energy at a specified price for a certain period (usually over the project lifetime). The use of renewable energy auctions, providing more freedom to local policymakers to enact appropriate mechanisms to reduce carbon emissions, has been widely used in many countries in recent years [33].

Another incentive mechanism to boost the adoption of renewable energy is a price-based mechanism where the price for electricity sold is fixed at an independent value (usually higher than the spot electricity price) over a specified time period (e.g. 25 years) to provide investors with some certainty of their expected return from the project and lenders with guarantees of loan repayments [34]. Instead of fixing the quantity of renewable energy at a specified price in renewable energy auctions discussed earlier, a common type of price-based mechanism called feed-in tariffs (FIT) focuses on fixing the price without the limit of delivered quantity. Although they are not particularly popular in the US in past years, FIT schemes have been widely used and have been the backbone of renewable energy development around the world. However, some criticisms state that the governments may not set the tariff prices correctly in response to the market demand. That is, too low the FIT prices may lead to no one pursuing renewable energy projects leaving the environmental objectives of the country unmet, or too high the FIT prices may encourage overinvestments in renewable energy projects with expensive costs in the consumer end. A variation of the

Table 2.4 Common Support Policies in Renewable Energy.

Type of policy	Example
Direct subsidy	Investment tax credits (ITC)
	Production tax credits (PTC)
Quantity-based mechanism	Renewable portfolio standards (RPS)
	Renewable energy credits (REC)
	Renewable energy auction or a competitive tender
Price-based mechanism	Feed-in tariffs (FIT)
	Price digressions
	Feed-in premium (FIP)

FIT mechanism is known as price digressions where stable declines in the tariffs are imposed to the original tariffs of the project to adjust the investor's rate of return in proportion to the declining risks of the project as the project matures. Another popular price-based mechanism is feed-in premium (FIP) where power producers receive a top-up on the wholesale price of electricity in the market. The absolute values of tariffs vary depending upon the location of the plant. That is, power produces in places where renewable energy is most needed might receive more revenue than others. Some floors and ceilings are incorporated into the FIP mechanism to help reduce the project's risks and ensure investors of the project's prospects. Moreover, the FIP schemes can help ease the burden of the electricity buyers as the risk of paying floating electricity prices is partly or wholly transferred to the power producer. Like the FIT schemes, the FIP mechanisms have been widely used.

2.7 Counterparties Involved in Project Finance

In renewable energy projects, project finance allows each project's risk to be allocated to the counterparty most suitable to handle it. Each party in the structure of project financing has its own distinct role. All contracts between counterparties related to, for instance, project development, construction, operation, financing, and ownership, to name a few, will be entered into project agreements by the project company. In addition to the project agreements, other intercompany agreements may be necessary to be incorporated to make the project financeable in the view of the lenders. These intercompany agreements may include administrative services agreement, technology license agreement, site lease agreement, power purchase agreement, engineering, procurement, and construction (EPC) agreement, agreements for feedstock commodities (in case of biofuels), renewable energy credit agreement, interconnection agreement, and agreements to take advantage of the tax incentives, etc. Fig. 2.2 below demonstrates main parties in a typical structure of project finance for renewable energy projects.

As discussed earlier, the project company is a special purpose vehicle (SPV) created with the sole purpose of serving the project. It is the center of all the contractual counterparties and is the culprit of a successful project. The project company is usually a limited liability company where the equity interest comes from at least one intermediate holding company (also a limited liability company). The equity by the holding company is pledged to the project lender (generally a group of financial institutions who provide construction and term loans to the project company and depend mainly on the project company's assets) against the project's foreclosure. This structure separates the liabilities of the holding company and other investors or project sponsors who invest in the holding company from the project company's liabilities in case of the project's default. The project sponsors are typically the backbone of the project's architecture, leading and organizing project development, construction, operation, financing, and other related functions. Unlike the project company's assets on which the project lenders rely, project equity interests from the project sponsors can be used to further lever the project and hence increase the return on equity with the back-leverage lender. Therefore, the back-leverage lender can replace the project sponsors and become a project owner in the event of default. Once the project is complete, a considerable reduction of project risks allows the sponsor to pursue the back-leverage loan with reasonable rates. However, back-leverage loans with limited securities of the sponsors' equity are usually priced more expensively than term loans.

Among the most important considerations, a guaranteed and stable revenue stream from the renewable energy generation with a creditworthy (usually with an investment-graded company to reduce the credit risk) power purchaser or off-taker is key to determine if the project is financeable from the lender's point of view. Under the long-term PPA contract, fixed price (typically adjusted for inflation) and contract maturity are generally defined. Without such a contract, the project company is exposed to the merchant (electricity) price risk. The engineering, procurement, and construction (EPC) contractor provides services of designing and building the project with pre-specified specifications and performance. In the EPC contract, construction milestones and penalties for missing the deadlines and expected performance are clearly defined. In most cases, performance guarantees such as liquidated damage coverage (pre-defined payments by the contractor), performance bond, and letter of credit from the parent company may be required by the lenders for any unexpected performance delays, equipment failures, inefficient operations, cost overrun, or installation defects. Apart from the EPC contract, a separate balance-of-plant (BOP) contract covering other equipment necessary to deliver a successful project such as wind turbines, solar panels, or feedstocks (for the biofuel technology) with vendors or suppliers may be needed. Lenders usually prefer a single point of contract or a fully wrapped turnkey contract in which all EPC-

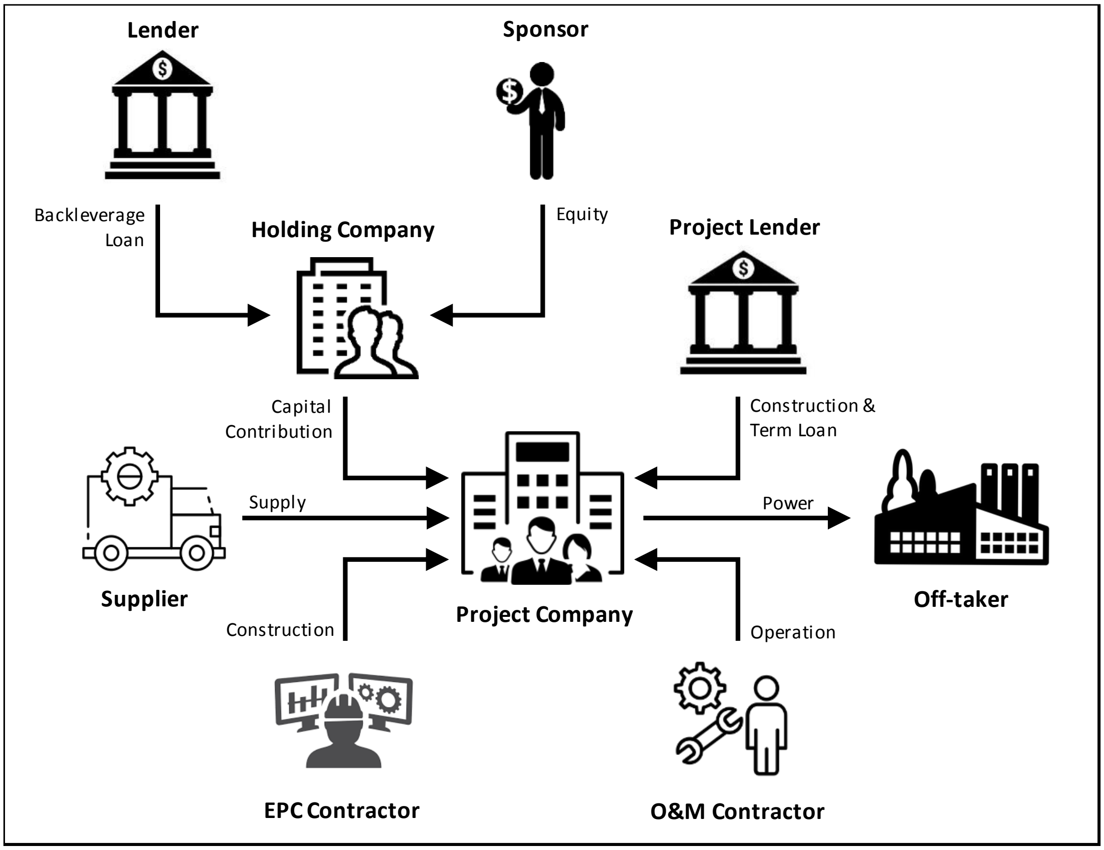

Fig. 2.2 Counterparties in Project Finance.

related contracts are bundled together and dealt with by one EPC contractor. Such a full-wrap contract may often be expensive. Once the project is built with expected performance and timeline, the operation and maintenance (O&M) contractor provides routine operation and maintenance in the renewable energy power plant. Performance bonuses and penalties are imposed on the O&M contractor when the actual performance exceeds or does not meet the pre-specified specifications. In addition to the O&M contract, other agreements such as asset management agreement (AMA) covering miscellaneous administration costs and energy service agreement (ESA) defining the management of the project's transmission interface to keep the project operation run smoothly may be required. Lastly, in the US context, tax partners or tax-equity investors who take advantage of the tax credits can be incorporated in the project finance structure in Fig. 2.2.

2.8 Risk Consideration and Credit Enhancement

When it comes to project financing where the project lenders rely on the prospect of the project alone, risks associated with each individual project need to be assessed by the financial institutions (project lenders) to arrive at the conclusion whether to approve the loan to the project sponsors. Interdisciplinary (i.e. engineering, accounting, finance, legal, real estate, environment, etc.) due diligence needs to be performed to understand the potential

Table 2.5 Summary of Project Risks.

Risk Type	Scenario
Sponsor risk	Project sponsor who organizes and manages the project goes bankrupt.
Technology risk	Project lenders are reluctant to a new and unproven (without historical evidence) technology (e.g. a new design of solar panel).
Construction risk	Plug-and-play style with modules of solar and wind technologies with certified performance have a lower constrution risk than building other types of renewable energy power plants.
Supply risk	Biomass projects may need feedstocks whose prices are subject to market volatility.
Operational risk	Project company incurs high O&M costs from an inexperienced O&M operator or the performance of the power plant drops continually as the plant ages.
Interconnection risk	The distance from the renewable energy power plant and the inter-connection point may increase transmission losses (reduce profitability) and significantly increase costs of cabling.
Off-taker risk	The off-taker defaults and the project sponsor may not be able to find another long-term PPA contract with the price higher than or equal to the original price.
Environmental risk	Birds are killed by wind turbines, the wildlife is forced to leave by preparing the land for a solar farm, or toxic chemicals from biofuel processes are present at site for a new project.
Approval risk	The project does not receive timely approval from the lender to reach the financial close and thus affects other (e.g. EPC and O&M) contracts.
Resource risk	Intermittency of renewable energy resources (which could affect future cash flows of the project) cannot be controlled by neither project sponsors nor project lenders.
Regulatory risk	A renewable energy project is built in an international landscape where laws and regulations are different and sometimes change frequently.
Force majeure risk	Projects may be exposed to natural disasters such as floods, earthquakes, hurricanes, landslides, etc.
Political risk	The project may be confiscated by the host government when the project is complete.
Real estate risk	Large wind projects may require large amount of land with long-term leases for a number of landlords.
Country risk	Political turmoils, economic downturns, and government regulations can peril the project that otherwise is financeable.
Interest rate risk	Increases in interest rate and inflation rate may shoot up the amount of debt repayments.
Currency risk	Projects with cash flows in foreign currency may be subject to foreign exchange rate risks.
Merchant price risk	A long-term fixed energy price under a PPA helps reduce merchant price risk and affect the project profitability.
Volume risk	Projects with quantity-based PPAs may have to sell their power exceeded the amount specified in the contract at the spot electricity market price, which may be lower or higher than the price under the PPA.

risks of the project. Table 2.5 below summarizes all the potential risks that the project company may have to manage or allocate to other counterparties. Mitigation and allocation of these risks should be carefully evaluated and clearly exhibited before arriving at the financial close with the lenders. Some examples of this process called credit enhancement of the project are given below.

Once key risks are clearly identified, appropriate measures can be taken to mitigate or allocate these risks (not all risks can be removed) to close the gaps or deficiencies of these risks and improve the creditworthiness of the project. Therefore, all parties in the contracts need to work together and negotiate back-and-forth to reach the financial closing. An example of risk allocation can be illustrated through the riskiest period: the construction period with the construction risk. During the construction period, the project lenders may be concerned that the construction milestones are not achieved by the EPC contractor in a timely manner, extending the overall construction period. This poses a problem to the PPA contract to sell electricity at a pre-specified date with the off-taker. As a result, the off-taker can even terminate the contract, making it hardly possible to get the project financed, if not at all. The O&M contractor may be in the same situation as the off-taker where the O&M contractor can walk away from the contract if the project is not completed on the pre-agreed date. This construction risk can be mitigated, for example, by negotiating with the EPC contractor by offering a higher price for a tighter schedule of the construction. Other measures to mitigate the construction risk can be implemented as elaborated in [3]: First, banks can require project sponsors to put the equity in the project before drawing on a loan; Second, banks may demand a contingency reserve from the sponsors upfront to cover any unexpected future construction cost overruns; Third, banks may divide the construction loan into tranches given upon each defined construction milestone; Fourth, banks may require the EPC contractor provide monthly construction reports to ensure that the construction process is as planned; Fifth, banks may impose loan-to-value ratio during the construction period than in the operation period.

Apart from the construction risk, the interest rate and inflation risks can impose more burden on the project company in terms of servicing its debt obligations as the loan relies on a floating interest rate that changes in accordance with the economy. These risks can be hedged by a financial instrument called an interest rate swap (IRS) where the floating rate is changed to a fixed rate with some spread and fees to the bank. Similarly, the currency risk of a project with cash flows in a foreign currency can be hedged by a cross-currency swap (CCS) where the loan and cash flows are not subject to foreign exchange rate risks. The off-taker risk can commonly be mitigated by, for instance, dealing with an investment-graded utility with acceptably high creditworthiness. Another example of the regulatory risk is when the law (e.g. renewable energy feed-in tariffs) is changed this risk can be avoided by entering the PPA contract, transferring the risk to the local off-taker. The project company also can be protected from the force majeure risk by procuring insurance against such natural disasters as hurricanes, landslides, and earthquakes. Lastly, the operational risk of the project can be mitigated by a performance bond to compensate if certain milestones are not reached, a security cash fund to cover liquidated damages, and insurance during the project operation.

In this section so far, the concept of project finance and its characteristics have been introduced. Its main advantages and drawbacks, when compared with corporate finance, have been discussed. The underlying supportive policies for project finance in renewable energy are reviewed. The structure of project finance and risk allocation have been mentioned. Now that the background of project finance has been covered, the next section will provide an insight into how a renewable energy (wind or solar) project is financially modeled in terms of cash flows (revenues and costs), and how the amount of debt needed for the project is calculated. Key factors used to evaluate whether this project should get built will be identified.

Chapter 3

3 Financial Modeling

Financial modeling is an important foundation of project finance since lenders depend only on the prospect of an individual project. Understanding the deal structure, underlying nature of renewable energy, project's cash flows, project risks, and debt sizing can help project sponsors to fine-tune the project and arrive at better terms. It should be noted that the framework of financial modeling presented in this section is just one simple way to approach modeling, in real life, each party has its own financial model where the assumptions may be considerably different.

In this section, the underlying nature of wind and solar energy will be first analyzed. Using the Monte Carlo method, net energy output from a renewable energy power plant can be statistically obtained. Different confidence levels lead to different levels of energy generation. Then, assuming the project enters a long-term PPA contract to sell its energy at a fixed price and applying recent data for costs associated with each technology (wind and solar), a revenue stream and expenses over the project's lifetime can be obtained. After that, the amount of debt associated with the project's underlying cash flows can be calculated. Finally, key factors determining the economic viability of the project are identified.

3.1 Power Generation from a Wind Turbine

Power generation from wind varies depending on wind speeds. Wind speed in nature tends to be volatile throughout the day. In other words, the wind does not always blow. Nonetheless, the projection of wind speeds to derive the energy generation and hence revenue from selling this energy is needed. Different locations (onshore, offshore, mountainous, etc.) and heights offer different wind speed profiles. Fig. 3.1 shows hourly data of the 2019 wind speed profile in Basel, Switzerland [35].

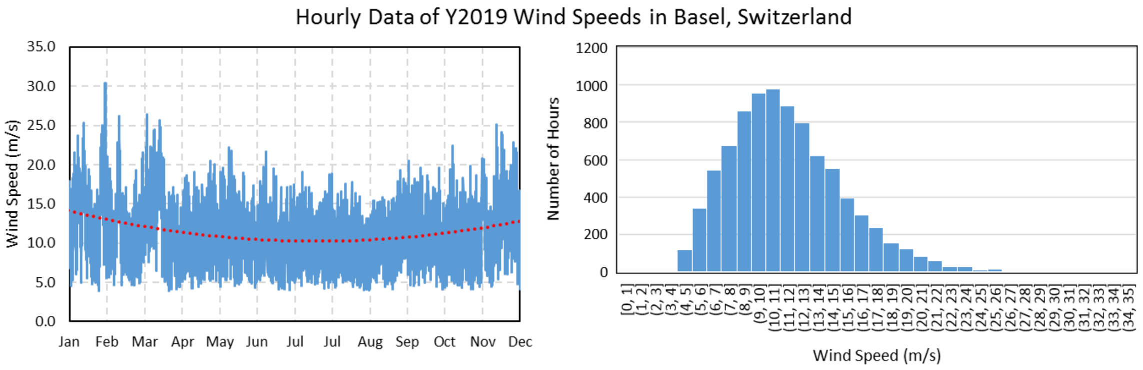

Fig. 3.1 Y2019 Hourly Data of Wind Speed Profile in Basel, Switzerland.

Table 3.1 Means and Standard Deviations of Wind Speed from 2010 to 2019.

Year	Mean	SD
2010	11.210	3.049
2011	9.527	2.737
2012	11.010	2.949
2013	9.940	2.724
2014	9.873	2.553
2015	11.049	2.890
2016	9.960	2.886
2017	11.364	3.146
2018	10.036	2.973
2019	12.371	3.184
10 Years	10.034	3.049

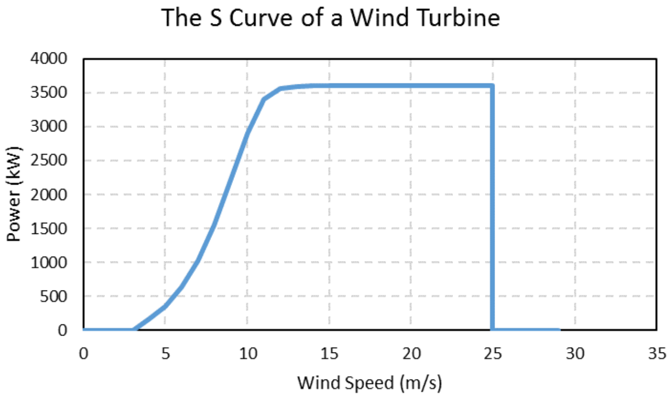

Fig. 3.2 The S Curve (Power Curve) of a Wind Turbine.

Table 3.1 displays the mean value and standard deviation of the wind speed of each year over 10 years (from 2010 to 2019). Now, the wind speed profile is combined with the "S curve" or the power curve of the wind turbine [36] with the rated speed of 12.5 m/s shown in Fig. 3.2 where no electricity is produced at low speeds below the cut-in speed (insufficient power to turn the blades) and after the cut-out speed (to avoid damage). The combined result

Table 3.2 p-values of Wind Speed for 1-Year and 10-Year Data.

Wind (m/s)	1-Year	10-Year
p-50	12.550	12.199
p-75	10.259	10.089
p-90	8.179	8.191
p-95	6.942	7.056
p-99	4.717	4.950

Table 3.3 p-values of Wind Energy for 1-Year and 10-Year Data.

Energy (MWh/year)	1-Year	10-Year
p-50	13,889.64	13,275.21
p-75	6,371.70	6,180.94
p-90	1,812.27	1,917.54
p-95	691.57	720.26
p-99	21.37	38.34

Table 3.4 p-values of Net Wind Energy Generation for 1-Year and 10-Year Data.

Energy (MWh/year)	1-Year	10-Year
p-50	12,535.40	11,980.87
p-75	5,750.46	5,578.30
p-90	1,635.57	1,730.58
p-95	624.14	650.04
p-99	19.29	34.60

is the energy profile in MWh/year vs. wind speed for 1-year data (2019) and 10-year data (2010-2019), shown in Fig. 3.3 with the mean values and standard deviations of the energy profile. It should be noted that the standard deviation of 10-year data is less than that of 1-year data due to the lower impacts from the contribution of extreme events of too strong wind.

Assuming a normal distribution of the data of wind speed, 50,000 samples are run using the Monte Carlo method based on the means and standard deviations in Fig. 3.3. The new distributions of wind speeds for 1-year and 10-year data are shown in Fig. 3.4. The percentiles at 50%, 75%, 90%, 95%, and 99% (also known as p-50, p-75, p-90, p-95, and p-99 values) of wind data can be found, shown in Table 3.2. In some textbooks [3], p-values are also defined as the probability of exceedance or confidence level. For instance, p-95 means that based on the historical data, the energy can be produced at least the amount equal to the p-95 value 95% of the time. In practice, 1-year p-90 and 10-year p-50 are commonly used as base-case and worst-case scenarios, respectively. Then, these p-values of wind speeds are plugged into the energy distribution with different wind speeds in Fig. 3.3; as a result, the p-values of wind energy are shown in Table 3.3.

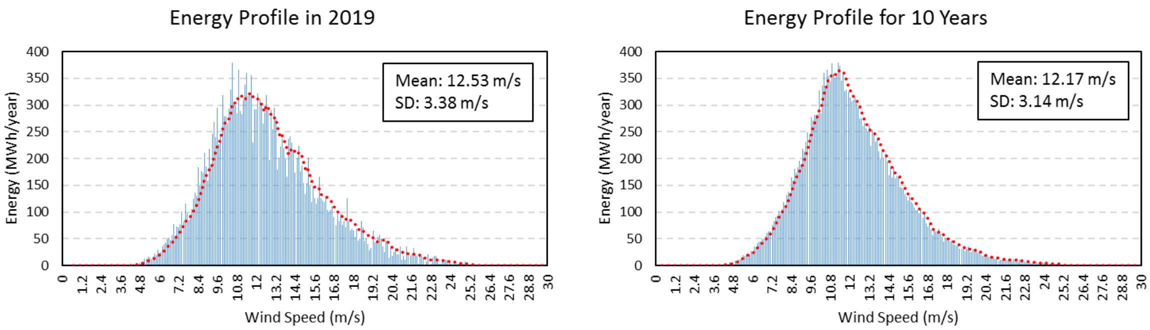

Fig. 3.3 Energy Profile vs. Wind Speed for 1-Year and 10-Year Data.

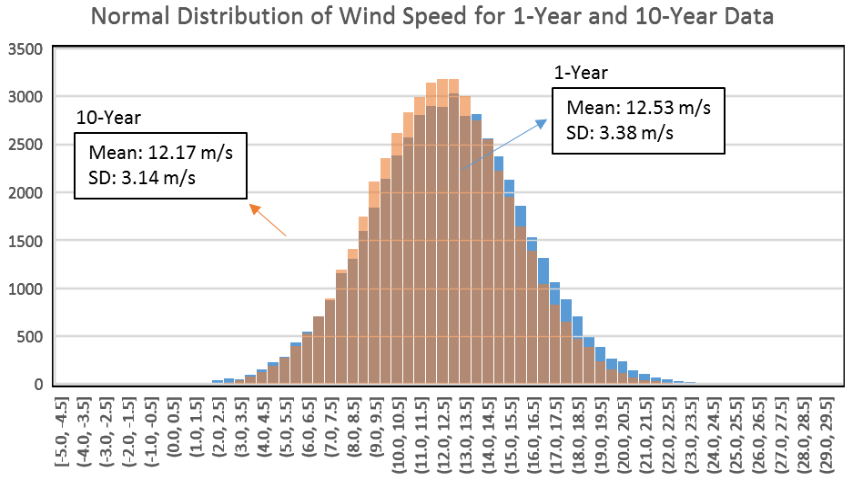

Fig. 3.4 Normal Distribution of Wind Speed for 1-Year and 10-Year Data Statistics.

For wind energy, there are energy losses from the point of generation (wind turbine) to the selling point (at the grid interface). For this model, only material losses are taken into consideration, namely turbine availability and electrical transmission efficiency [37]. For simplicity, both losses are assumed constant at 0.05. Consequently, the 1-year and 10-year energy profiles are reduced by 0.9025 (0.95 x 0.95), yielding new p-values for net energy generation in Table 3.4, which can be visualized in Fig. 3.5.

The numbers in Table 3.4 and Fig. 3.4 are for one wind turbine of 3.6 MW. For the whole wind farm with a capacity of, for instance, 180 MW, 50 wind turbines of 3.6 MW are needed, which is expected to generate between 82 GWh/year and 599 GWh/year using the 1-year p-90 value (worst case) and 10-year p-50 value (base case), respectively. Another important parameter used to compare efficiencies of energy production across technologies is the capacity factor. The capacity factor is the ratio of actual electrical energy output over a given period of time to the maximum possible energy output over that period [38]. The capacity factor, illustrated in Table 3.5, of 10-Year p-50 of 38.8% can be considered as the base-case

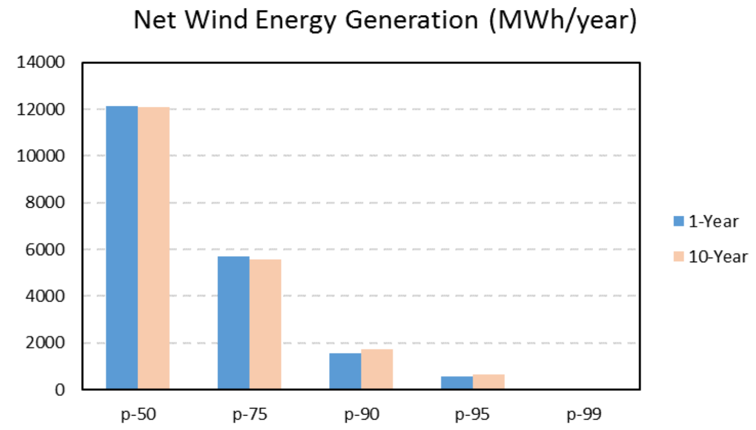

Fig. 3.5 p-values of Net Wind Energy Generation for 1-Year and 10-Year Data (Bar Chart).

Table 3.5 p-values of Net Wind Energy Generation and Capacity Factors.

p-value	Energy (MWh/year)		Max Energy	Capacity Factor	
	1-Year	10-Year		1-Year	10-Year
p-50	12,535.40	11,980.87	31,104.00	40.3%	38.5%
p-75	5,750.46	5,578.30	31,104.00	18.5%	17.9%
p-90	1,635.57	1,730.58	31,104.00	5.3%	5.6%
p-95	624.14	650.04	31,104.00	2.0%	2.1%
p-99	19.29	34.60	31,104.00	0.1%	0.1%

scenario that the turbine is expected to operate in normal conditions and 1-Year p-90 of 5% can be thought of as the worst-case scenario.

3.2 Power Generation from a Solar PV

Power generation from solar energy varies depending on solar irradiance. There are 3 types of solar irradiances: direct irradiance, diffused irradiance, and global irradiance [39], as shown in Fig. 3.6. Also, the energy from the sun is absorbed differently depending on the configuration of the solar panel installment. Three widely used configurations are fixed horizontal, fixed tilted, and tracking configurations. Therefore, global horizontal irradiance (GHL) will be used as solar data to illustrate the calculation method of energy from solar irradiance though data from other combinations of the irradiance and configuration could easily be applied to this method. As an example, the 1996 GHL profile of Hawaii, the USA from [40] is shown in Fig. 3.7. Table 3.6 displays the mean value and standard deviation of the solar irradiance of daily radiations for each year over 10 years (from 1996 to 2005). Again, it should be noted that the standard deviation of 10-year data is less than that of 1-year data due to the lower impacts from the contribution of extreme events of too strong solar radiation.

Since the data of solar irradiance is already in MW, a Monte Carlo simulation with 50,000 samples is then performed based on the means and standard deviations of 1996 and 10-year

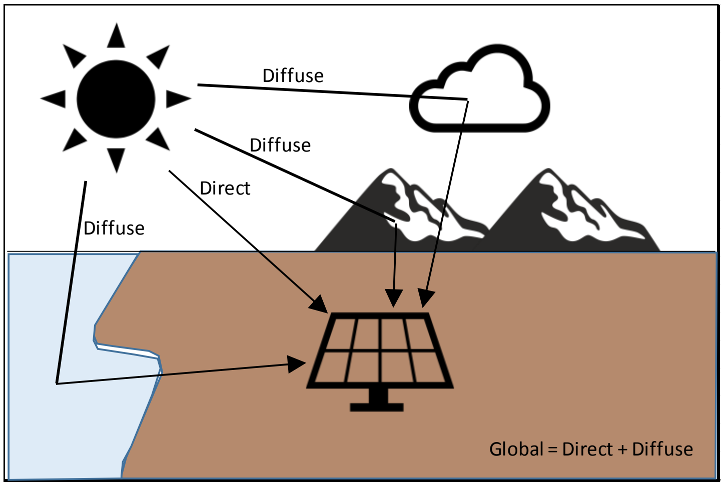

Fig. 3.6 Types of Solar Irradiance.

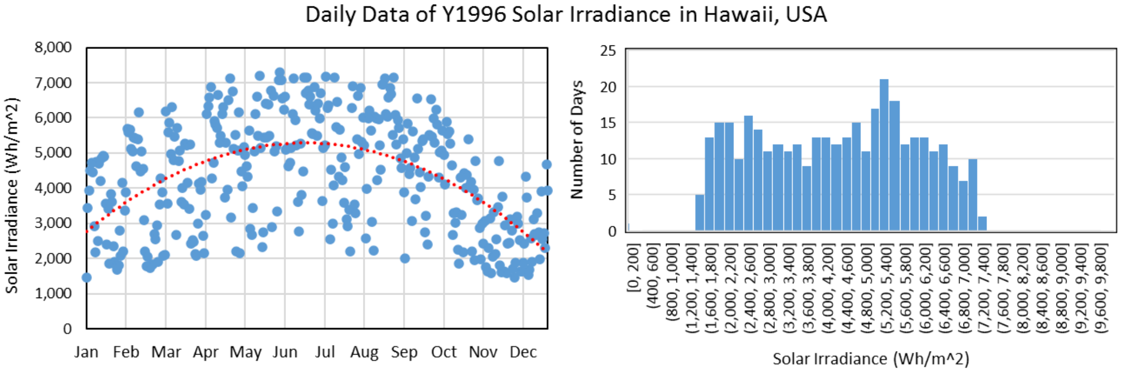

Fig. 3.7 Y1996 Daily Data of Solar Irradiance Profile in Hawaii, USA.

Table 3.6 Means and Standard Deviations of Solar Irradiance from 1996 to 2005.

Year	Mean	SD
1996	4310.8	1608.4
1997	4268.8	1423.6
1998	3637.9	1293.7
1999	3559.4	1431.7
2000	3680.9	1406.4
2001	3682.0	1307.7
2002	3787.1	1335.2
2003	4009.1	1500.7
2004	4217.3	1425.2
2005	4180.4	1297.8
10 Years	3933.4	1379.6

data, assuming a normal distribution of the data of solar irradiance. The distributions of solar energy for the two cases are plotted in Fig. 3.8. Similar to the losses assumed in the wind example, material losses for solar energy mainly from DC-to-AC conversion from an inverter (since solar panels only generate a DC power output) and electrical transmission efficiency

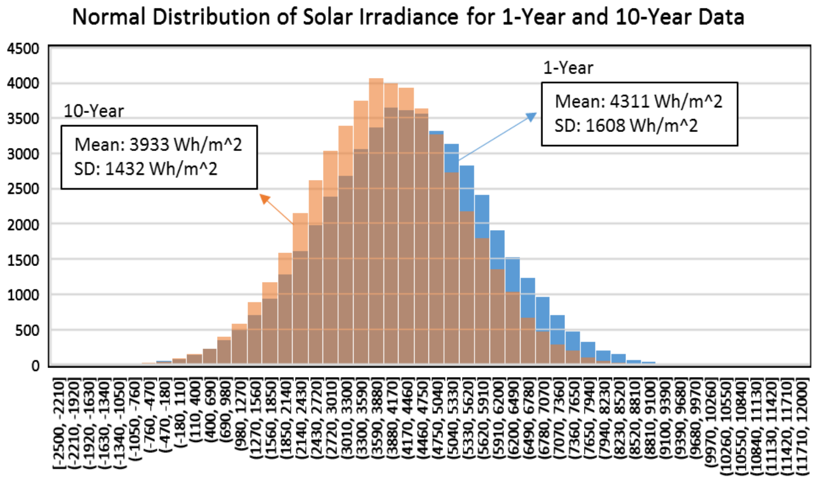

Fig. 3.8 Normal Distribution of Solar Irradiance for 1-Year and 10-Year Data.

Table 3.7 p-values of Net Solar Energy Generation for 1-Year and 10-Year Data.

Net Solar Energy	Per hour (Wh/m^2)		Per year (kWh/m^2)	
	1-Year	10-Year	1-Year	10-Year
p-50	388.9	355.7	1,399.9	1,280.5
p-75	291.8	268.9	1,050.4	968.2
p-90	201.6	192.0	725.6	691.3
p-95	149.5	145.2	538.2	522.6
p-99	51.8	53.8	186.5	193.6

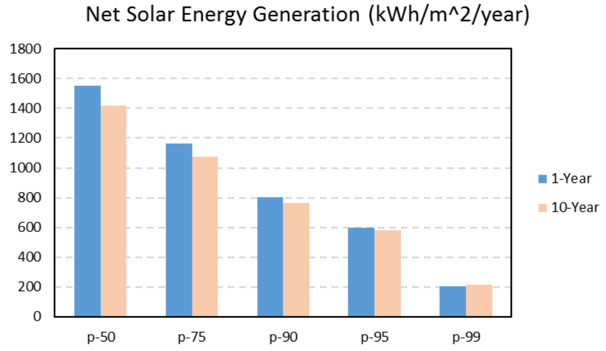

Fig. 3.9 p-values of Net Solar Energy Generation for 1-Year and 10-Year Data (Bar Chart).

[41] are assumed constant at 0.05. The p-values of net solar energy generation for 1-year and 10-year data taking into account these losses and converted to appropriate 1-hour energy by divided the 1-day energy by 10 hours of daylight and to 1-year energy by multiplying the 1-day energy with 360 days are shown in Table 3.7.

Then, suitable solar panels (e.g. using per-hour data) can be chosen and scaled up to a solar farm. For instance, a solar farm that covers an area of 200 x 200 meters is expected to generate between 29 GWh/year and 51 GWh/year using the 1-year p-90 value (worst case)

Table 3.8 p-values of Net Solar Energy Generation and Capacity Factors.

p-value	Energy (kWh/m^2/year)		Max Energy	Capacity Factor	
	1-Year	10-Year		1-Year	10-Year
p-50	1,399.93	1,280.55	5,154.94	27.2%	24.8%
p-75	1,050.44	968.21	5,154.94	20.4%	18.8%
p-90	725.61	691.28	5,154.94	14.1%	13.4%
p-95	538.20	522.62	5,154.94	10.4%	10.1%
p-99	186.53	193.55	5,154.94	3.6%	3.8%

and 10-year p-50 value (base case), respectively. Series and parallel configurations are designed to match grid requirements at the transmission point. Similar to that of wind, the capacity factor, shown in Table 3.8, of 10-Year p-50 of 24.8% can be considered as the base-case scenario that the solar panels are expected to operate in normal conditions and 1-Year p-90 of 14.1% can be thought of as the worst-case scenario, assuming a solar panel of 114 W/m2 with the aperture efficiency of 19.1% from Black Diamond, Mitsubishi Electric US [42]. Both the wind and solar capacity factors are reasonably in the range of IRENA costs report [43].

3.3 Revenues and Costs of the Project

Revenues in renewable energy projects can be forecasted by multiplying the net energy generation obtained in the previous session by the fixed price under a long-term PPA contract with some adjustments for other losses or price escalation (linking to the inflation). Examples of PPA prices and capacity of wind onshore and solar PV projects in the US are shown in Fig. 3.10 and Table 3.9. The database is drawn from Bloomberg New Energy Finance (BNEF) [43] and is useful as a reference of the average PPA price and capacity in wind and solar technologies used in the financial model.

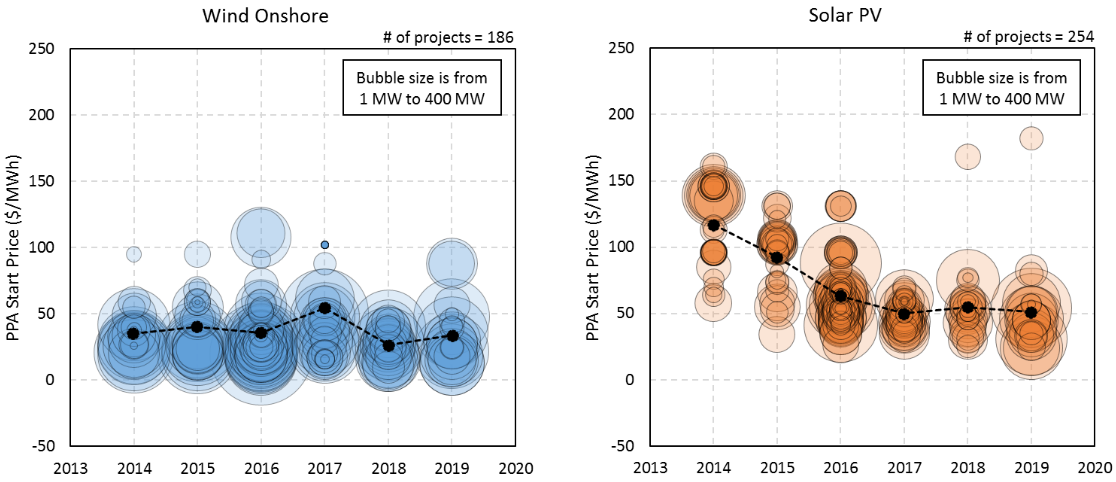

Fig. 3.10 PPA Price and Capacity of Wind Onshore and Solar PV Projects in the US.

Table 3.9 Statistics of PPA Price and Capacity of Wind Onshore and Solar PV Projects in US.

	Year	Unit: $/MWh				Unit: MW			
		Avg PPA Price	SD PPA Price	Max PPA Price	Min PPA Price	Avg Capacity	SD Capacity	Max Capacity	Min Capacity
Wind	2014	36.05	17.08	95	19	94.18	82.12	250	2
	2015	41.15	20.68	95	19	88.67	72.30	250	1
	2016	36.40	22.37	111	16	111.23	82.47	400	7
	2017	55.24	34.87	102	16	58.26	68.60	298	2
	2018	27.19	10.54	45	10	91.92	53.64	212	22
	2019	34.68	21.47	88	13	96.64	66.43	221	7
Solar	2014	116.86	30.75	161	58	39.86	34.56	151	10
	2015	92.42	24.83	131	34	36.33	18.76	80	7
	2016	63.32	22.97	131	26	50.60	44.77	250	1
	2017	50.07	9.48	70	33	45.47	30.75	130	2
	2018	54.83	25.77	168	25	40.17	31.77	150	4
	2019	50.96	30.64	182	24	77.58	63.46	247	1

In some cases, the PPA contract may not cover the entire useful life of the project. Hence, some portion of electricity output is subject to the risk that future electricity prices may vary (i.e. merchant risk). This merchant risk is usually dealt with by using the forward price curve of electricity to estimate future power prices. Although the estimation process can be complex and subject to a number of assumptions to account for the illiquid characteristic of the market, various methods of future price estimation exist [45]-[48].

There are various expenses that may be considered as the costs used renewable energy projects. First and foremost, the capital expenditure (CAPEX) of total installed costs. These costs cover almost every expense necessary to build the power plant, for instance, in solar cases, racking and mounting, solar PV modules and inverters, cabling and wiring, grid connection, electrical and mechanical installation, safety and security of the plant, and other soft costs (financing costs, system design, permitting costs, customer acquisition, lender’s margins, etc.) [43]. Apart from the initial installed costs that get the project off the ground, the operational expense (OPEX) or operation and maintenance (O&M) costs of the project are needed once the project is complete. It should be mentioned that the insurance and asset management costs should also be incorporated in the model apart from the O&M costs. To add more complexity, different countries also have different cost structures and cost levels.

Table 3.10 2019 Global Weighted Average Total Installed and O&M Costs.

Renewable Energy Technology	2019 Global Weighted Average (USD/kW)	
	Total Installed Costs	O&M Costs per Year
Wind Onshore	1,473	28
Wind Offshore	3,800	67
Solar PV	995	14
Solar Concentration	5,774	77
Hydropower	1,704	40
Geothernal	3,916	115
Bioenergy	2,141	86

The cost data that will be used in the financial model in the next sections are extracted from the report of IRENA power generation costs [43]. The summary of the latest (2019) global weighted average total installed costs and O&M costs of different renewable energy technologies are shown in Table 3.10. The database of total installed costs and O&M costs in wind onshore and solar PV technologies by country is drawn from the BNEF [43] and is shown in Table 3.11 with inflation from the World Bank [49] and long-term (10-year) interest rates from Thomson Reuters [50]. Though global weighted averages will be used in the financial model in the next section, observation of the data by country in Table 3.11 is useful to realize the cost differences between countries and jurisdictions.

3.4 Debt Sizing

Now that the ballpark numbers of components for revenues and costs are known, future profits that determine the amount of debt can be raised can be obtained. Since project lenders depend largely on the cash flows generated by the project in a non-recourse basis of project finance, the lenders typically demand certain ratios to be maintained so that the project company can meet its debt obligations. The most important ratio used in project finance is debt service coverage ratio (DSCR), which is the ratio of cash flow available for debt service (CFADS) to the mandatory debt service (the sum of interest and amortization), as shown in

Table 3.11 Costs in Wind Onshore and Solar PV, Inflation, and Long-term Interest Rate.

Country	Wind Onshore			Solar PV			Inflation (%)	Long-Term Interest Rate (%)
	Loan Margin (bps)	CAPEX (M$/MW)	O&M Costs (k$/MW/Yr)	Loan Margin (bps)	CAPEX (M$/MW)	O&M Costs (k$/MW/Yr)		
Argentina	1075	1.51	28.35	1170	1.08	16.6	50.62	54.41
Australia	475	1.31	17.8	475	0.71	11.4	1.61	1.44
Brazil	1100	1	15.5	1100	0.79	12.6	3.73	7.80
Canada	400	1.49	28.2	415	0.805	13.75	1.95	1.56
Chile	588	1.77	25.4	588	0.88	17.1	2.56	3.52
China	490	1.02	11.9	575	0.585	6.7	2.90	3.19
Denmark	400	1.63	20	-	-	-	0.76	-0.21
France	250	1.47	23.25	200	0.76	13.6	1.11	0.09
Germany	200	1.55	25.6	175	0.71	13.6	1.45	-0.24
Guatemala	-	-	-	690	1.08	23.5	3.70	6.71
India	1012.5	0.865	9.9	1012.5	0.465	6.2	7.66	6.87
Italy	375	1.45	24.3	250	0.76	13.6	0.61	1.84
Japan	207	2.61	40.1	200	1.605	40.4	0.48	-0.10
Malaysia	-	-	-	650	1.04	14.7	0.66	3.62
Mexico	840	1.48	23.6	640	0.88	18.1	3.64	7.54
Netherlands	250	1.5	23.4	-	-	-	2.63	-0.10
Panama	700	1.94	27.4	-	-	-	-0.36	3.86
Peru	460	1.77	25.4	588	0.97	19.6	2.14	4.73
Poland	400	1.68	27.2	-	-	-	2.23	2.39
South Africa	1100	1.67	23.6	1200	0.84	15.4	4.12	9.08
Spain	400	1.38	23.7	-	-	-	0.70	0.60
Sweden	350	1.12	19.9	-	-	-	1.78	0.09
Thailand	-	-	-	550	1.04	19.6	0.71	1.96
Turkey	550	1.83	21.3	436	0.88	14.6	15.18	7.04
United Arab Emirates	-	-	-	475	0.85	17.35	-1.93	4.83
United Kingdom	400	1.495	24.65	350	0.83	13.7	1.74	0.85
United States	430	1.37	27.6	422.5	0.99	12.55	1.81	2.08
Uruguay	-	-	-	1100	0.97	17.1	7.88	5.44

Eq. (1). The DSCR reflects the ability of the project company to service its debts and demonstrates that the project company has enough cash to honor its debts. The DSCR is determined by the lenders' viewpoints and depends largely on the outlook of an individual project. That is, if the project is deemed riskier, the lenders may require higher DSCR and vice versa. For example, the lenders may require the DSCR of 2x in the base-case scenario where the net energy generation is expected at 50% chance, while the lenders may require the DSCR of 1x in the worst-case scenario since they are (90%) more certain about the expected net energy generation. Once the DSCR is set by the lenders, the amount of debt that can be raised for the project can be back-solved, setting the amount of principal at the maturity period to zero. The debt amortization is typically set such that the DSCR is maintained at the lenders' requirement level. This process is also known as debt sculpting.

$$DSCR = \frac{CFADS}{Debt\ Service} \qquad \ldots(1)$$

As will be seen later in the section of sensitivity analysis, many factors, ranging from the type, useful life, and fixed price under the PPA of power plant to the inflation and interest rates and the DSCR, can affect the prospect and thus the borrowing amount of the project. Therefore, reasonable assumptions of these factors need to be made. Table 3.12 illustrate the assumptions of a solar PV plant under base-case and worst-case scenarios. The solar panels

Table 3.12 Assumptions Used in Financial Modeling for Base-Case and Worst-Case Scenarios.

Assumptions	Base Case	Worst Case	Unit
Plant Type	Solar PV	Solar PV	-
Plant Capacity	200	200	MW
Plant Area	335,213	335,213	m^2
Useful Life	20	20	Years
Net Generation	429,255	243,235	MWh per Year
PPA Price	60	60	$ per MWh
CAPEX	995	995	k$ per MW
O&M Cost	14	14	k$ per MW-Yr
Admin & Miscell Costs	10	10	k$ per MW-Yr
Selling Components at Maturity	50	50	k$ per MW
PPA Escalation Rate	2.0	2.0	%
Inflation Rate	2.5	2.5	%
Corporate Tax	24	24	%
Flat Interest Rate	2.0	2.0	%
Construction Margin	300	300	bps
Lender's Margin	250	250	bps
Required DSCR	1.5	1.0	Ratio
Start of Construction	31/12/2020	31/12/2020	-
Commerial Operation Date	31/03/2023	31/03/2023	-
Construction Milestone 1st Year	60	60	%
Construction Milestone 2nd Year	90	90	%
Construction Milestone 3rd Year	100	100	%

from Table 3.8, extending to the capacity of this solar farm, are used to arrive at the plant area and net energy generation per year. The fixed price under the 20-year PPA contract (assuming that the PPA contract covers entirely the useful life of the project) with the off-taker is estimated using data in Table 3.9, and the data of CAPEX and O&M costs are drawn from Table 3.10. Lastly, the inflation of 2.5%, the term loan interest rate of 2%, the construction loan interest rate of 8%, and lender's margin (borrowing fees) of 250 bps are assumed based on the numbers from Table 3.11. It should be noted that depending on the jurisdiction and frequency of the debt repayments, different indices of interest rates such as the London Inter-bank Offered Rate (LIBOR) 3M, LIBOR 6M, the Euro Interbank Offered Rate (EURIBOR) 3M, or EURIBOR 6M might be used. More recently, in the replacement of the term rates such as LIBOR 3M and EURIBOR 6M, overnight rates such as the Secured Overnight Financing Rate (SOFR) and Euro Short-Term Rate (ESTR) are becoming popular to be used as the interest rates. The term structures of LIBOR 3M and EURIBOR 6M are demonstrated in Fig. 3.11. Nonetheless, a flat interest rate (that is, the interest rate is the same throughout) is applied annually throughout the project's useful life. Although a financial model with a quarterly basis might give better results and more accurately reflect reality, opportunity costs between quarters within a year is ignored for the sake of concise illustration. Furthermore, this project presumes corporate tax of 24% and no foreign currency risk (thus, the cross-currency swap (CCS) is not needed). Lastly, it is assumed that there are no adjustments to working capital and debt service reserve account for the sake of simplicity.

The construction of a solar farm is started on December 31st, 2020 and takes 2 years and 3 months to complete. The power plant's construction is assumed to be 60% and 90% complete in the first and second years, respectively. The last 10% of the construction takes 3 months and is done on March 31st, 2023. Once the construction is completed as expected, the project starts its operation immediately. The capital expenditure of the project

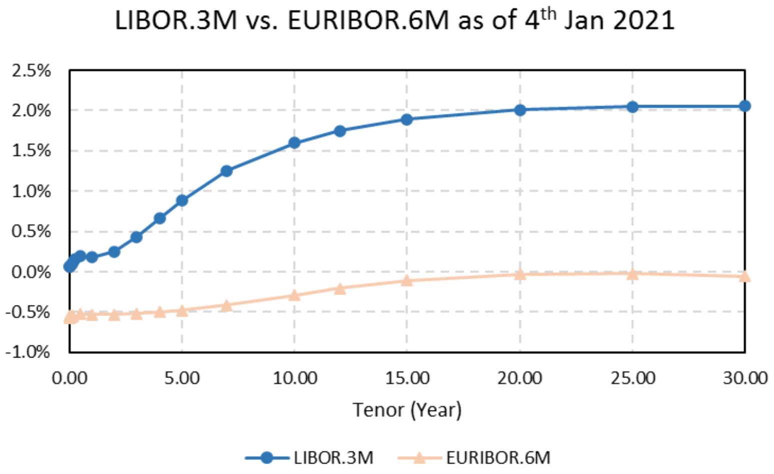

Fig. 3.11 Term Structures of LIBOR-3M and EURIBOR-6M.

construction is divided throughout the construction period depending upon the construction milestones reached. Before the year end of 2023, the plant can operate and generate up to 75% (the remaining 9 months) of its expected energy generation. Therefore, the project company pays only 75% of the O&M costs for the first year of project's operation.

The interest expense paid to the project lenders is divided into 2 periods: the construction period with the construction loan rate and the operation period with the term loan rate. It should be noted that in year 2023, the interest expense is calculated using 25% of the construction loan rate and 75% of the term loan rate since the project is complete on March 31st, 2023. Since the free cash flows (FCF) stay negative during the first 3 years, no interest is paid to the lenders until after 2024. Because of the negative free cash flows, the overall amount of interest expense during the first 3 years is averaged out over the remaining 19.25 years equally and is added on the regular (term-loan) interest payments. The amortization amount is subtracted to adjust the amount of debt service such that the DSCR is maintained (e.g. debt sculpting).

The spreadsheets of the financial models for base-case and worst-case scenarios are illustrated in Table 3.13 and Table 3.14, respectively. With the aforementioned assumptions, the lenders calculate the amounts of debt that can be raised for the project under these two cases by setting the principal at the last period to zero. The debt principals are $176.87 million and $134.30 million for the base-case (with the DSCR of 1.5x) and worst-case (with the DSCR of 1.0x) scenarios, respectively. Then, the lower (more conservative) amount ($134.30 million) will be used in debt financing by the lender. The profiles of debt (interest and amortization) repayments for base-case and worst-case scenarios in Fig. 3.12 are scheduled to the lenders. The interests reduce as the project ages while the amount of debt principal drops, and the principal repayments stay constant.

Then, after the amount of debt is known, the amount of equity can be calculated such that the sum covers the costs for the construction, administration, management, and miscellaneous fees during the first 3 years. The leverage ratio of this project can be found by dividing the amount of debt by the amount of assets. Lastly, the equity holders (project sponsors) pay for the costs at the leverage ratio during the first 3 years where the free cash flows are still negative. As demonstrated in Table 3.13 and Table 3.14, the maximum project leverage ratios are 82.7% and 62.2% for the base-case and worst-case scenarios, respectively. Lastly, at the end of the project's useful life, it is assumed that all the solar panels and other equipment of this solar PV project are sold with the factor of $50k per MW. The value at the end of the project's operation is known as a terminal value.

Table 3.13 The Financial Model under Base Case.

Financial Model Unit: '000 USD

Forecast																								
Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2042
Discounting Period	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Construction Milestone	0%	60%	90%	100%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Operation Period	-	-	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Energy Generation (%)		-	-	75.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	25.0%
Energy Generation (MWh)		-	-	321,941	429,255	429,255	429,255	429,255	429,255	429,255	429,255	429,255	429,255	429,255	429,255	429,255	429,255	429,255	429,255	429,255	429,255	429,255	429,255	107,314
PPA Escalation Rate		-	-	1.00	1.02	1.04	1.06	1.08	1.10	1.13	1.15	1.17	1.20	1.22	1.24	1.27	1.29	1.32	1.35	1.37	1.40	1.43	1.46	1.49
Inflation (Base 2021)		1.00	1.03	1.05	1.08	1.10	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.38	1.41	1.45	1.48	1.52	1.56	1.60	1.64	1.68	1.72
Inflation (Base 2023)		-	-	1.00	1.03	1.05	1.08	1.10	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.38	1.41	1.45	1.48	1.52	1.56	1.60	1.64
PPA Price		-	-	60.00	61.20	62.42	63.67	64.95	66.24	67.57	68.92	70.30	71.71	73.14	74.60	76.09	77.62	79.17	80.75	82.37	84.01	85.69	87.41	89.16
Electricity Revenue		-	-	19,316	26,270	26,796	27,332	27,878	28,436	29,005	29,585	30,176	30,780	31,396	32,024	32,664	33,317	33,984	34,663	35,357	36,064	36,785	37,521	9,568
Less: CAPEX		(119,400)	(59,700)	(19,900)																				
Less: Admin & Miscell Costs		(2,000)	(2,050)	(2,101)	(2,154)	(2,208)	(2,263)	(2,319)	(2,377)	(2,437)	(2,498)	(2,560)	(2,624)	(2,690)	(2,757)	(2,826)	(2,897)	(2,969)	(3,043)	(3,119)	(3,197)	(3,277)	(3,359)	(861)
Less: O&M Cost		-	-	(2,100)	(2,870)	(2,942)	(3,015)	(3,091)	(3,168)	(3,247)	(3,328)	(3,412)	(3,497)	(3,584)	(3,674)	(3,766)	(3,860)	(3,956)	(4,055)	(4,157)	(4,261)	(4,367)	(4,476)	(1,147)
EBITDA		(2,000)	(2,050)	15,115	21,247	21,646	22,054	22,468	22,891	23,321	23,759	24,205	24,659	25,122	25,593	26,072	26,561	27,058	27,565	28,081	28,606	29,141	29,685	7,560
Less: Change in Net Working Capital		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CFO		(2,000)	(2,050)	15,115	21,247	21,646	22,054	22,468	22,891	23,321	23,759	24,205	24,659	25,122	25,593	26,072	26,561	27,058	27,565	28,081	28,606	29,141	29,685	7,560
FCFF (CFO-CAPEX)		(121,400)	(61,750)	(4,785)	21,247	21,646	22,054	22,468	22,891	23,321	23,759	24,205	24,659	25,122	25,593	26,072	26,561	27,058	27,565	28,081	28,606	29,141	29,685	7,560
Tax Consideration																								
D&A from CAPEX		-	-	(7,463)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(2,488)
EBIT		(2,000)	(2,050)	7,653	11,297	11,696	12,104	12,518	12,941	13,371	13,809	14,255	14,709	15,172	15,643	16,122	16,611	17,108	17,615	18,131	18,656	19,191	19,735	5,072
EBT		(2,000)	(2,050)	7,653	1,994	2,807	3,628	4,456	5,292	6,135	6,987	7,846	8,714	9,590	10,474	11,368	12,269	13,180	14,100	15,030	15,968	16,917	17,875	3,703
Corporate Tax		-	-	(1,837)	(478)	(674)	(871)	(1,069)	(1,270)	(1,472)	(1,677)	(1,883)	(2,091)	(2,302)	(2,514)	(2,728)	(2,945)	(3,163)	(3,384)	(3,607)	(3,832)	(4,060)	(4,290)	(889)
Net Income		(2,000)	(2,050)	5,816	1,515	2,133	2,757	3,386	4,022	4,663	5,310	5,963	6,622	7,288	7,961	8,639	9,325	10,017	10,716	11,423	12,136	12,857	13,585	2,814
FCFF (After-Tax)		(121,400)	(61,750)	(6,621)	20,768	20,973	21,183	21,399	21,621	21,848	22,082	22,322	22,568	22,820	23,079	23,344	23,616	23,895	24,181	24,473	24,773	25,081	25,395	16,671
Debt Sizing																								
Beginning		176,870	176,870	176,870	176,870	172,328	167,445	162,201	156,578	150,554	144,107	137,215	129,852	121,994	113,614	104,685	95,176	85,059	74,300	62,867	50,724	37,835	24,161	9,662
Add: Interest Expense		8,844	8,844	8,180	7,959	7,755	7,535	7,299	7,046	6,775	6,485	6,175	5,843	5,490	5,113	4,711	4,283	3,828	3,344	2,829	2,283	1,703	1,087	109
Less: Interest Paid		-	-	-	(9,303)	(9,099)	(8,879)	(8,643)	(8,390)	(8,119)	(7,829)	(7,518)	(7,187)	(6,833)	(6,456)	(6,055)	(5,627)	(5,171)	(4,687)	(4,173)	(3,626)	(3,046)	(2,431)	(1,452)
Less: Principal Paid (Debt Sculpting)		-	-	-	(4,543)	(4,883)	(5,243)	(5,623)	(6,024)	(6,447)	(6,893)	(7,363)	(7,858)	(8,380)	(8,929)	(9,508)	(10,117)	(10,759)	(11,433)	(12,143)	(12,889)	(13,674)	(14,499)	(9,662)
Ending	**176,870**	176,870	176,870	176,870	172,328	167,445	162,201	156,578	150,554	144,107	137,215	129,852	121,994	113,614	104,685	95,176	85,059	74,300	62,867	50,724	37,835	24,161	9,662	**(0)**
CFADS		-	-	-	20,768	20,973	21,183	21,399	21,621	21,848	22,082	22,322	22,568	22,820	23,079	23,344	23,616	23,895	24,181	24,473	24,773	25,081	25,395	16,671
Target DSCR of 1.5		-	-	-	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Debt Service		-	-	-	13,845	13,982	14,122	14,266	14,414	14,566	14,721	14,881	15,045	15,213	15,386	15,563	15,744	15,930	16,120	16,316	16,516	16,720	16,930	11,114
Debt Schedule																								
Beginning		176,870	176,870	176,870	176,870	167,682	158,494	149,306	140,118	130,930	121,742	112,554	103,366	94,178	84,990	75,802	66,614	57,425	48,237	39,049	29,861	20,673	11,485	2,297
Add: Interest Expense		8,844	8,844	8,180	7,959	7,546	7,132	6,719	6,305	5,892	5,478	5,065	4,651	4,238	3,825	3,411	2,998	2,584	2,171	1,757	1,344	930	517	26
Less: Interest Paid		-	-	-	(9,303)	(8,889)	(8,476)	(8,063)	(7,649)	(7,236)	(6,822)	(6,409)	(5,995)	(5,582)	(5,168)	(4,755)	(4,341)	(3,928)	(3,514)	(3,101)	(2,688)	(2,274)	(1,861)	(1,370)
Less: Principal Paid		-	-	-	(9,188)	(9,188)	(9,188)	(9,188)	(9,188)	(9,188)	(9,188)	(9,188)	(9,188)	(9,188)	(9,188)	(9,188)	(9,188)	(9,188)	(9,188)	(9,188)	(9,188)	(9,188)	(9,188)	(2,297)
Ending	**176,870**	176,870	176,870	176,870	167,682	158,494	149,306	140,118	130,930	121,742	112,554	103,366	94,178	84,990	75,802	66,614	57,425	48,237	39,049	29,861	20,673	11,485	2,297	**0**
Debt Service					18,491	18,078	17,664	17,251	16,837	16,424	16,010	15,597	15,183	14,770	14,356	13,943	13,529	13,116	12,703	12,289	11,876	11,462	11,049	3,667
Real DSCR					1.1	1.2	1.2	1.2	1.3	1.3	1.4	1.4	1.5	1.5	1.6	1.7	1.7	1.8	1.9	2.0	2.1	2.2	2.3	4.5
Equity Contribution																								
Terminal Value	10,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10,000
Accumulated CF		-	(183,150)	(189,771)	(169,003)	(148,030)	(126,847)	(105,449)	(83,828)	(61,980)	(39,898)	(17,576)	4,992	27,812	50,891	74,235	97,851	121,746	145,927	170,400	195,173	220,254	245,649	262,321
FCFE		(20,970)	(10,667)	(1,144)	4,988	5,702	6,424	7,153	7,889	8,634	9,386	10,146	10,915	11,691	12,477	13,271	14,073	14,885	15,706	16,536	17,375	18,224	19,083	14,222
Equity Contribution	**36,932**																							
Max Project Leverage	**82.7%**																							

Table 3.14 The Financial Model under Worst Case.

Financial Model Unit: '000 USD

Forecast																								
Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2042
Discounting Period	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Construction Milestone	0%	60%	90%	100%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Operation Period	-	-	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Energy Generation (%)		-	-	75.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	25.0%
Energy Generation (MWh)		-	-	182,426	243,235	243,235	243,235	243,235	243,235	243,235	243,235	243,235	243,235	243,235	243,235	243,235	243,235	243,235	243,235	243,235	243,235	243,235	243,235	60,809
PPA Escalation Rate		-	-	1.00	1.02	1.04	1.06	1.08	1.10	1.13	1.15	1.17	1.20	1.22	1.24	1.27	1.29	1.32	1.35	1.37	1.40	1.43	1.46	1.49
Inflation (Base 2021)		1.00	1.03	1.05	1.08	1.10	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.38	1.41	1.45	1.48	1.52	1.56	1.60	1.64	1.68	1.72
Inflation (Base 2023)		-	-	1.00	1.03	1.05	1.08	1.10	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.38	1.41	1.45	1.48	1.52	1.56	1.60	1.64
PPA Price		-	-	60.00	61.20	62.42	63.67	64.95	66.24	67.57	68.92	70.30	71.71	73.14	74.60	76.09	77.62	79.17	80.75	82.37	84.01	85.69	87.41	89.16
Electricity Revenue		-	-	10,946	14,886	15,184	15,487	15,797	16,113	16,435	16,764	17,099	17,441	17,790	18,146	18,509	18,879	19,257	19,642	20,035	20,435	20,844	21,261	5,422
Less: CAPEX		(119,400)	(59,700)	(19,900)																				
Less: Admin & Miscell Costs		(2,000)	(2,050)	(2,101)	(2,154)	(2,208)	(2,263)	(2,319)	(2,377)	(2,437)	(2,498)	(2,560)	(2,624)	(2,690)	(2,757)	(2,826)	(2,897)	(2,969)	(3,043)	(3,119)	(3,197)	(3,277)	(3,359)	(861)
Less: O&M Cost		-	-	(2,100)	(2,870)	(2,942)	(3,015)	(3,091)	(3,168)	(3,247)	(3,328)	(3,412)	(3,497)	(3,584)	(3,674)	(3,766)	(3,860)	(3,956)	(4,055)	(4,157)	(4,261)	(4,367)	(4,476)	(1,147)
EBITDA		(2,000)	(2,050)	6,744	9,862	10,034	10,209	10,387	10,568	10,751	10,938	11,128	11,320	11,516	11,715	11,917	12,123	12,331	12,543	12,759	12,977	13,200	13,425	3,414
Less: Change in Net Working Capital		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CFO		(2,000)	(2,050)	6,744	9,862	10,034	10,209	10,387	10,568	10,751	10,938	11,128	11,320	11,516	11,715	11,917	12,123	12,331	12,543	12,759	12,977	13,200	13,425	3,414
FCFF (CFO-CAPEX)		(121,400)	(61,750)	(13,156)	9,862	10,034	10,209	10,387	10,568	10,751	10,938	11,128	11,320	11,516	11,715	11,917	12,123	12,331	12,543	12,759	12,977	13,200	13,425	3,414
Tax Consideration																								
D&A from CAPEX		-	-	(7,463)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(2,488)
EBIT		(2,000)	(2,050)	(718)	(88)	84	259	437	618	801	988	1,178	1,370	1,566	1,765	1,967	2,173	2,381	2,593	2,809	3,027	3,250	3,475	926
EBT		(2,000)	(2,050)	(718)	(7,152)	(6,666)	(6,177)	(5,685)	(5,190)	(4,693)	(4,192)	(3,689)	(3,182)	(2,672)	(2,159)	(1,643)	(1,124)	(601)	(75)	454	987	1,523	2,063	(114)
Corporate Tax		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(109)	(237)	(366)	(495)	-
Net Income		(2,000)	(2,050)	(718)	(7,152)	(6,666)	(6,177)	(5,685)	(5,190)	(4,693)	(4,192)	(3,689)	(3,182)	(2,672)	(2,159)	(1,643)	(1,124)	(601)	(75)	345	750	1,157	1,568	(114)
FCFF (After-Tax)		(121,400)	(61,750)	(13,156)	9,862	10,034	10,209	10,387	10,568	10,751	10,938	11,128	11,320	11,516	11,715	11,917	12,123	12,331	12,543	12,650	12,741	12,834	12,930	13,414
Debt Sizing																								
Beginning		134,299	134,299	134,299	134,299	131,501	128,404	124,993	121,251	117,160	112,701	107,855	102,601	96,919	90,784	84,175	77,066	69,431	61,245	52,478	43,210	33,434	23,125	12,256
Add: Interest Expense		6,715	6,715	6,211	6,043	5,918	5,778	5,625	5,456	5,272	5,072	4,853	4,617	4,361	4,085	3,788	3,468	3,124	2,756	2,362	1,944	1,505	1,041	138
Less: Interest Paid		-	-	-	(7,064)	(6,938)	(6,799)	(6,645)	(6,477)	(6,293)	(6,092)	(5,874)	(5,637)	(5,382)	(5,106)	(4,808)	(4,488)	(4,145)	(3,776)	(3,382)	(2,965)	(2,525)	(2,061)	(1,158)
Less: Principal Paid (Debt Sculpting)		-	-	-	(2,798)	(3,096)	(3,411)	(3,742)	(4,091)	(4,459)	(4,846)	(5,254)	(5,683)	(6,134)	(6,609)	(7,109)	(7,634)	(8,187)	(8,767)	(9,268)	(9,776)	(10,309)	(10,869)	(12,255)
Ending	**134,299**	134,299	134,299	134,299	131,501	128,404	124,993	121,251	117,160	112,701	107,855	102,601	96,919	90,784	84,175	77,066	69,431	61,245	52,478	43,210	33,434	23,125	12,256	**0**
CFADS		-	-	-	9,862	10,034	10,209	10,387	10,568	10,751	10,938	11,128	11,320	11,516	11,715	11,917	12,123	12,331	12,543	12,650	12,741	12,834	12,930	13,414
Target DSCR of 1		-	-	-	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Debt Service		-	-	-	9,862	10,034	10,209	10,387	10,568	10,751	10,938	11,128	11,320	11,516	11,715	11,917	12,123	12,331	12,543	12,650	12,741	12,834	12,930	13,414
Debt Schedule																								
Beginning		134,299	134,299	134,299	134,299	127,322	120,346	113,369	106,393	99,416	92,440	85,463	78,486	71,510	64,533	57,557	50,580	43,604	36,627	29,650	22,674	15,697	8,721	1,744
Add: Interest Expense		6,715	6,715	6,211	6,043	5,730	5,416	5,102	4,788	4,474	4,160	3,846	3,532	3,218	2,904	2,590	2,276	1,962	1,648	1,334	1,020	706	392	20
Less: Interest Paid		-	-	-	(7,064)	(6,750)	(6,436)	(6,122)	(5,808)	(5,494)	(5,180)	(4,866)	(4,552)	(4,238)	(3,924)	(3,610)	(3,296)	(2,982)	(2,669)	(2,355)	(2,041)	(1,727)	(1,413)	(1,040)
Less: Principal Paid		-	-	-	(6,977)	(6,977)	(6,977)	(6,977)	(6,977)	(6,977)	(6,977)	(6,977)	(6,977)	(6,977)	(6,977)	(6,977)	(6,977)	(6,977)	(6,977)	(6,977)	(6,977)	(6,977)	(6,977)	(1,744)
Ending	**134,299**	134,299	134,299	134,299	127,322	120,346	113,369	106,393	99,416	92,440	85,463	78,486	71,510	64,533	57,557	50,580	43,604	36,627	29,650	22,674	15,697	8,721	1,744	**0**
Debt Service					14,040	13,726	13,412	13,099	12,785	12,471	12,157	11,843	11,529	11,215	10,901	10,587	10,273	9,959	9,645	9,331	9,017	8,703	8,389	2,784
Real DSCR					0.7	0.7	0.8	0.8	0.8	0.9	0.9	0.9	1.0	1.0	1.1	1.1	1.2	1.2	1.3	1.4	1.4	1.5	1.5	4.8
Equity Contribution																								
Terminal Value	10,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10,000
Accumulated CF		-	(183,150)	(196,306)	(186,443)	(176,409)	(166,200)	(155,813)	(145,245)	(134,494)	(123,556)	(112,428)	(101,108)	(89,592)	(77,877)	(65,959)	(53,837)	(41,506)	(28,962)	(16,313)	(3,572)	9,262	22,192	35,606
FCFE		(45,900)	(23,347)	(4,974)	(2,483)	(2,072)	(1,659)	(1,242)	(823)	(401)	25	453	884	1,318	1,756	2,197	2,641	3,088	3,539	3,993	4,450	4,911	5,375	10,879
Equity Contribution	**81,648**																							
Max Project Leverage	**62.2%**																							

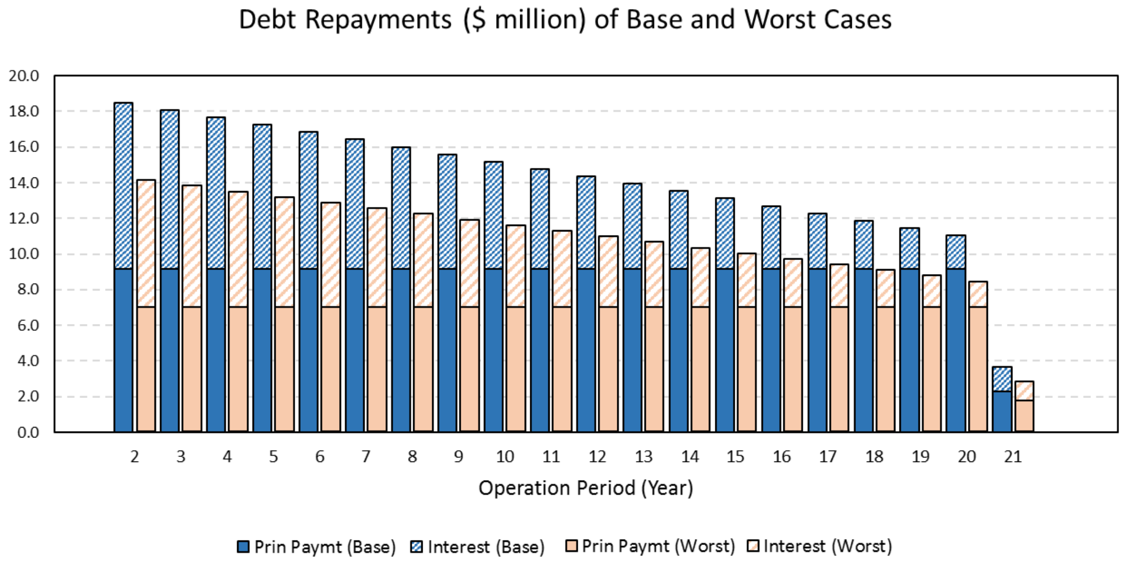

Fig. 3.12 Debt Repayments of Base and Worst Cases.

Once free cash flows in the financial model are obtained, in the next section, a common technique that incorporates the time value of money, namely discounted cash flows (DCF) will be used to value a renewable energy project using the financial model obtained in this section based on the assumptions in Table 3.12. Using this technique, individual renewable energy projects and companies with a portfolio of operating renewable energy projects can be valued and compared with the investment decision-making tools introduced in the next section.

Chapter 4

4 Project Valuation

Due to the non-recourse financing of project finance, valuation for renewable energy projects may differ from traditional projects under corporate finance. The information about the project given out to the outside investors is often limited, making it more difficult to gauge how a project is doing. Furthermore, the risks during development, construction, and operation periods are significantly different, let alone distinct characteristics of individual projects, making valuation even more difficult.

A common technique to value a renewable energy project is to look at the cash flows. Particularly, the analysis of project's cash flows in its construction and operation phases together with the concept of time value of money is done through discounted cash flows (DCF). Apart from the free cash flows (FCF) obtained in previous section, the cost of capital which will be converted into a discount factor can greatly vary depending upon the assumptions used and should be set to reflect the underlying risks associated with the project. More specifically, the cost of capital is commonly referred to as the weighted average cost of capital (WACC) that mainly incorporates the cost of equity, the cost of debt, and the capital structure of the project. The WACC can be calculated using Eq. (2) where r_e is the required return on equity, r_d is the required return on debt, E is the portion of project's equity, D is the portion of project's debt, and T_c is the corporate tax.

$$WACC = r_e \cdot \left(\frac{E}{D+E}\right) + r_d \cdot \left(\frac{D}{D+E}\right) \cdot (1 - T_c) \qquad \ldots(2)$$

With the free cash flows discounted by the WACC, a project can be valued through the DCF approach. Once the value of a single project is known, the DCF approach can be extended to a portfolio of operating projects to value a renewable energy company. In other words, renewable energy (and other electricity) generation companies are commonly valued as a portfolio of projects that are in operation. It should be noted that valuation of projects under development (before financial close) can also be done by multiplying the probability of success with the expected (and often calculated) value of the underlying project's cash flows. However, this section will only limit the valuation of renewable energy projects under construction and operation due to the complexity and subjectivity of the estimation of probability of success.

4.1 Required Return on Equity

The required rate of return on equity is typically estimated using capital asset pricing model (CAPM). The concept of CAPM has been widely used in finance for pricing risky assets and the cost of capital. The CAPM formula is shown in Eq. (3) where r_f is the risk-free rate that accounts for time value of money, r_m is the equity market return, (r_m-r_f) is the market risk premium or the return from the market above the risk-free rate, β_i is a measure of volatility of the return (or the individual risk)of a security i or asset i when compared to that of the market, and re is the required return on equity, which is the excess return of asset i over the market return that incorporates time value of money.

$$r_e = r_f + \beta_i\left(r_m - r_f\right) \qquad \ldots(3)$$

Despite the fact that the CAPM formula provides the expected return on a fairly valued asset, there are some crucial assumptions behind CAPM that might not hold in reality. The CAPM formula relies on the assumptions of efficient markets with rational, risk-averse, and return-maximizing investors, of the risk measurement through the volatility of security's price, of constant risk-free rate over the discounting period, and of approximation of the return on local market equity index as a representative of the market return [51]. Nonetheless, the CAPM formula is still widely used in finance owing largely to its simplicity of providing the investors an understanding of the expected risk-reward tradeoff.

The required return on equity can vary depending on jurisdiction with different risk profiles (risk-free rates and market risk premium or systematic risk) and on individual companies (idiosyncratic risk). In this section, a project is assumed to be built in Europe, using betas of companies in Spain, Germany, Italy, and France. Table 4.1 illustrates some listed renewable energy generation companies, their associated local stock indices, project examples, and their off-takers. The monthly movements of companies' stock prices and local stock indices obtained from Bloomberg database [52] are shown in Fig. 4.1 with their returns shown in Fig. 4.2.

Table 4.1 Listed Renewable Energy Companies and Project Examples.

Company	Bloomberg Code	Country	Local Stock Index	Project	Offtaker
Voltalia SA	VLTSA	France	CAC 40	Voltalia France PV Plant	Credit Mutuel Alliance Federale
Innogy Renewables	IGY	Germany	DAX	Innogy Nordsee Ost Offshore Wind Farm	Deutsche Bahn
Orsted A/S	ORSTED	Germany	DAX	Orsted Borkum Riffgrund 3 Offshore Wind Farm	Covestro
Eni SpA	ENI	Italy	FTSE MIB	Eni Saline Conti Vecchi PV Plant	Eni SpA, Gestore dei Servizi Elettrici SpA
Elecnor SA	ENO	Spain	IBEX 35	Enerfin Cofrentes Wind Farm	Compania Espanola de Petroleos
Encavis	CAS	Spain	IBEX 35	Encavis Seville PV Plant	Amazon
Enel Green Power	EGPW	Spain	IBEX 35	Enel Blesa and Moyuela Wind Farm	BBVA
Engie SA	ENGI	Spain	IBEX 35	Go Fit PV Plant	GO Fit
Iberdrola	IBE	Spain	IBEX 35	Iberdrola Andevalo PV Plant	Heineken

Fig. 4.3 illustrate the movements of betas obtained from Bloomberg database [52] for the renewable energy generation firms in Table 4.1. Since a beta is defined as the sensitivity of the firm's stock price to market index. Particularly, betas can be derived by solving for the slope where the x axis is the local market return and y axis is the firm's stock return. A beta below one indicates the firm's stock-price's insensitivity to the market sentiments (index movement), a beta more than one suggests the firm's stock price is more volatile that the market index, and a beta equal to one means the firm's stock price closely follows the market. As can be seen in Fig. 4.3, the average beta for the 9 renewable energy generation companies stays between 0.64 and 0.80, indicating the insensitivity of the power generation industry to the market sentiment; in other words, renewable energy generation companies are perceived as safer (or safe-haven stocks as some stock-brokers call) than the other listed companies on average. One example could be that renewable energy power plants, once built, keep generating energy with the dependence on the weather and their cash flows are unaffected by the economy instability or political turmoil.

As demonstrated in Fig. 4.4 for France, Germany, Italy, and Spain, 10-year and 30-year government bond yields are often used to represent long-term risk-free rates to reflect the true time value of money of the business. In this case, the yield curve is upward sloping as 30-year yields are higher than the 10-year yields. Depending on the nature of the company, 10-year government yield might be preferred than 30-year government yield. Nevertheless, 30-year government bond yield is adopted as the risk-free rate to calculate the required rate of return on equity since renewable energy power plants usually operate around 25 to 35 years for wind and solar energy.

After the risk-free rates of countries where the firms locate and firms' betas are obtained, 10-year average returns of market indices are used to represent the equity market returns. One commonly used and credible source that provides the reference for equity risk premium (which is the expected market return less risk-free rate) is Damodaran [53]. Lastly, two cases of the required returns on equity for 9 renewable energy generation companies are calculated using Eq. (3) with the market returns from 10-year average market indices and equity market risk premium from Damodaran. The results are shown in Table 4.2 with the averages of the first four companies and all the companies. The required returns on equity for renewable energy company (for a portfolio of operating renewable energy projects) range between 5.25% to 5.92%. Finally, the fact that the averages from the two cases do not differ materially can be a way to validate whether the results make sense. The average required return on equity of 5.6% will be used to calculate the WACC later on.

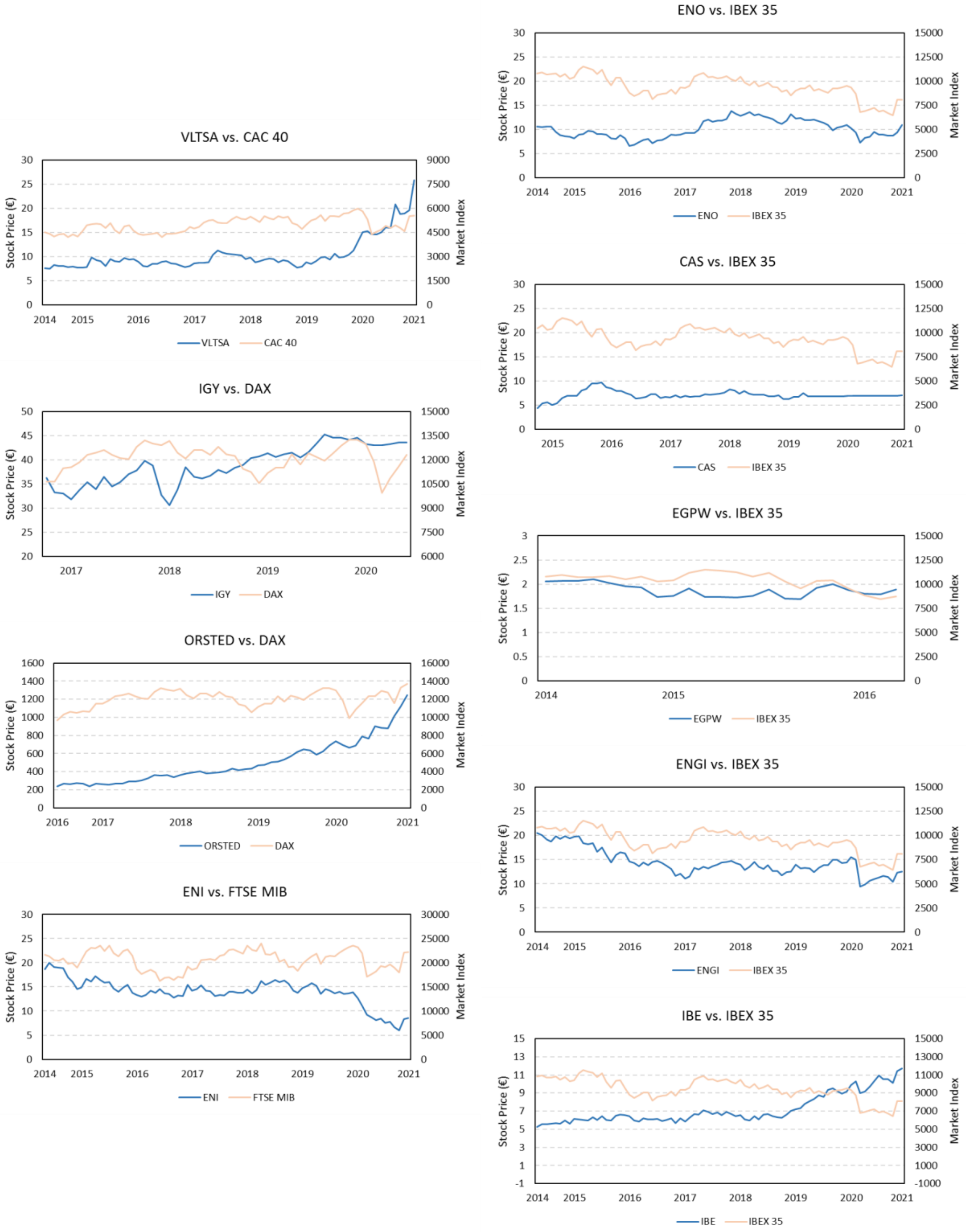

Fig. 4.1 Movements of Stock Prices and Local Stock Indices.

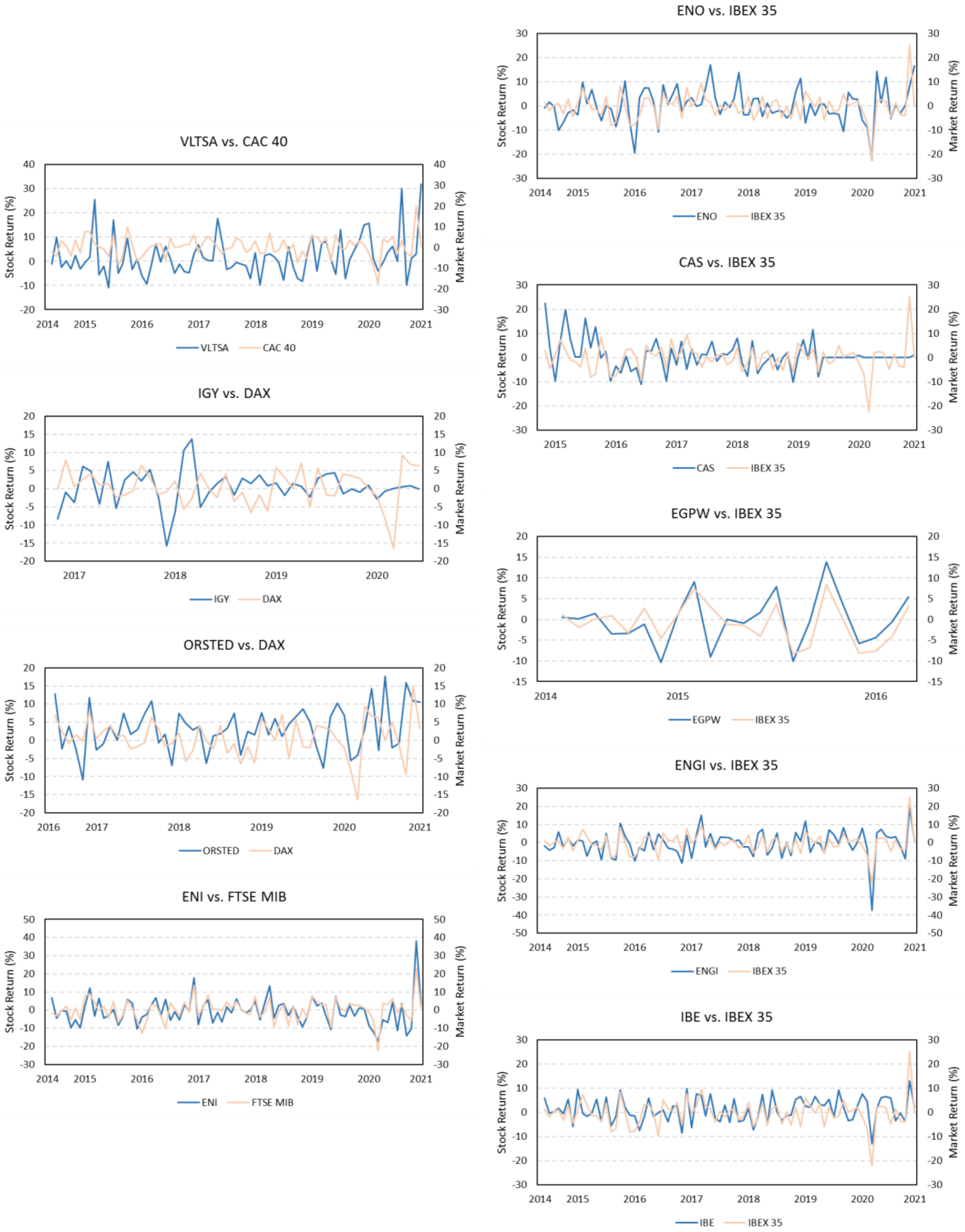

Fig. 4.2 Returns of Stock Prices and Local Stock Indices.

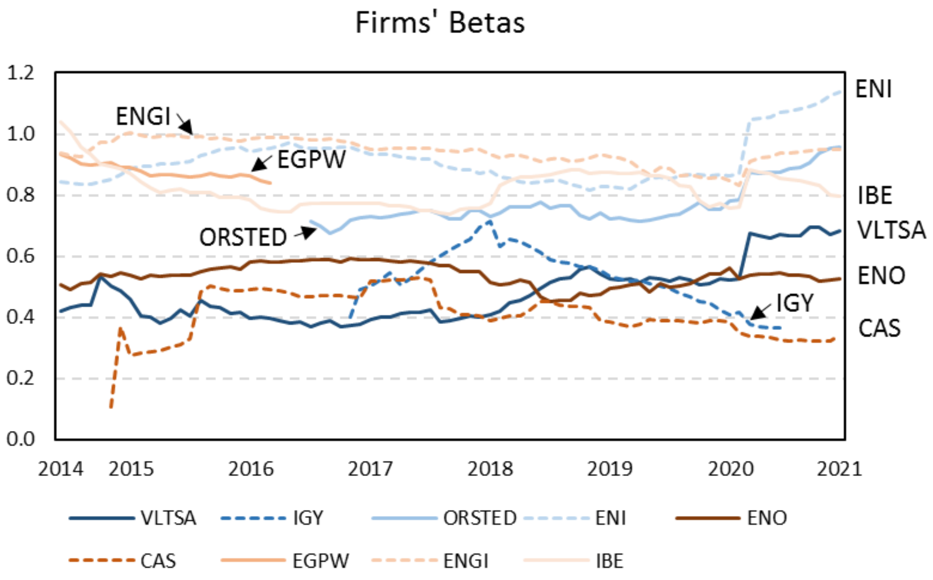

Fig. 4.3 Firms' Betas.

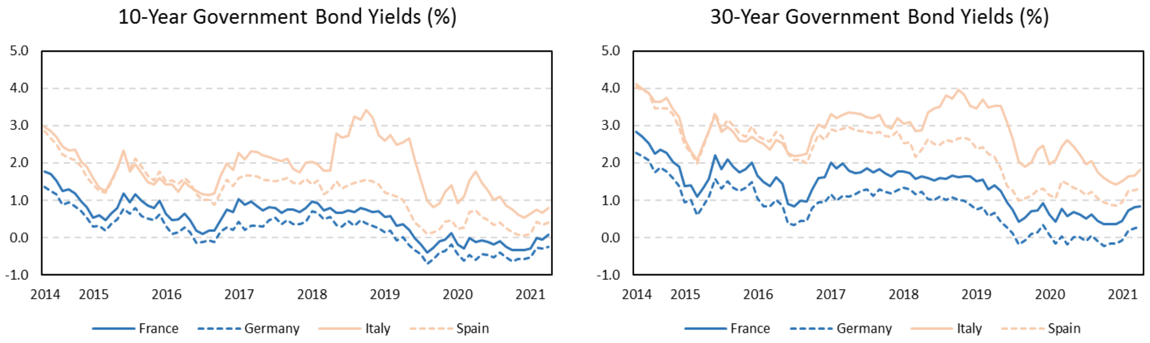

Fig. 4.4 10-Year and 30-Year Government Bond Yields.

Table 4.2 Countries' Risk-Free Rates, Firms' Betas, 10-Year Average Market Return, Equity Risk Premium from Damodaran, and Required Rates of Return (from 10-Year Average and Damodaran Equity Premium).

No	Company	Country	Risk-Free Rate (30Y Govt Bond)	Stock Index	Beta	10Y-Avg Stock Market Return	Equity Premium Damodaran	Return on Equity (10Y-Avg Mkt)	Return on Equity (Damodaran)
1	Voltalia SA	France	0.85%	CAC 40	0.68	7.66%	5.20%	5.51%	4.40%
2	Innogy Renewables	Germany	0.29%	DAX	0.37	8.82%	4.72%	3.42%	2.02%
3	Orsted A/S	Germany	0.29%	DAX	0.96	8.82%	4.72%	8.45%	4.80%
4	Eni SpA	Italy	1.82%	FTSE MIB	1.14	5.77%	6.85%	6.30%	9.60%
5	Elecnor SA	Spain	1.33%	IBEX 35	0.53	6.25%	6.27%	3.92%	4.63%
6	Encavis	Spain	1.33%	IBEX 35	0.34	6.25%	6.27%	3.00%	3.46%
7	Enel Green Power	Spain	1.33%	IBEX 35	0.84	6.25%	6.27%	5.46%	6.60%
8	Engie SA	Spain	1.33%	IBEX 35	0.95	6.25%	6.27%	6.00%	7.28%
9	Iberdrola	Spain	1.33%	IBEX 35	0.79	6.25%	6.27%	5.24%	6.31%
	Average (No. 1-4)	-	0.81%	-	0.79	7.77%	5.37%	5.92%	5.21%
	Average (No. 1-9)	-	1.10%	-	0.73	6.92%	5.87%	5.25%	5.46%

4.2 Required Return on Debt

The required return on debt reflects the overall cost that a company pays for debt financing. The higher the required return on debt, the riskier (with high default probability) the company is perceived by investors. To find the required return on debt (the effective interest rate that a particular company pays on its debts), the yields of corporate bonds in the market are usually observed. Fig. 4.5 demonstrates the yields and maturities of corporate bonds in the electric industry obtained from Bloomberg for different company's ratings in 4 countries: France, Germany, Italy, and Spain. The average yield curves for different company's ratings in 4 countries are also illustrated. Some of the names of companies that issued the corporate bonds are shown in Table 4.3. Lastly, the average yields for electric industry by country, by rating, and by maturity are displayed in Table 4.4. It can be seen that the cost of debt (bond) can be different depending on the industry, country's investment environment, firm's characteristics, issuance maturity, to name a few. Nonetheless, the average yield of 2.7% for all rated companies in electric industry in all 4 countries (France, Germany, Italy, and Spain) with 20 to 30 years of maturity will be used as a proxy for the cost of debt in this Section.

Now that the required return on equity of 5.6% (from Table 4.2), the required return on debt of 2.7% (from Table 4.4), and the capital structure (equity and debt amounts) of a project (from Table 3.13) with the corporate tax of 24% are determined, the cost of capital or the WACC for the base-case scenario can be calculated using Eq. (2) as follows:

$$WACC_{Base} = 5.6\% \cdot \left(\frac{36.93}{36.93 + 176.87}\right) + 2.7\% \cdot \left(\frac{176.87}{36.93 + 113.85}\right) \cdot (1 - 24\%)$$

$$WACC_{Base} = 2.66\% \qquad \text{…(4a)}$$

With the same equation, the WACC for the worst-case scenario can be found using the data in Table 3.14.

$$WACC_{Worst} = 3.39\% \qquad \text{…(4b)}$$

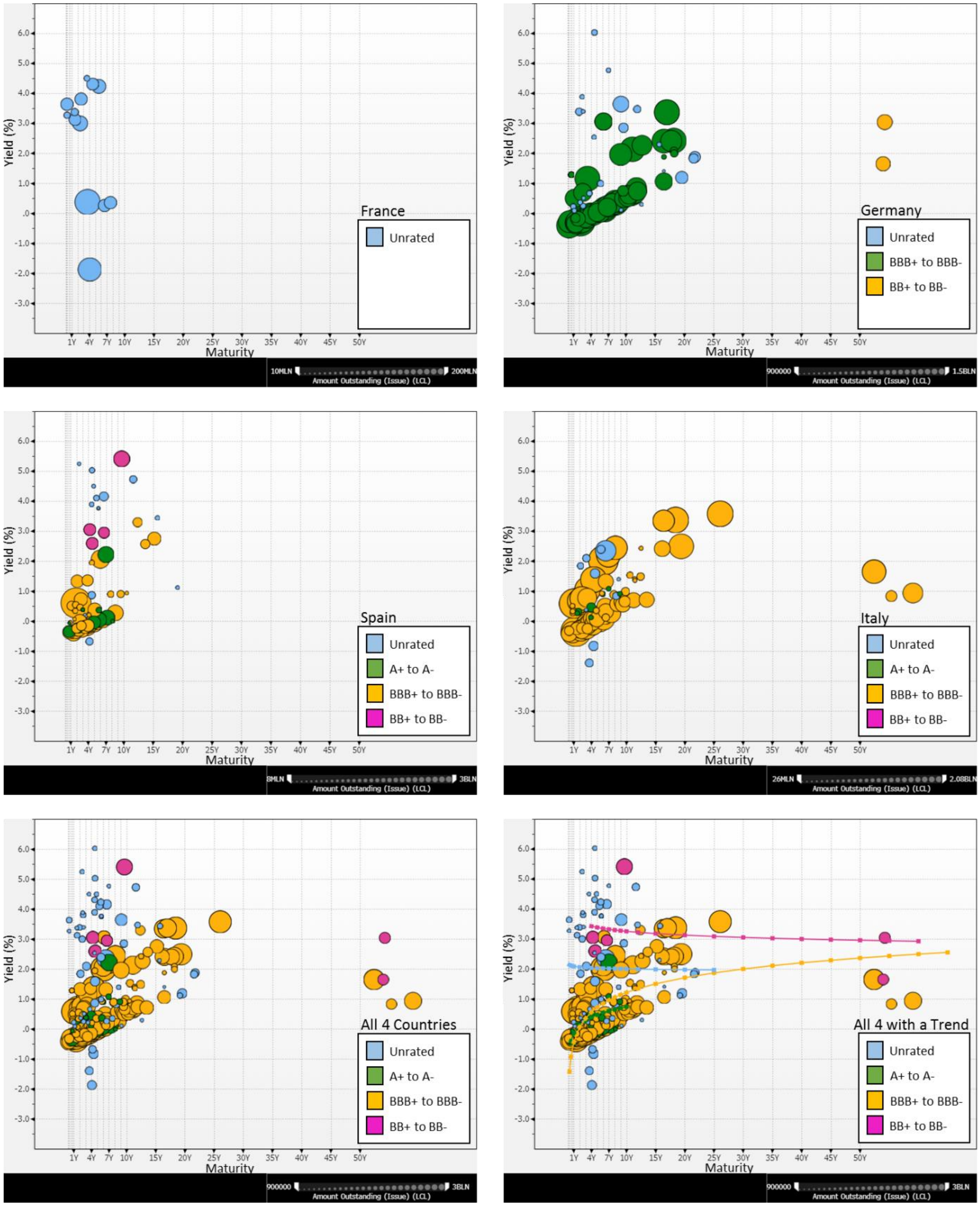

Fig. 4.5 Yields and Maturities of Corporate Bonds in Electric Industry.

Table 4.3 Examples of Issuers and Ratings of Corporate Bonds.

Country	Rating	Issuer
France	Unrated	Akuo Energy SAS
		Total Direct Energie SA
		Neoen SA
		Voltalia SA
		Albioma SA
Germany	Unrated	Solar Millennium AG
		Deutsche Agrar Holding GmbH
		MBB Clean Energy AG
		Landesbank Baden-Wuerttemberg
		Greenrock Energy AG
		Energiekontor GmbH & Co KG
		Mainzer Stadtwerke AG
		Stadtwerke Solingen GmbH
		Danpower GmbH
		N-ERGIE AG
		EWZ Deutschland GmbH
	BBB+ to BBB-	E.ON SE
		WindMW GmbH
		Eurogrid GmbH
	BB+ to BB-	RWE AG

Country	Rating	Issuer
Italy	Unrated	FRI-EL Biogas Holding - Srl
		Energy Lab SpA
		Evolvere SPA Societa Benefit
	A+ to A-	Enel Finance International NV
	BBB+ to BBB-	Iren SpA
		Terna Rete Elettrica Nazionale SpA
		ERG SpA
	BB+ to BB-	Andromeda Finance Srl
Spain	Unrated	Greenalia SA
		Audax Renovables SA
		Gecal SA
		Atlantica Sustainable Infras Jersey Ltd
	A+ to A-	Red Electrica Financiaciones SAU
		Iberdrola Finance Ireland DAC
	BBB+ to BBB-	IE2 Holdco SAU
		International Endesa BV
		Solaben Luxembourg SA
	BB+ to BB-	Union Fenosa Preferentes SA
		ContourGlobal Power Holdings SA
		EnfraGen Energia Sur SA

Table 4.4 Average Yields by Rating and Maturity Range from Bloomberg as of May 5th, 2021.

Country	Rating	Avg	Maturity (Year)								
			<1	1-2	2-3	3-5	5-7	7-10	10-20	20-30	30+
All 4	Avg	1.07	0.53	-0.21	0.9	0.71	1.37	1.39	2.03	2.72	1.34
	A-	0.36	-0.2	0.29	-0.23	0.2	0.61	0.82	--	--	--
	BBB+	0.68	0.05	-1.04	0.29	0.35	0.9	1.2	2.11	3.58	--
	BBB	0.53	-0.34	-0.16	-0.1	0.11	0.17	0.6	1.8	--	--
	BBB-	1.22	1.29	--	0.01	0.1	1.75	0	--	--	1.22
	BB+	2.35	--	--	--	--	--	0	--	--	2.35
	BB	2.87	--	--	--	2.83	2.96	--	--	--	--
	BB-	5.41	--	--	--	--	--	5.41	--	--	--
	Unrated	2.04	2.38	2.5	2.48	1.21	2.89	2	2.25	1.86	0
France	Avg	1.65	3.46	3.25	3.41	-0.4	2.25	0.36	--	--	--
	Unrated	1.65	3.46	3.25	3.41	-0.4	2.25	0.36	--	--	--
Germany	Avg	1.19	0.57	0.28	0.82	1.11	0.89	1.46	1.74	1.86	2.35
	BBB+	0.57	--	--	-0.24	-0.05	0.24	0.76	1.09	--	--
	BBB	0.7	-0.34	-0.14	0.01	0.16	0.13	0.65	1.88	--	--
	BBB-	2	1.29	--	--	--	3.06	--	--	--	--
	BB+	2.35	--	--	--	--	--	--	--	--	2.35
	Unrated	2.01	0.23	1.75	1.69	3.08	1	2.85	1.74	1.86	--
Italy	Avg	0.91	0	0.25	0.42	0.31	1.06	1.05	2.16	3.58	1.29
	A-	0.59	--	0.29	0	0.3	1	0.92	--	--	--
	BBB+	1.15	0.18	0.32	0.44	0.43	1.02	1.69	2.28	3.58	--
	BBB	0.15	-0.34	-0.24	-0.32	0.07	0.3	0.54	0.71	--	--
	BBB-	1.12	--	--	--	0.1	0.5	0	--	--	1.29
	BB+	0	--	--	--	--	--	0	--	--	--
	Unrated	1.07	0	0	1.85	0.38	2.38	1.12	0	--	--
Spain	Avg	1.06	-0.2	-1.94	0.76	1.24	2.05	1.91	2.7	0	1.12
	A-	0.23	-0.2	0	-0.23	0.15	0.21	0.78	--	--	--
	BBB+	0.01	-0.2	-1.94	0.31	0.31	0.7	0.7	2.39	--	--
	BBB-	0.92	--	--	0.01	--	0.38	--	--	--	1.12
	BB+	0	--	--	--	--	--	--	--	--	0
	BB	2.87	--	--	--	2.83	2.96	--	--	--	--
	BB-	5.41	--	--	--	--	--	5.41	--	--	--
	Unrated	3.16	0	0	5.25	2.31	3.95	0	3.1	0	--

4.3 Construction Risk

After the financial close, the construction of a power plant begins. The risks during the construction phase are associated with the deadlines of the construction. Failure to meet the deadlines (or construction milestones) or cost constraints can increase the default probability of the project. Therefore, the construction risk is present and should be concerned. Table 4.5 illustrates the default rates of projects utilizing project finance mainly for power (2645 projects), infrastructure (1884 projects), and oil & gas (830 projects) industries using historical data from 1983 to 2015 published by Moody's [54]. The results are divided into groups: A rated, Baa rated, and Ba rated (or, in layman's terms, good, medium, and bad credit ratings) companies. As can be seen, the risks are higher during the first few years after financial close, reflecting the fact that the project is more vulnerable during the construction period than the operation period. This is true especially for power projects as the construction often involves complex electrical and mechanical systems for the transmission interface and equipment. Once the project reaches its operational phase, the default rate reduces greatly when the project company gains more operational experience.

To find the construction risk of the base-case example in Table 3.13, a diagram of cash flows is firstly drawn in Fig. 4.6 to clearly illustrate the time periods by which the cash flows are discounted. As demonstrated, the capital expenditure is scheduled to be paid in proportion to the achieved construction milestones after the financial close is reached, the administration and miscellaneous costs are annually paid to run the company, the revenues from selling electricity and O&M costs are calculated in accordance with the expected energy generation each year for 20 years. Since it is deemed to be fixed and known ahead of time, the construction cost is treated as a fixed liability that should be discounted with the risk-free rate which is, from the observation of risk-free rates in Table 4.2, assumed to be 1%. The forecasted cash flows including the administration and miscellaneous costs, O&M costs, and electricity revenues should be discounted with the appropriate risk-free rate (1%) and cost of capital (or the WACC) obtained in Eq. (4). The calculations of cash flows are done and shown in Table 4.6. As expected, the WACC of 21.1% under 2.25-year construction is significantly higher than the WACC of 2.66% under the 20-year operation, reflecting higher uncertainty and risks during the construction. The rationale behind high WACC under construction is the fact that high fixed liability is incurred before the project generates positive cash flows. Lastly, it should be noted that the WACC under construction could not be found if the sum of the expected discounted future cash flows from energy generation is lower than the capital expenditure for the construction.

Table 4.5 Annual Default Rates of Projects under Project Finance Published by Moody's.

Year	Marginal Annual Default Rate (%)				
	Data Set (Basel II)	Data Set (Moody's)	Moody's A	Moody's Baa	Moody's Ba
1	1.47%	1.15%	0.06%	0.20%	0.96%
2	1.41%	1.10%	0.13%	0.31%	1.72%
3	1.18%	0.89%	0.21%	0.35%	2.12%
4	0.91%	0.64%	0.22%	0.42%	2.28%
5	0.72%	0.49%	0.26%	0.42%	2.05%
6	0.47%	0.31%	0.29%	0.43%	1.92%
7	0.32%	0.19%	0.30%	0.41%	1.75%
8	0.23%	0.14%	0.32%	0.41%	1.67%
9	0.14%	0.06%	0.33%	0.43%	1.62%
10	0.09%	0.03%	0.32%	0.48%	1.65%

Source: Moody's Analytics Project Finance Data Consortium

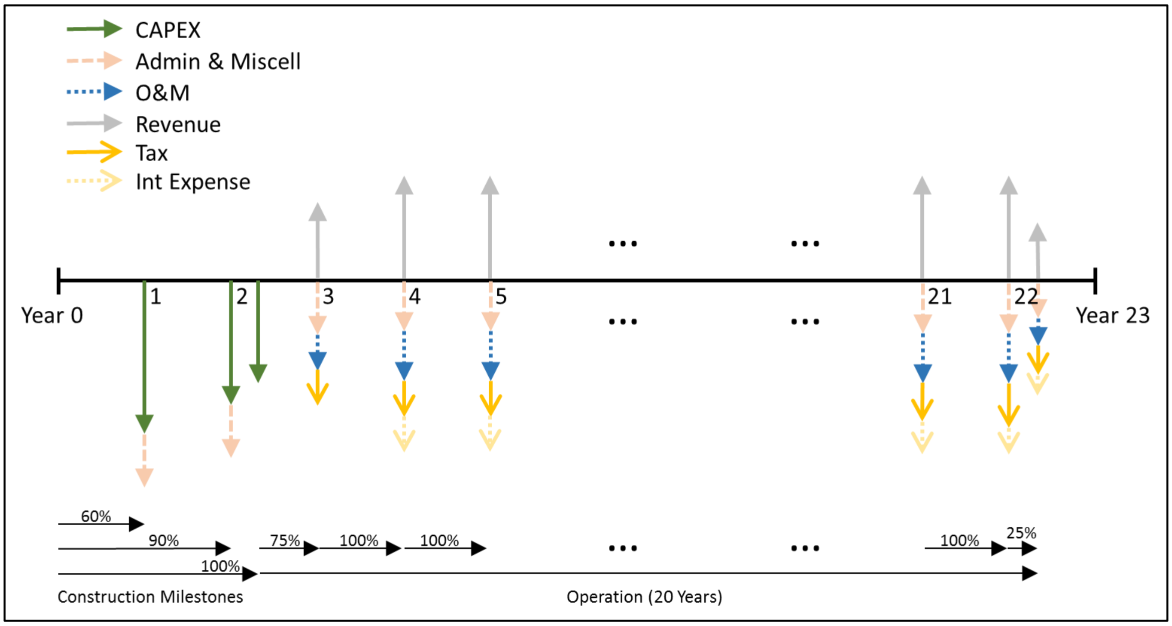

Fig. 4.6 Yields and Maturities of Corporate Bonds in Electric Industry.

Table 4.6 Cash Flows and Calculation for WACC under Construction of Base-Case Scenario.

Unit: '000 USD

Base-Case Scenario	Discount Rate	Year									
		0	1	2	2.25	3	4	...	21	22	22.5
CAPEX	1.0%	-	(119,400)	(59,700)	(19,900)	-	-	...	-	-	-
Admin & Miscell Cost	3.9%	-	(2,000)	(2,050)	-	(2,101)	(2,154)	...	(3,277)	(3,359)	(861)
O&M Cost	3.9%	-	-	-	-	(2,100)	(2,870)	...	(4,367)	(4,476)	(1,147)
Electricity Revenue	3.9%	-	-	-	-	19,316	26,270	...	36,785	37,521	9,568
Net Cash Flow at Year 0	-	108,602	-	-	-	-	-	...	-	-	-
Net Cash Flow at Year 2.25	-	-	-	-	131,560	-	-	...	-	-	-
WACC during Construction	-	21.1%									

4.4 Investment Appraisal

To assess whether the investments in certain renewable energy projects are worthwhile and superior to other projects, some investment tools are commonly adopted. Among them are the internal rate of return (IRR), payback period, net present value (NPV), profitability index, and the levelized cost of electricity (LCOE). Each tool provides a different viewpoint to the project and sometimes is used with different objectives.

The internal rate of return (IRR), expressed in the form of percentage, is the rate at which the present value of future cash flows equals the cash outflow and can be calculated using Eq. (5) where CF_0 is the initial investment, CF_t is the cash flow at period t, and T is the useful life of the project. The IRR aims to find the breakeven rate at which the present value of future cash flows combining with the cash outflow becomes zero. Therefore, the return of individual investment over its lifetime can be determined.

$$\sum_{t=1}^{T} \frac{CF_t}{(1+IRR)^t} = CF_0 \qquad (5)$$

The payback period, expressed in the form of time period (e.g. year), is the time within which the project company can recover the initial cash outflow and can be calculated in two ways. First, the payback period can be calculated using linear interpolation of the two years covering when the accumulated cash flows turn positive. Because the first method ignores the present value of future cash flows, the second method of calculating the payback period is priced in the interest rates and discount factors, and the payback period can be calculated using linear interpolation of the two years covering when the accumulated discounted cash flows turn positive. If the project generates constant cash inflows for every period, payback period can be calculated as follows:

$$Payback\ Period = \frac{Initial\ Cash\ Outlay}{Periodic\ Cash\ Inflow} \qquad \ldots(6)$$

The net present value (NPV) is the present value of all future cash flows, less the present value of the cash outflow shown in Eq. (7) where r is the interest rate during period t. The NPV compares the present value of future cash inflow to the present value of cash outflow and decide whether or not the investment should be made. In other words, the NPV determines how much the investment generates surplus returns while pricing in the concept of time value of money.

$$NPV = \left(\sum_{t=1}^{T} \frac{CF_t}{(1+r)^t}\right) - CF_0 \qquad \ldots(7)$$

The profitability index, expressed in the form of ratio, is the ratio of present value of future cash inflow to cash outflow and can be calculated using Eq. (8). The profitability index addresses how many times the project can generate cash over the initial investment.

$$Profitability\ Index = \frac{Present\ Value\ of\ Future\ Cash\ Flows}{Initial\ Cash\ Outlay} \qquad \ldots(8)$$

The levelized cost of electricity (LCOE), expressed in the form of currency returns per energy unit, is an economic measure that shows the averaged lifetime costs of electricity produced. It is typically used to compare across different power generation technologies with dissimilar characteristics such as useful lives, capital costs, project sizes, construction costs, operation and maintenance (O&M) costs, etc. It can be calculated using Eq. (9).

$$LCOE = \frac{\sum_{t=1}^{T} Present\ Value\ of\ Costs}{\sum_{t=1}^{T} Present\ Value\ of\ Energy\ Generation} \qquad \ldots(9)$$

4.5 Valuation Results

The IRR, payback period, the NPV, profitability index, and the LCOE are calculated and shown in Table 4.7. In this valuation, the energy generation is assumed to have the same value as in the base-case scenario as the power plant is expected to operate on average at p-50 value. The amount of debt obtained previously under the worst-case scenario of $134.30 million is used in this valuation. With the corresponding equity enough for the CAPEX and other expenses, the WACC of this project is now 3.3%. The project IRR at maturity is 8.0% while the equity IRR is 14.1%. It takes 11.95 years for the project to recover its initial investment while it only takes 9.3 years for the equity sponsors.

The NPV for this project calculated using the new WACC of 3.3% and risk-free rate of 1% obtained previously is $102.4 million. The corresponding profitability index is 1.52. The profitability index demonstrates that future cash flows will reimburse and exceed the initial cash outlay for this project. Lastly, the LCOE of $68.38 per MWh for this project suggests that the investment in this project is competitive to other when compared to the 2019 global average of $65.37 per MWh and 2018 global average of $70.89 per MWh 61[43].

As we have seen that different assumptions affect the cash flows and investment indicators differently, the understanding of how sensitive the project is to each factor can be valuable to manage or avoid risks in the unforeseen circumstances. In the next section, sensitivity analysis will be performed on the key factors used in the financial model (from Table 3.12). In other words, Section V will address how the prospect of the project in terms of debt size and the investment decision-making indicators is affected by the assumptions made in Table 3.12.

Table 4.7 Valuation Results.

Financial Model

Unit: '000 USD

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2042
Forecast																								
Discounting Period	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Construction Milestone	0%	60%	90%	100%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Operation Period	-	-	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Energy Generation (%)		-	-	75.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	25.0%
Energy Generation (MWh)		-	-	321,941	429,255	429,255	429,255	429,255	429,255	429,255	429,255	429,255	429,255	429,255	429,255	429,255	429,255	429,255	429,255	429,255	429,255	429,255	429,255	107,314
Electricity Revenue		-	-	19,316	26,270	26,796	27,332	27,878	28,436	29,005	29,585	30,176	30,780	31,396	32,024	32,664	33,317	33,984	34,663	35,357	36,064	36,785	37,521	9,568
Less: CAPEX		(119,400)	(59,700)	(19,900)																				
Less: Admin & Miscell Costs		(2,000)	(2,050)	(2,101)	(2,154)	(2,208)	(2,263)	(2,319)	(2,377)	(2,437)	(2,498)	(2,560)	(2,624)	(2,690)	(2,757)	(2,826)	(2,897)	(2,969)	(3,043)	(3,119)	(3,197)	(3,277)	(3,359)	(861)
Less: O&M Cost		-	-	(2,100)	(2,870)	(2,942)	(3,015)	(3,091)	(3,168)	(3,247)	(3,328)	(3,412)	(3,497)	(3,584)	(3,674)	(3,766)	(3,860)	(3,956)	(4,055)	(4,157)	(4,261)	(4,367)	(4,476)	(1,147)
EBITDA		(2,000)	(2,050)	15,115	21,247	21,646	22,054	22,468	22,891	23,321	23,759	24,205	24,659	25,122	25,593	26,072	26,561	27,058	27,565	28,081	28,606	29,141	29,685	7,560
Less: Change in Net Working Capital		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CFO		(2,000)	(2,050)	15,115	21,247	21,646	22,054	22,468	22,891	23,321	23,759	24,205	24,659	25,122	25,593	26,072	26,561	27,058	27,565	28,081	28,606	29,141	29,685	7,560
FCFF (CFO-CAPEX)		(121,400)	(61,750)	(4,785)	21,247	21,646	22,054	22,468	22,891	23,321	23,759	24,205	24,659	25,122	25,593	26,072	26,561	27,058	27,565	28,081	28,606	29,141	29,685	7,560
Tax Consideration																								
D&A from CAPEX		-	-	(7,463)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(9,950)	(2,488)
EBIT		(2,000)	(2,050)	7,653	11,297	11,696	12,104	12,518	12,941	13,371	13,809	14,255	14,709	15,172	15,643	16,122	16,611	17,108	17,615	18,131	18,656	19,191	19,735	5,072
EBT		(2,000)	(2,050)	7,653	4,233	4,947	5,668	6,396	7,133	7,877	8,629	9,389	10,157	10,933	11,718	12,512	13,314	14,126	14,946	15,776	16,615	17,464	18,322	4,033
Corporate Tax		-	-	(1,837)	(1,016)	(1,187)	(1,360)	(1,535)	(1,712)	(1,890)	(2,071)	(2,253)	(2,438)	(2,624)	(2,812)	(3,003)	(3,195)	(3,390)	(3,587)	(3,786)	(3,988)	(4,191)	(4,397)	(968)
FCFF (After-Tax)		(121,400)	(61,750)	(6,621)	20,231	20,459	20,693	20,933	21,179	21,430	21,688	21,951	22,221	22,498	22,780	23,069	23,365	23,668	23,978	24,294	24,618	24,949	25,288	16,592
Debt Schedule																								
Beginning		134,299	134,299	134,299	134,299	127,322	120,346	113,369	106,393	99,416	92,440	85,463	78,486	71,510	64,533	57,557	50,580	43,604	36,627	29,650	22,674	15,697	8,721	1,744
Add: Interest Expense		6,715	6,715	6,211	6,043	5,730	5,416	5,102	4,788	4,474	4,160	3,846	3,532	3,218	2,904	2,590	2,276	1,962	1,648	1,334	1,020	706	392	20
Less: Interest Paid		-	-	-	(7,064)	(6,750)	(6,436)	(6,122)	(5,808)	(5,494)	(5,180)	(4,866)	(4,552)	(4,238)	(3,924)	(3,610)	(3,296)	(2,982)	(2,669)	(2,355)	(2,041)	(1,727)	(1,413)	(1,040)
Less: Principal Paid		-	-	-	(6,977)	(6,977)	(6,977)	(6,977)	(6,977)	(6,977)	(6,977)	(6,977)	(6,977)	(6,977)	(6,977)	(6,977)	(6,977)	(6,977)	(6,977)	(6,977)	(6,977)	(6,977)	(6,977)	(1,744)
Ending	**134,299**	134,299	134,299	134,299	127,322	120,346	113,369	106,393	99,416	92,440	85,463	78,486	71,510	64,533	57,557	50,580	43,604	36,627	29,650	22,674	15,697	8,721	1,744	0
Equity Contribution																								
Terminal Value	10,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10,000
Accumulated CF		-	(183,150)	(189,771)	(169,541)	(149,081)	(128,388)	(107,455)	(86,276)	(64,846)	(43,158)	(21,206)	1,015	23,513	46,293	69,362	92,728	116,396	140,373	164,668	189,286	214,235	239,523	256,115
FCFE		(42,856)	(21,799)	(2,337)	8,902	9,540	10,186	10,839	11,500	12,169	12,845	13,530	14,223	14,924	15,634	16,352	17,079	17,815	18,560	19,315	20,078	20,852	21,635	15,025
Equity Contribution	**73,277**																							
Max Project Leverage	**64.7%**																							
Investment Appraisal																								
Project IRR	**8.0%**	-	-100.0%	-100.0%	-60.1%	-39.3%	-26.5%	-18.0%	-12.0%	-7.7%	-4.4%	-1.9%	0.1%	1.7%	2.9%	4.0%	4.8%	5.5%	6.1%	6.7%	7.1%	7.5%	7.8%	8.0%
Equity IRR	**14.1%**	-	-100.0%	-100.0%	-56.0%	-34.0%	-20.6%	-11.7%	-5.6%	-1.1%	2.2%	4.7%	6.7%	8.2%	9.4%	10.4%	11.2%	11.9%	12.4%	12.9%	13.3%	13.6%	13.9%	14.1%
Project Payback Period	**11.95Y**																							
Equity Payback Period	**9.3Y**																							
WACC of 3.3%	1.0000	1.0330	1.0672	1.1024	1.1389	1.1765	1.2154	1.2556	1.2970	1.3399	1.3842	1.4299	1.4772	1.5260	1.5764	1.6285	1.6823	1.7379	1.7953	1.8547	1.9159	1.9793	2.0447	2.0614
DCF (After-Tax) Less CAPEX		(1,936)	(1,921)	12,045	17,764	17,390	17,026	16,673	16,329	15,994	15,668	15,352	15,043	14,743	14,451	14,166	13,889	13,619	13,356	13,099	12,849	12,605	12,368	8,049
Risk-Free Rate of 1%	1.0000	1.0100	1.0201	1.0226	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CAPEX Discounted with Rf		(118,218)	(58,524)	(19,459)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Project NPV	**102,418**																							
Profitability Index	**1.52**																							
Discounted Expense		(120,154)	(60,445)	(23,270)	(13,781)	(13,244)	(12,730)	(12,238)	(11,766)	(11,315)	(10,884)	(10,471)	(10,075)	(9,697)	(9,335)	(8,988)	(8,657)	(8,340)	(8,037)	(7,747)	(7,469)	(7,204)	(6,950)	(2,000)
Discounted Elec Generation (MWh)				292,025	376,911	364,854	353,184	341,886	330,950	320,363	310,116	300,196	290,593	281,298	272,300	263,589	255,158	246,996	239,095	231,447	224,043	216,877	209,939	52,060
LCOE ($/MWh)	**68.38**																							

Chapter 5

5 Sensitivity Analysis

With the goal of ensuring that the project can generate enough cash flows to repay its debt obligations, the lenders need to quantitatively address the project risks. Sensitivity analysis is typically performed on the assumptions made in the financial model using in conjunction with the debt sizing. The sensitivity analysis also helps the lenders to understand the reliability and robustness of the project's cash flows to various stresses over the useful life of the project.

Assumptions in Table 3.12 are separated into independent factors which will be used as the inputs of the financial model. These inputs are varied (shocked) to observe the impact on the project cash flows and other variables. With the financial model built at hand, more detailed scenarios with some effects in certain periods and different effects in others can be tested. Nonetheless, the examples shown in this section will illustrate only the variations of the inputs to the financial model for the sake of simplicity.

5.1 Results

The results of the sensitivity analysis of the project by increasing the shock factors (obtained in Table 3.12) by 10% without utilizing the benefits of a larger debt size are demonstrated in Table 5.1 with the changes (or differences) from the original values. The changes of the project's prospect or investment decision-making tools (debt size, the IRR, payback period, the NPV, profitability index, and the LCOE) can also be visualized in Fig. 5.1. Moreover, the larger debt size is utilized and increased or decreased accordingly with the results in Table 5.2 and Fig. 5.2.

Table 5.1 Results of the Sensitivity Analysis.

Shock Factor	10% Shock	Debt Size (k$)	Maximum Leverage (%)	Project IRR (%)	Equity IRR (%)	Project Payback (Year)	NPV (k$)	Profitability Index	LCOE ($/MWh)
Original	-	**134,298.99**	**64.70%**	**7.98%**	**14.06%**	**11.95Y**	**102,417.99**	**1.52**	**68.38**
Revenue Factor									
Plant Capacity	+20 MW	17,687.06	1.68%	-0.05%	-0.79%	0.05Y	1,457.48	-0.04	-1.02
Useful Life	+2 Years	15,868.26	6.84%	0.38%	0.93%	0.09Y	22,350.41	0.11	-3.19
Net Generation	+43 GWh	19,288.18	8.98%	1.17%	2.99%	-0.85Y	32,322.05	0.16	-6.29
PPA Price	+$6	19,288.18	8.98%	1.17%	2.99%	-0.85Y	32,322.05	0.16	-0.08
PPA Escalation Rate	+0.2 %	3,591.56	1.56%	0.19%	0.38%	-0.09Y	5,823.05	0.03	0
Cost Factor									
CAPEX	+$99.5k	1,965.56	-4.87%	-0.94%	-2.83%	0.77Y	-23,580.87	-0.16	4.26
O&M Cost	+$1.4k	-2,196.24	-1.02%	-0.14%	-0.35%	0.11Y	-3,664.15	-0.02	0.83
Admin & Miscell Costs	+$1k	-1,648.16	-0.91%	-0.13%	-0.33%	0.10Y	-3,351.11	-0.02	0.71
Macroeconomics Factor									
Inflation Rate	+0.25 %	-989.71	-0.44%	-0.05%	-0.11%	0.03Y	-1,619.82	-0.01	0.37
Flat Interest Rate	+0.2 %	-1,636.81	-0.96%	0.03%	-0.25%	-0.03Y	288.18	0.001	0.37
Corporate Tax	+2.4 %	-2,007.75	-0.88%	-0.12%	0.11%	0.08Y	-1,849.92	-0.01	-0.77
Lender Factor									
Construction Margin	+30 bps	-498.89	-0.50%	0.01%	-0.13%	-0.01Y	-209.94	-0.001	0.12
Lender's Margin	+25 bps	-1,638.26	-0.79%	0.03%	-0.21%	-0.03Y	535.37	0.003	0.36
Required DSCR	+0.15	-16,808.74	-7.42%	0%	0%	0Y	0	0	0

Table 5.2 Results of the Sensitivity Analysis (Adjust Debt Size Accordingly).

Shock Factor	10% Shock	Debt Size (k$)	Maximum Leverage (%)	Project IRR (%)	Equity IRR (%)	Project Payback (Year)	NPV (k$)	Profitability Index	LCOE ($/MWh)
Original	-	**134,298.99**	**64.70%**	**7.98%**	**14.06%**	**11.95Y**	**102,417.99**	**1.52**	**68.38**
Revenue Factor									
Plant Capacity	+20 MW	17,687.06	1.68%	0.02%	0.28%	-0.02Y	13,056.06	0.01	0.33
Useful Life	+2 Years	15,868.26	6.84%	0.45%	2.37%	0.03Y	34,302.77	0.17	-1.97
Net Generation	+43 GWh	19,288.18	8.98%	1.25%	5.25%	-0.92Y	46,479.47	0.24	-4.80
PPA Price	+$6	19,288.18	8.98%	1.25%	5.25%	-0.92Y	46,479.47	0.24	1.56
PPA Escalation Rate	+0.2 %	3,591.56	1.56%	0.20%	0.65%	-0.10Y	8,246.83	0.04	0.30
Cost Factor									
CAPEX	+$99.5k	1,965.56	-4.87%	-0.93%	-2.75%	0.77Y	-22,394.77	-0.15	4.42
O&M Cost	+$1.4k	-2,196.24	-1.02%	-0.15%	-0.49%	0.11Y	-5,093.96	-0.03	0.64
Admin & Miscell Costs	+$1k	-1,648.16	-0.91%	-0.13%	-0.44%	0.11Y	-4,424.79	-0.02	0.57
Macroeconomics Factor									
Inflation Rate	+0.25 %	-989.71	-0.44%	-0.06%	-0.18%	0.03Y	-2,268.19	-0.01	0.28
Flat Interest Rate	+0.2 %	-1,636.81	-0.96%	0.02%	-0.36%	-0.02Y	-790.45	-0.004	0.22
Corporate Tax	+2.4 %	-2,007.75	-0.88%	-0.13%	-0.03%	0.09Y	-3,207.23	-0.02	-0.93
Lender Factor									
Construction Margin	+30 bps	-498.89	-0.50%	0.003%	-0.16%	-0.002Y	-536.60	-0.003	0.08
Lender's Margin	+25 bps	-1,638.26	-0.79%	0.02%	-0.32%	-0.02Y	-550.30	-0.003	0.22
Required DSCR	+0.15	-16,808.74	-7.42%	-0.07%	-1.05%	0.07Y	-10,960.83	-0.06	-1.40

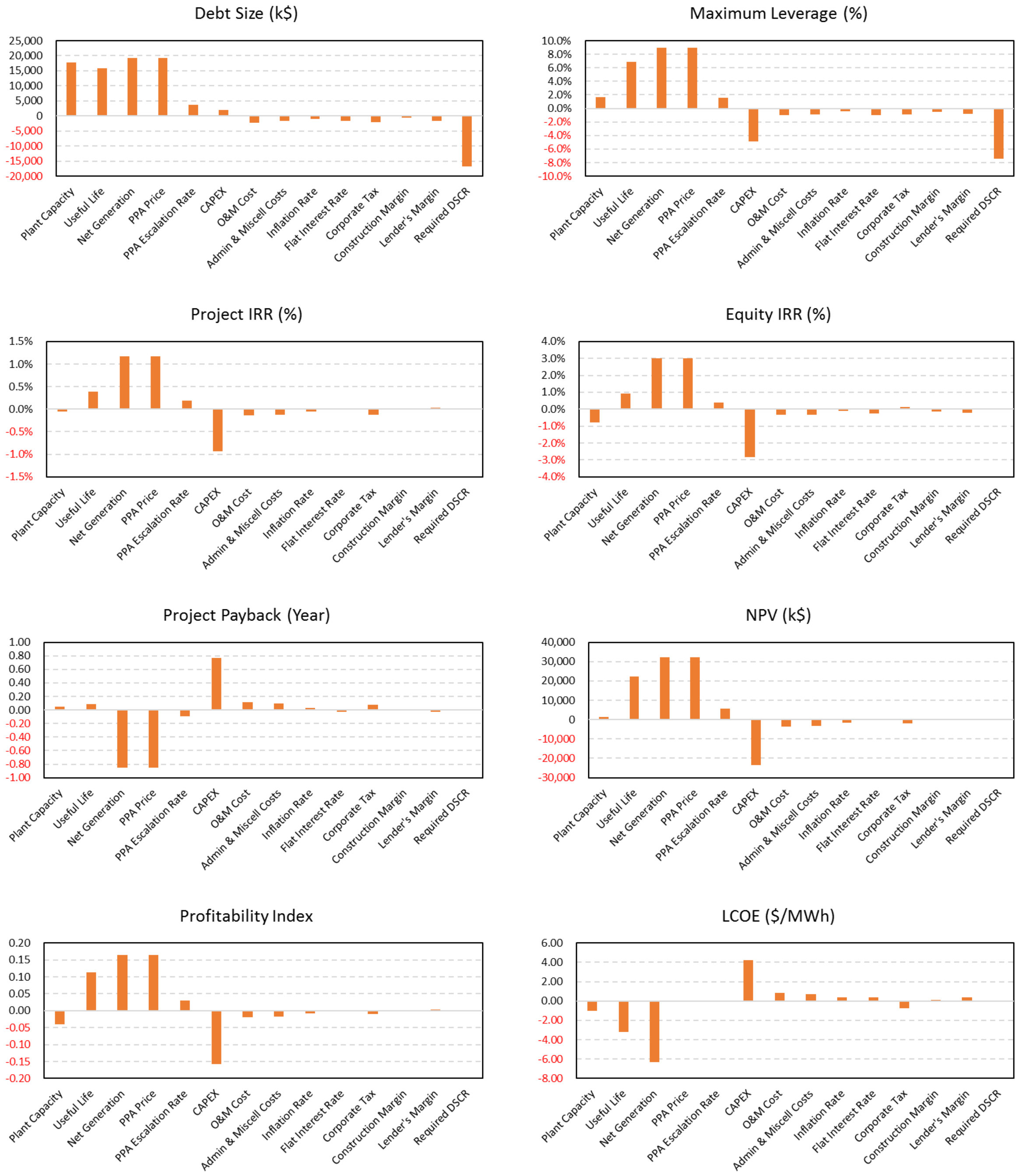

Fig. 5.1 Results of the Sensitivity Analysis (Bar Chart).

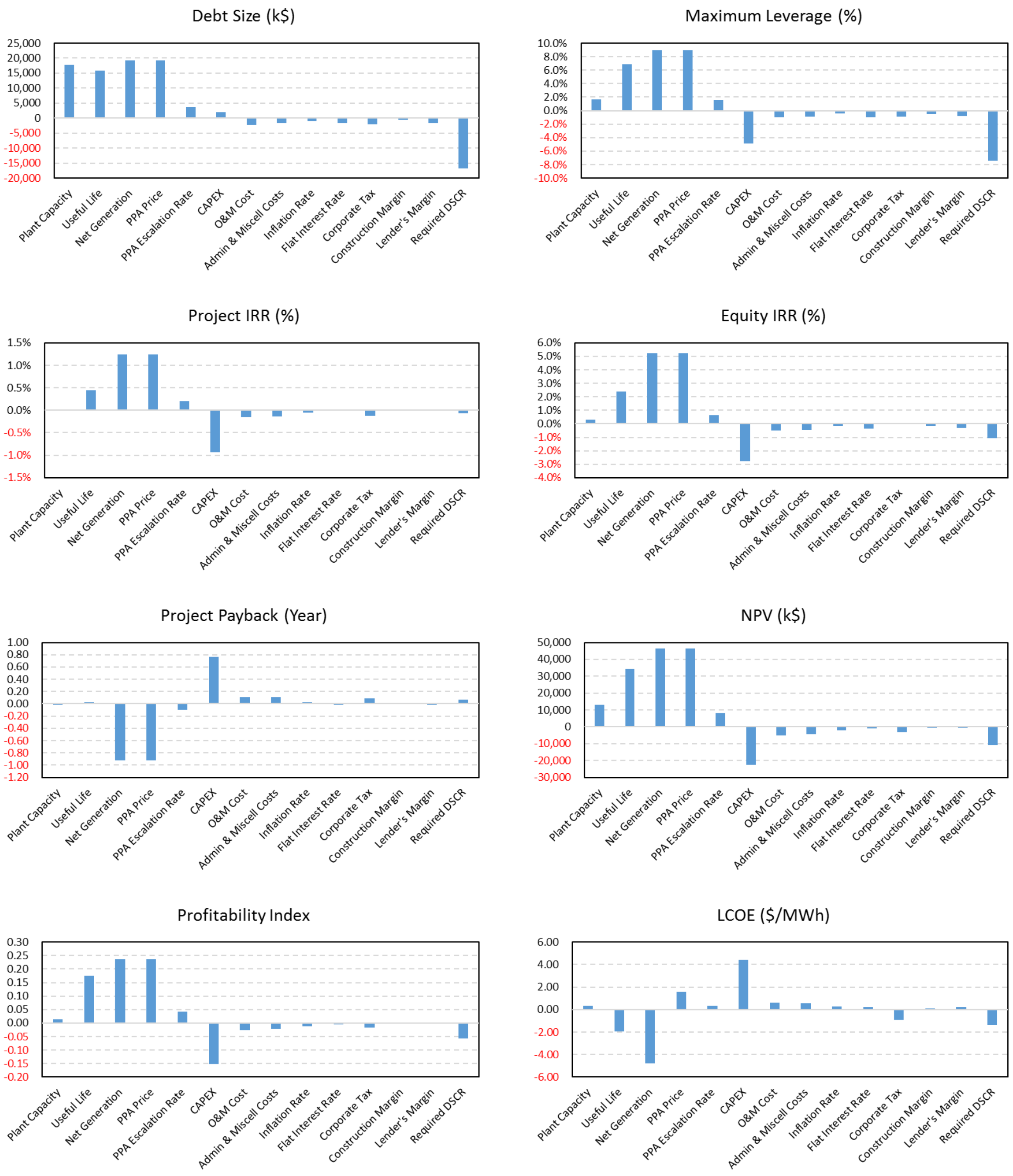

Fig. 5.2 Results of the Sensitivity Analysis (Adjust Debt Size Accordingly) (Bar Chart).

5.2 Result Discussion

More tangible macroeconomic factors such as interest rates and inflation rates are more easily observed (they are usually varied in the range of 0.25% to 0.75% by the central banks) than more static parameters devoted only for the project such as plant characteristics and costs. Therefore, the 10% shock of all factors is seen as appropriate to make a comparison between the impacts from all factors. The impacts on debt size and investment decision-making tools can be broadly divided into four components: revenue, cost, macroeconomic, and lender's factors.

First, the revenue components such as the plant capacity, plant's useful life, net energy generation, PPA fixed price, and PPA escalation rate are important and can determine whether the project company will get the loan from the lenders. In fact, together with the cost components, the lenders decide to give a loan based largely on the revenues that the project can generate. The revenues can be increased from larger net energy generation, which can be improved by choosing a plant site with an abundant solar or wind resource or by enlarging the power plant capacity. Although the price of electricity sold under the PPA to the off-taker is crucial to determine the debt size and project prospect, the PPA escalation rate plays a less important role and is usually used to compensate for the risk from the rise in inflation rates. Furthermore, the longer the useful life, the more revenue can be generated from the project (e.g. $15.9 million of debt can be additionally raised by extending the project's useful life two more years). Hence, the project's useful life can also affect the project's credibility. Recently, financial institutions are becoming comfortable to extend the loan term to 25 years for solar and 35 years for wind projects.

Beside the debt size, the investment indicators (IRR, payback period, profitability index, NPV, and LCOE) can be greatly affected by the revenue component. As the plant capacity gets larger, the already positive NPV of the unshocked scenario is scaled up. The LCOE is also reduced as more energy is generated. However, the bigger plant capacity negatively affects the other investment tools (the IRR, payback period, and profitability index) as not only the net generation increases, but the CAPEX also gets bigger. Conversely, holding the CAPEX constant (because of the constant plant capacity), a 10% increase in net energy generation has a positive impact on all investment tools (e.g. it can increase the NPV of the project by $32.3 million). Similarly, a longer useful life of the power plant is advantageous to the project companies as more years mean more revenues. It should be noted that the longer payback period is caused by lower D&A part as it is extended to more years. Also, the 10% shocks of PPA fixed price improves the revenues and thus affect all investment decision-making tools (e.g. similar to the shock of net energy generation, 10% increase in PPA fixed price boost up the project's NPV by $32.3 million) and slightly affects the LCOE as the WACC is reduced from less risky projects with higher PPA price. Lastly, unlike the PPA fixed price, the PPA escalation rate relatively has a smaller impact on the debt size and investment tools and no impact on the LCOE as the WACC does not change as the PPA escalation rate is there only for tackling with the inflation.

Second, in terms of the costs incurred in the project, the initial cash outlay (or CAPEX), the O&M, and administration and miscellaneous costs can deteriorate the project's profits and increase the payback period and LCOE. It should be noted that the results show more dominant impact from the CAPEX than that from the O&M and Admin & Miscell costs due to the larger scale of the CAPEX (e.g. the impact of $23.6 million from CAPEX vs. $3.7 million and $3.4 million from the O&M and Admin & Miscell costs on the project's NPV). In practice, larger power plants can also utilize the benefit from the economies of scale where strategic negotiation of lower O&M costs or CAPEX can be done. However, this is not incorporated in the financial model that assumes the growth of the costs is higher than that of the revenues. In the model, this means that the bigger the power plant, the less marginal benefit from the increased revenue as the growth of EBITDA gradually decreases. As seen in Fig. 5.1, the reason why CAPEX positively affects the debt sizing is that higher CAPEX translates to more savings from the D&A, leading to higher CFADS and larger debt size. However, the maximum leverage is decreased because the equity sponsors need to put more money to cover the necessary capital expenditure. Having said that, the CAPEX, O&M, and Admin & Miscell costs can negatively influence the investment appraisal, reducing the IRR, profitability index and the NPV, and increasing the payback period and the LCOE.

Third, albeit less impactful, macroeconomic factors such as interest rates, inflation rates, and corporate tax can consistently change and affect project creditability. For instance, unforeseen political turmoil, country's protests, trade war, and the country's outlook can affect the project prospects, apart from the plant characteristics such as the revenue and cost factors. It should be noted that, according to the model, unlike the inflation that has a negative impact for all variables, higher interest rates can lead to more tax benefits (save more from taxes) and higher FCFF. This can be seen by the improvements of payback period, project IRR, NPV and profitability index. Furthermore, it is worth mentioning that a higher corporate tax, although meaning more tax, can lead to higher tax benefits in accounting (with the same amount of interests paid) and hence lower LCOE.

Forth, factors such as lender's conservatism through the construction margin, loan margin, and the DSCR can essentially reduce the amount of debt being raised and maximum leverage. The project IRR when shocking the construction margin and loan margin can be improved as higher margins means a lower tax amount and higher FCFF. However, in terms of the NPV, increasing the margins can also increase the WACC. In the case of construction margin, the DCF drops faster than the tax benefits rise due to the increased WACC. The opposite is true for the case of loan or lender's margin. In addition, the riskier the renewable energy project is, the higher the DSCR the lenders demand. Unlike other factors that have an impact on the investment tools, the DSCR only affect the debt sizing process as the debt size is not changed and utilized accordingly in Table 5.1. However, as can be seen in Table 5.2

when the debt size is adjusted, higher DSCR (when the lenders become more stringent) has negative impacts on all investment tools except the LCOE as the WACC also increases.

In many cases of project financing renewable energy projects, the relationship between the required DSCR, expected project revenue, leverage, and financing amount is crucial and worth mentioning. When the revenue components (e.g. net electricity generation or price under the PPA) are negatively affected, making the expected revenue to decrease, banks are prone to impose higher DSCR to the project developers. Consequently, the project developer cannot maintain the same debt size. The project debt size and maximum leverage are then reduced.

In summary, sensitivity analysis provides a good overview of how the project is affected by each parameter and quantify the risks. It should be noted that the opposite interpretation of the results for +10% shock can be easily drawn if the shocks were -10%; for instance, the risks arising from lower-than-expected electricity production. Essentially, project developers can utilize these numbers for better investment decisions. Finally, in this report, we try to make the model as complex as possible, but it still requires interdisciplinary understanding of many factors such as the laws for the lease contracts and regulatory affairs, etc. to properly address all the risks and increase the success probability of building a project.

Chapter 6

6 Conclusion

One of the driving forces for the transition towards a greener economy to reduce global warming is the development of renewable energy. To meet the global expectation of CO_2 emissions reduction, trillions of dollars will be required for the investments in renewable energy through the capital markets. The most common method of financing energy and infrastructure projects is through project finance. Project finance in renewable energy remains complex regarding the risk allocation between parties and sophisticated financial modeling. Therefore, in this paper, we provide the fundamental knowledge, structure, and we then advance to the financial modeling and sensitivity analysis of renewable energy projects, particularly wind and solar. Beginning from choosing a site for the power plant, this report also provides calculations of energy generation from natural resources (wind and sun) and the debt size with certain assumptions made, quantitative measures for project valuations (particularly for the projects built in Europe), and the sensitivity analysis of potential risks (used as assumptions in the model) on the project.

We categorize the risks into 4 factors: revenue, cost, macroeconomics, and lender. We mainly find that the effects of macroeconomics such as (interest rates and inflation) and lender's (such as loan margins and the DSCR ratio) factors on project's prospect are relatively smaller when compared to those of project's characteristics from revenue (such as plant's capacity, energy generation, PPA price, and plant's lifetime) and cost (such as CAPEX and O&M costs) factors. The outcomes of this paper will be particularly useful for project companies that seek to get their renewable energy power plants off the ground and successfully built. Essentially, this report provides an insight to managing the project risks both qualitatively and quantitatively and guidelines to make the project attractive to investors.

6.1 Future Work

For the unpredictable resources of power such as wind and solar, installing wind turbines and solar cells connected to the same grid on different locations can improve the reliability and capacity factors of the power plant. This benefit is not incorporated in our model. For the fully-merchant and quasi-merchant projects without reliance on the subsidies such as a PPA contract, the banks usually require the forward curve of future power prices used in the debt sizing process, where the risks if properly managed can potentially increase the profitability to the project company. The forward curve of future power prices is another area worth exploring.

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