FitchRatings

Global Infrastructure & Project Finance
Power
Global

Renewable Energy Project Rating Criteria

Sector-Specific Criteria

Table of Contents

This report updates and replaces *the Renewable Energy Project Ratings Criteria* dated Feb. 26, 2019.

Related Criteria

Infrastructure and Project Finance Rating Criteria (March 2020)

Analysts

North America
Christopher Joassin
+1 312 339-9617
christopher.joassin@fitchratings.com

Andrew Joynt
+1 212 908-0594
andrew.joynt@fitchratings.com

EMEA
Alvaro Utrera–
+34 91 076-1981
alvaro.utrera@fitchratings.com

APAC
Sajal Kishore
+65 6796-7095
sajal.kishore@fitchratings.com

Latin America
Bruno Pahl
+ 55 11 4504-2204
bruno.pahl@fitchratings.com

Jesus Enriquez
+52 81 8399-9106
jesus.enriquez@fitchratings.com

Scope

This criteria report outlines Fitch Ratings' approach to rating new and existing debt instruments where repayment depends on cash flow from the construction and/or operation of renewable energy projects. These criteria primarily cover onshore and offshore wind projects, solar projects (photovoltaic (PV) and concentrated solar power (CSP), and reservoir-based and run-of-river hydropower plants. But the key rating drivers may also be applied to other renewable energy projects where the natural resource cannot be transported or traded, for example geothermal power projects. This report covers greenfield and existing plants and individual or portfolio assets.

This criteria report is intended for global application. The evaluation of any transaction involves consideration of additional risks common to all project finance debt. It should be read in conjunction with Fitch's *Infrastructure and Project Finance Rating Criteria*.

Key Rating Drivers

The list below outlines Fitch's key rating drivers for debt financing for renewable energy projects. As a general rule, Revenue risk – Volume and Revenue risk – Price have the most direct influence on renewable energy project ratings, but the weakest driver may attract greater analytical weighting. The table on pages 3–4, *Key Rating Driver Assessments for Wind, Solar and Hydropower Projects* compares the attributes that Fitch considers in assessing the risk factors as 'Stronger', 'Midrange' or 'Weaker' for solar, and wind and hydropower projects. Revenue counterparties will typically cap the ratings.

Completion Risk: Terms of the construction contracts; quality of construction contractor(s); complexity and timescale of the construction phase.

Operation Risk: Exposure to cost increases based on the operator's experience, scope of operation and maintenance (O&M) contract, reliability of technology, cost predictability and structural protections.

Revenue Risk – Volume: Characteristics of renewable energy resource and risk of not meeting projected energy production.

Revenue Risk – Price: Stability and predictability of power generation remuneration. For contracted projects, the credit quality of the revenue counterparty could constrain a rating irrespective of whether the key rating drivers' assessments and financial metrics are in line with guidance for a higher rating level.

Debt Structure: Payment waterfall ranking, refinance risk, financial profile, covenant package, structural features, hedging financial risk, liquidity and reserves, security.

Financial Profile: Fitch develops cases to assess a project's financial flexibility as it encounters stresses expected to occur over the relevant analysis period. We use metrics, sensitivities and break-even financial scenarios to evaluate debt service coverage ratios, liquidity and overall leverage.

Framework for Renewable Energy Projects Rating Range

Across the Fitch-rated renewable energy project portfolio, ratings generally range from the low end of the 'A' category to the 'B' category. The overall band of ratings is wide, yet the majority of them fall in the 'BBB' and 'BB' categories. Investment-grade ratings are typically associated with transactions displaying at least 'Midrange' attributes for the key rating drivers identified in this report.

Ratings in the 'A' category are achieved by projects that show sufficiently high financial coverage in addition to a combination of 'Stronger' and 'Midrange' attributes. The level of exposure to key rating drivers is typically inconsistent with ratings above the 'A' category, absent external credit enhancement or government support. Debt structures that include a guarantee of payment may be linked to the credit quality of the guarantor, such that a renewable energy project rating could exceed stand-alone creditworthiness.

Renewable energy projects rated by Fitch tend to employ proven technology from experienced and reputable manufacturers. Ratings on projects using technologies with limited commercial operating experience are typically constrained to below investment-grade unless technology risk is adequately mitigated.

Renewable energy projects often benefit from long-term power purchase agreements (PPAs) with investment-grade counterparties or operate under public incentive schemes, substantially mitigating price risk. When applicable, energy production requirements are typically not onerous, resulting in minimal termination risk of the offtake agreement. Exposure to market power prices is limited in prevalence and, generally, magnitude.

Even if a project meets the financial metrics requirements for investment grade, other factors may constrain it to a lower rating category. Excessive technical risk, sub-investment-grade counterparties, or other key risk factor assessments may support a lower rating. Projects otherwise meeting stronger qualitative rating thresholds, but exhibiting debt service coverage ratio (DSCR) profiles lower than indicative for investment grade, are assessed based on the facts and circumstances particular to the project. For example, a wind project with DSCR profiles near 1.20x under the Fitch rating case could be rated in the 'BB' category if it shows low cash-flow volatility or in the 'B' category if it uses technology with a short operating track record.

The application of these criteria typically results in ratings not higher than 'A' category, reflecting the gearing of the debt structures and constraints posed by revenue counterparties' credit quality. Furthermore, ratings of project finance transactions in general are unlikely to exceed the 'A' category due to most projects' single-asset nature and finite life.

Global Rating Rationale — Key Rating Driver Assessments

'Key Rating Driver Assessments for Wind, Solar and Hydropower Projects' on pages 3-4 outline the attributes that Fitch considers consistent with the assessment (Stronger, Midrange, Weaker) of a typical wind, solar or hydropower project. This table provides qualitative guidance in the assessment of a project. Fitch's financial stresses are directly affected by some key risk driver assessments, namely 'Revenue Risk – Volume' and 'Operation Risk'.

The attributes are not exhaustive and some are not relevant for every project. While investment-grade projects typically display attributes that are at least 'Midrange', projects normally display combinations of attributes. Fitch's assessment considers the various attributes based on their materiality, potential effect on performance, and the project's general characteristics. A few strong attributes may outweigh a greater number of midrange attributes to result in an overall assessment of 'Stronger', for example.

The assessments table primarily reflects project qualities that we typically consider in the assignment of a new rating to a project under construction or with a limited operating track record. The same considerations are relevant for the ongoing monitoring of existing ratings, but attributes relating to forecasts (e.g. energy production and operating costs) may be complemented and eventually superseded by the availability of actual performance data.

Key Rating Driver Assessments for Wind, Solar and Hydropower Projects

	Operation Risk	Revenue risk – Volume	Revenue risk – Price
	Exposure to cost increases based on scope of O&M contract, cost predictability and structural protections.	Characteristics of renewable energy resource and risk of not meeting projected and contracted energy production.	Stability and predictability of power generation's remuneration.
Stronger	• Fixed-price scheduled and unscheduled maintenance contract with IG operator covers full life of the debt • Operator has material experience with technology and scope of services • Large pool of experienced replacement operators • Multiyear forward-looking maintenance reserves and active detailed maintenance plan • Technology with a long operating history • Robust key equipment redundancy, onshore location, limited interconnection risk • Detailed cost analysis from TA • Long operating track record demonstrating a stable cost profile	• Robust forecast based on at least one to three full years of operational history showing P50 and one-year P90 difference[a] <= 6% and/or actual generation for all years (minimum of three years) within 6% of initial Fitch base case with no dip below rating case; or remuneration largely insulated from actual production • No curtailment risk, fully compensated or otherwise mitigated	• No merchant market price exposure in Fitch's financial analysis • Prices are fixed or indexed using simple, broad-based publicly available indexation formulas.
Midrange	• Fixed-price scheduled maintenance agreement or O&M agreement shorter than debt term or with sub-investment-grade operator • Operator experienced with technology and scope of services • Some experienced replacement operators available • Some maintenance reserve features and outlined reactive maintenance plan • Proven technology, or immaterial incremental change • Some redundancy in key equipment, offshore wind project does not bear transmission risk. • TA cost analysis has some limitations • Operating track record shows modest variability	• Robust, well-supported energy production forecast reflecting a difference between P50 and one-year P90[a] between 6% and 16% or actual generation for most years (minimum of three years) within 16% of initial FBC with no more than one year out of 10 below initial FRC. • Limited curtailment risk, partially compensated or capped under PPA/incentive mechanism	• Merchant market price exposure limited to a small portion of revenues in Fitch's financial analysis • Prices adjusted for time of day or other independent factors or regulated price/remuneration subject to periodic review
Weaker	• O&M largely cost-plus or short-term O&M agreement. • Operator has little experience with the technology and/or scope of services, unrated operator • Limited pool of experienced replacement operators • Inadequate or lack of maintenance reserves, or limited maintenance plan • Unproven or obsolete technology, little or poor utility scale operating history • No or very limited redundancy for key equipment, offshore wind project bears risk transmission risk, challenging meteorological conditions or logistics. • Limited or no cost analysis from TA • Actual historical plant operation and costs demonstrating high volatility	• Difference between P50 and one-year P90[a] is higher than 16% or actual generation for most years (minimum of three years) lower than the initial FBC by more than 16% and/or more than one year out of 10 below initial FRC. • Energy production forecast is weakly supported or reflects limited analysis. • Significant curtailment risk, not compensated or mitigated under PPA/incentive mechanism.	• Merchant market price exposure represents a significant portion of revenues in Fitch's financial analysis • Variable prices or indexed using opaque or complex indexation formulas
Relevant indicators	• Contract scope and O&M contractor credit quality • Operator experience • Availability of replacement operators • O&M reserves, major maintenance reserves and maintenance plan • Technology track record • Project configuration and equipment redundancy • Scope and quality of TA's cost analysis • Actual plant operating data	• Volatility of renewable resource. • Actual generation output and operating data • Reliability of energy production forecast • Curtailment risk and contractual mitigations	• Portion and duration of contracted sales versus merchant sales • Price indexation predictability

[a]The difference between P50 and P90 calculated as (1-P90/P50). IG – Investment grade. TA – Technical adviser. P (P50, P90) – Probability of exceedance. Probability of exceedance scenarios provide an estimate of energy output that is expected to be exceeded with 50% confidence (P50) and 90% confidence (P90) over the project life. The one-year P90 estimate represents the output that has a 90% probability of being exceeded in any given year.PPA – Power purchase agreement. FBC – Fitch base case, FRC – Fitch rating case. DSCR – Debt service coverage ratio. *Continued on next page.*
Source: Fitch Ratings.

Key Rating Driver Assessments for Wind, Solar and Hydropower Projects (Continued)

Financial Profile	This key rating driver considers metrics for liquidity, debt service coverage and leverage in the context of the overall risk profile determined by review of the other key rating drivers. For example, a fully contracted wind project with predominantly 'midrange' characteristics could be rated in the 'BBB' category with debt service coverage ratios of 1.30x and higher in the rating case, and below investment grade with coverage ratios under 1.30x. Moreover, a project's rating may be constrained by a 'weaker' assessment on a key rating driver notwithstanding coverage ratios of 1.30x and higher. This is discussed more fully under *Global Rating Rationale – Key Rating Driver Assessments* on page 2 and *Financial Profile* on page 10.
Completion risk	When present, this key risk factor is assessed using the analytical framework outlined in the criteria report, *Completion Risk Rating Criteria*. The framework is used to derive the maximum possible rating during completion phase, based on complexity, scale and duration, contractor expertise and implementation plan, availability of replacement contractors and contract terms, as well as liquidity available to support a project in case of contractor default.
Debt Structure	The analysis of renewable energy projects' debt features follows Fitch's approach, as outlined in the *Infrastructure and Project Finance Rating Criteria* report. Fitch considers each rated debt instrument separately, taking into account the debt's payment waterfall ranking, refinance risk, financial profile, covenant package, structural features, hedging financial risk, liquidity and reserves and security.

Source: Fitch Ratings.

Structure and Information

Use of Third-Party Reports

The two most important third-party reports for a renewable energy project's debt rating are a third-party energy production assessment and a third-party engineering report.

An energy production assessment estimates the project's probability-weighted annual output. In Fitch's experience, overly optimistic pre-construction energy production forecasts are the most frequent reason behind a project's underperformance against base case expectations. This is particularly the case for wind projects. As a result, the agency pays particular attention to the analysis supporting these studies and may apply haircuts to the forecasts as explained in more detail in the *Revenue Risk – Volume* and *Financial Profile* sections. Energy production forecasts are also important for projects with operating history.

A third-party engineering report evaluates the viability of the design of the project, the technology, the construction budget and timeline and the long-term operations and maintenance costs of the plant(s), among other factors. Where relevant, the engineering report should also validate assumptions made regarding the availability of transmission resources and the risk of curtailment due to limits on transmission capacity. Fitch will consider technical advisers' (TAs) or independent engineers' (IEs) experience with a project's technology to provide credible evaluations and opinions.

Where these reports contain matters of fact, Fitch will evaluate the source and reliability. Where the information is a forecast or opinion, the agency looks for well-reasoned analysis supported by facts. If Fitch does not receive these two reports, or determines them to be inadequate in their scope, quality or authorship, we may choose not to provide a rating absent mitigating factors.

Completion Risk

When present, this key risk factor is assessed using the analytical framework outlined in the criteria report, *Completion Risk Rating Criteria*. The framework is used to derive the maximum possible rating during completion phase, based on complexity, scale and duration, contractor expertise and implementation plan, availability of replacement contractors and contract terms, as well as liquidity available to support a project in case of contractor default.

Operation Risk

Operator

Fitch will assess whether the operator has experience with the same or similar technology to manage the day-to-day monitoring and maintenance and longer-term major maintenance of the plant(s). Fitch also reviews whether operators have adequate resources and qualified staff to execute operational tasks, as demonstrated by balance-sheet strength and operating track record. Fitch also relies on the TA's evaluation to assess the operator's capabilities, especially

for smaller, lesser-known entities. For projects in operation, Fitch will review the performance history to evaluate the operator's ability to maintain stable plant operations.

Fitch also evaluates how the operator is incentivized to maximize the project's performance. Operator performance-based bonuses and penalties for non-performance may result in a positive alignment of interests between project and operator. However, the reputational importance to the operator of a high-profile project, either in respect of technology, scale or national prestige, is unlikely to benefit the rating without any specific contractual undertakings.

Operators in the renewable energy industry are sometimes affiliates of the sponsor, engineering, procurement and construction (EPC) contractor, or equipment manufacturer. Equipment manufacturers are often the O&M providers in the initial years of operation, after which O&M services may be renewed or transitioned in-house or to an operator that is an affiliate of the sponsor or a third-party operator. The delivery of a high-quality maintenance regime is not only a function of the operator's skills, but may also be influenced by specific circumstances, such as project location or provision of spare parts.

Operating Costs

O&M costs are determined by the technology used and its track record as well as the contractual structure underpinning the project's operation and maintenance (e.g. fixed-price scheduled and unscheduled maintenance, management fee with out-of-pocket cost reimbursements, cost-plus or self-operation).

Subject to the operator's financial strength, longer-term and more comprehensive O&M agreements result in a stronger mitigation of the risk that O&M costs are higher than budgeted. Projects structured with O&M agreements for the provision of scheduled and unscheduled maintenance services at a fixed price for the full term of the debt offer the highest degree of risk mitigation, particularly if the operator has strong credit quality. Such structures reduce the relevance of the customary operation and maintenance reserves.

We consider operator agreements that appear under-priced or are with a counterparty of weak credit quality to be credit negative, as the operator may have to be replaced with a higher-cost third-party operator in the future. Similar cases may occur where the operator is an affiliate of the sponsor. The agency would address this risk by increasing stress on the operating contract to test the level of higher costs that could be borne by the project. Higher stresses are also likely to be applied, all things being equal, to projects lacking pass-through of cost risk to a third party, as would be the case for self-operated projects.

In the case of operators of weak credit quality, Fitch considers the extent to which the operating service can be provided by replacement operators and what the cost implications of such replacement might be. Commentary from the TA on the availability of suitably qualified replacement operators and the ability to absorb potential increased costs and delays if the operator is replaced will be an important consideration. If Fitch considers the availability of substitute operators to be unlikely given specialised technology, size, or location of the project, the rating may be capped at that of the operator.

Fitch reviews in detail the assumptions on which operating cost budgets are based, paying attention to the TA's report for validation of assumptions regarding the evolution of these costs over the life of the debt. Inflation-based, cost-plus and similar contracts will be evaluated for the effect on cash flows. We also use benchmarking of the project's O&M budget against those of similar projects.

In projects that are operating, the availability of consistent and reliable historical data is credit positive, as it provides a reasonable basis for prediction of future costs. Fitch also undertakes stress testing, as described in the *Break-Even Analysis and Individual Stresses* section below.

Teething issues during the first years of operation may result in higher O&M costs in the early years, even if these are often mitigated by warranties and guarantees from the manufacturers. O&M costs are also likely to increase late in the life of the project, as equipment ages. We evaluate these risks based on the third-party engineer's report, together with historical data when available and relevant.

Fitch considers whether there is a major maintenance reserve to cover the cost of major repairs and overhauls. An O&M reserve could provide flexibility to cover incidental higher O&M costs. These reserves are mitigating factors to rising or unplanned costs and are more important for more complex projects, relying on moving parts and having few modular components. The benefit of such reserves depends on their size: reserves structured to lock-in, in full or in part, several years of future expenditures are considered stronger features.

Technology Risk

Besides considerations relating to O&M contract terms, a key factor in Fitch's assessment of the risk of possible O&M cost deviations from budget is the degree to which a technology is proven, as longer and more extensive operating track records increase confidence in the accuracy of estimated maintenance and repair costs.

Fitch's analysis of technology risk focuses on complexity, commercial viability, performance uncertainty and utility-scale applicability. As a benchmark, Fitch views technologies with a successful utility-scale operating history of five years or more as having lower operational uncertainty than less-tested peers. Project debt ratings are likely to be constrained to sub-investment-grade in projects that employ technologies with no or limited track record, unless appropriate warranties and performance guarantees are provided by credible investment-grade manufacturers.

Revenue Risk – Volume

A key peculiarity of renewable energy projects' financings is the reliance on natural resources, which are inherently volatile, challenging to predict and beyond the control of the project. Renewable energy resource cannot be transported or traded. Except for selected cases, renewable energy projects are dependent on energy production forecasts, with production being a direct driver of revenue generation.

An assessment of the uncertainty in the forecast and the volatility of the natural resource are central in Fitch's analysis of this key rating driver.

Probability of Exceedance Scenarios

The result of an energy production forecast is a prediction of a project's output that we expect to be exceeded with corresponding probability levels over a certain time period (except for the P50, which does not vary with time). Fitch uses the net P50 as the basis for its base case production assumption and the net one-year P90 as the starting point in the determination of its rating case production assumption, as discussed further in the *Financial Profile* section.

Assessment of Energy Production Forecasts' Reliability

In Fitch's experience, and in accordance with the views of the technical advisers, the uncertainty in energy production forecasts is lower when these are based on a sufficiently long operating history, as this allows the replacement of estimates of some of the projects' operating parameters with actual measured data. This is particularly the case for wind projects.

For this reason, only forecasts performed for projects already in operation for at least a year may be considered in line with a 'Stronger' assessment of Revenue Risk – Volume. A longer operating history may be considered necessary depending on the specific project's characteristics, for example, for wind projects located in complex terrain or projects using technology with a limited track record. We will typically assess projects that rely on robust energy production assessments performed at greenfield stage (or benefitting from less than one full year of actual production data), as 'Midrange'.

Onsite measurements from high-quality, well-maintained instruments and in line with projects' characteristics (e.g. at heights consistent with wind turbines' hubs and in locations adequate to reflect overall project configuration) are considered most reliable. The importance of such data is lower when forecasts benefit from actual production data. Higher site topography complexity results in greater importance of local, accurate and diverse natural resource measurement data. The length of the measurements should be consistent with the expected inter- and intra-annual variability in the natural resource.

The correlation to a long-term reference is another key aspect of the energy assessment. It is good industry practice for this to be performed on the basis of sound statistical methods and on reliable and representative data. In Fitch's experience, meteorological stations or masts located in proximity to the project usually represent the most dependable sources of long-term correlation data for wind and solar, while for hydropower projects, the most dependable data is the river flow data at nearby gauging stations.

'Stronger' and 'Midrange' assessments of this attribute are associated with robust and well-supported energy production forecasts, while a weaker assessment would be assigned in the case of a weakly supported forecast or with limited analysis. Key considerations in Fitch's assessment of a forecast's robustness are the availability of accurate and sufficiently long measurements of the natural resource for the specific site, especially in the absence of actual production data, and the reliability of the data used for the correlation to a long-term reference.

Natural Resource Volatility

A key aspect of the analysis of *Revenue Risk – Volume* is the assessment of the inter-annual volatility of energy production as a result of variability in the underlying natural resource measured as the difference between P50 and one-year P90, as this has a direct corresponding effect, in most cases, on a project's revenue generation.

In this context, 'Stronger' assessments of *Revenue Risk – Volume* are associated with projects where the difference between P50 and one-year P90 is less than 6% (the difference between P50 and P90 calculated as [1-P90/P50]) as supported by a robust energy production forecast based on at least one year of operating history. We are also likely to assess *Revenue Risk – Volume* as 'Stronger' in projects where contractual or regulatory mechanisms materially insulate revenues from actual power generation (independently from the considerations on the natural resource's volatility and uncertainty).

We expect most wind and solar energy projects to display natural resource volatility in line with 'Midrange' attributes, defined as a difference between P50 and one-year P90 of 6%-16%. For hydropower, some projects may have differentials greater than 16%, which would generally result in a 'Weaker' assessment of this attribute.

In the context of the monitoring of existing ratings and in the absence of a revised energy production forecast, once a project develops a sufficiently long operating history (generally defined as at least three full years of operation), Fitch may revise its assessment of *Revenue Risk – Volume* to reflect the project's performance. A 'Stronger' assessment is associated with projects with performance close to and not worse than expectations, with maximum negative deviation from the initial Fitch base case of 6% and no dip below the initial Fitch rating case.

A 'Midrange' assessment is associated with projects with actual generation for most years within 16% of the initial Fitch base case and not more than one year out of 10 below the initial Fitch rating case, excluding outliers for one-off major technical failures. Higher observed volatility or more frequent dips below the initial Fitch rating case would be considered in line with a 'Weaker' assessment.

Energy Production Haircut

Fitch believes that all energy production assessments carry with them a degree of uncertainty and potential for error. Therefore Fitch will apply a haircut to the results of energy production forecasts. For solar and wind projects the haircuts depend on the assessment of *Revenue Risk – Volume* as shown, for example, in *Indicative Fitch Base and Rating Cases – PV Projects* on page 16. For hydropower projects, the haircuts will be determined on a case-by-case basis, as described on page 24. Energy production haircuts are generally up to 10%, but may be higher if warranted by a project's severe underperformance compared to expectations or in the event of particularly weak forecasts.

Portfolio Effect

In case of a portfolio of different projects, there is potential for an overall reduction in uncertainty, compared with the sum of the individual projects because of the statistical independence of some of the uncertainty parameters among projects. The extent of this diversification benefit, referred to as the portfolio effect, depends on the diversity of the

projects, both geographically – due to the variation in regional natural resource regimes – and technically, in terms of the variation of technology and project infrastructure.

Fitch understands that for a well-diversified set of wind projects, the portfolio effect may result in an increase in the aggregate P90 estimate by 2%-5%, compared to the sum of the P90s of single projects. When determining the amount of credit (if any) to give to the portfolio effect, Fitch looks for transparent analysis from the TA reflecting well-reasoned assumptions. No credit is likely to be given in case of weaker forecasts.

Curtailment Risk

This is the risk that the energy generated by a power project may be rejected, or curtailed, by the transmission system to which it is interconnected. This risk typically applies only marginally to projects operating under regulated incentive frameworks, as generally these benefit from priority of dispatch over other forms of power generation.

A power project can be curtailed when the transmission system experiences unexpected congestion that threatens system reliability. This can be caused by insufficient available transmission capacity, significant fluctuations in electricity supply/demand profiles, or a high proportion of intermittent generation (typically wind generation). For reservoir-based hydropower projects, curtailment may occur if there are competing demands on the water resource, for example when households, industry and irrigation are prioritized over power generation.

Fitch evaluates curtailment risk in terms of the financial impact on revenues of potential levels of non-compensated curtailment. Curtailment risk is best mitigated by contractually excluding it in the PPA, placing all curtailment risk on the power purchaser. PPAs may also define allowable causes and limits for compensated and non-compensated curtailment. In projects without any PPA protection from curtailment risk, this risk might be mitigated by regulatory provisions or through firm transmission capacity contracts in areas with significant excess capacity. Fitch will look for TA's assessment for the amount and likelihood of potential curtailment, where applicable, and identify any equipment upgrades required to minimize it.

For monitored ratings, actual curtailment significantly and persistently exceeding expected levels may result in rating action.

Revenue Risk – Price

Renewable energy projects operate typically on the basis of long-term PPAs, regulatory incentive mechanisms such as contracts for difference (CfDs), feed-in tariffs (FITs) and green certificates, or combinations thereof. In a few jurisdictions, projects are remunerated on the basis of the initial capex investment and, in some cases, projects derive revenues from the sale of power at market prices.

Stability and predictability of power generation remuneration are highest for projects that have a secure revenue stream through long-term PPAs or regulatory incentive mechanisms insulated from market dynamics and where price indexation, if present, is based on transparent measures. Exposure to market price risk reduces remuneration predictability depending on the share of the associated revenues compared with the total. Indexation of contractual prices may also result in lower stability and predictability of remuneration depending on the complexity and transparency of indexation formulas.

Counterparty Credit Quality

In fully contracted transactions, the credit quality of the revenue counterparty typically caps the project's rating. This means that in the case of counterparties with a weak financial profile, the debt instrument's rating may be driven primarily by the counterparty's credit quality irrespective of otherwise 'Midrange' or 'Stronger' key rating drivers' assessments and financial metrics in line with guidance for higher rating levels.

Absent a counterparty rating, Fitch may assume that the respective portion of revenues is exposed to merchant price risks, as described in the section on *Merchant Exposure* below. There may also be situations where Fitch's assessment of the credit quality of the payment obligation is not constrained by the payment counterparty's credit quality as the payment risk ultimately lies with a broader sector or a group of end users. Such circumstances are described

in more detail in the *Counterparty Risk* section of the *Infrastructure and Project Finance Rating Criteria*.

Hedging Instruments

Energy hedges are transactions between the project and a counterparty intended to provide stability to certain project revenue components. When revenue risk is influenced by hedges, such as energy pricing hedges, proxy revenue swaps, or certain insurance products, Fitch will assess the structural features and resulting impact on the cash-flow profile. Structural considerations include the duration of the hedge product, credit quality of the provider, basis risk to the pricing index hub, the specificity of measurement techniques and timeframe to settle the hedge, the level of project credit support or security posting required, hedge security ranking, covenants of the agreements, and termination provisions. Like the payment counterparties, the hedge counterparty's creditworthiness may cap the rating.

Merchant Exposure

We evaluate exposure to merchant market power prices based on the ratio of merchant to total revenues that the project is forecast to receive under the Fitch rating case over the debt's remaining life irrespective of the timing of receipt of merchant revenues. In assessing the price risk of a project, no distinction is made in the calculation between projects that derive a portion of their revenues from merchant sales throughout the life of the debt and projects that are exposed to merchant prices during only some of the debt's life.

Where a project is exposed to price risk, Fitch will stress power prices and in determining its assumptions will rely on a combination of the opinions of independent market experts, its in-house views and expectations, market-quoted forward prices and historical price and volume trends (if the quality and evidence are considered to have predictive value).

As discussed in the *Break-Even Analysis and Individual Stresses* section, a central consideration in Fitch's analysis of merchant price risk is the assessment of the market price decrease that a project can sustain and still meet debt obligations at a particular rating level (i.e. power price break-even level). This analysis is performed by reference to historical prices in the relevant market and informed by Fitch's internal view and discussions with market consultants on future market dynamics and fundamentals. Ratings may be constrained to sub-investment-grade in case of limited meaningful historical data for a specific power market or, in Fitch's view, particularly high future uncertainty in market dynamics.

Price Indexation

The price payable by the revenue counterparty under PPAs and regulatory incentive frameworks may be fixed for the life of the contract, increased periodically by a fixed percentage or indexed based on a variety of indexation formulas. The predictability of price evolution is likely to be lower in the latter case and is dependent on the complexity and transparency of the indexation formula.

Inflation and foreign-exchange assumptions are modelled in line with Fitch's internally generated forecasts. Assumptions will be based on historical values and the agency's judgement where a formal in-house view is not available. Fitch is likely to apply stresses to the sponsor's forecast in case of opaque indexation formulas.

Regulatory Incentives

As for any industry relying on government subsidies, the financial performance of projects dependent on public regulatory incentives relies on the supporting regulations not being modified within the timeframe of the financing. Fitch cautions that even in countries with strong credit ratings a threat exists to subsidy stability and longevity. Financial pressures and competing national priorities may force countries to re-examine the subsidies they provide.

Fitch does not rate to a change in law or regulation. For existing projects, the agency generally assumes in its analysis that once approved, governments will not apply targeted retroactive cuts. A change in the regulatory regime that reduces a project's subsidy support during the life of the debt will trigger Fitch's revaluation of the project's credit quality.

Performance Requirements

A project's remuneration may be tied to the requirement of meeting certain minimum production levels. Failure to meet such minimum thresholds may result in lower remuneration, the need to purchase energy in the spot market, or even termination of the revenue contract. Fitch reviews the PPA or the applicable regulatory framework to determine how stringent power plant performance requirements are, but in the agency's experience, these are generally set at levels well below reasonable downside performance. Nevertheless, Fitch will review whether specific performance requirements do result in a risk of contract termination, in which case associated revenues may be treated as merchant.

Debt Structure

The analysis of renewable energy projects' debt features follows Fitch's approach, as outlined in the *Infrastructure and Project Finance Rating Criteria* report. Fitch considers each rated debt instrument separately, taking into account the debt's payment waterfall ranking, refinance risk, financial profile, covenant package, structural features, hedging financial risk, liquidity and reserves and security.

Specific considerations to renewables asset class include expected economic lives. Depending on the project's characteristics such as technology reliability, operator experience and maintenance plan and budget and absent major mid-life capex investments, we deem the useful life of a wind project to be around 20 years and up to a maximum of 25 years, and that of PV and CSP projects around 25 years and generally up to a maximum of 30 years. Hydropower assets have long economic lives stretching to 50 years and sometimes beyond.

Financial Profile

Consistent with the *Infrastructure and Project Finance Rating Criteria* report, Fitch develops base case, rating case and individual financial stress scenarios to assess cash flow resiliency and capacity for debt repayment.

The scenarios outlined in *Indicative Fitch Base and Rating Cases – PV Projects*, *Indicative Fitch Base and Rating Cases – CSP Projects* on pages 16and 17, *Indicative Fitch Base and Rating Cases – Wind Projects* on page 20 and *Indicative Fitch Base and Rating Cases – Hydropower Projects* on page 24 reflect Fitch's indicative financial analysis scenarios. While the scenarios reflect the agency's typical approach to financial analysis, Fitch may apply more or less stress to key performance variables to adequately reflect the distinct characteristics of each project with respect to technology, project location, construction contractor and operator; in the case of projects with a reasonably long operating history, stresses will also be informed by the observed performance. Fitch will also adjust stress scenarios based upon TA's opinion and peer comparisons of other Fitch-rated projects.

Manufacturers' availability guarantees, O&M contracts and third-party insurance/guarantees are given credit in line with their terms and the counterparty rating. For example, no stress is likely to be applied to O&M costs and/or availability to the extent that these are covered by a fixed-price schedule and unscheduled maintenance contract and/or an availability guarantee from a counterparty rated at least as highly as the project debt.

Base Case

When analyzing a transaction, Fitch first builds a scenario reflecting the project's expected long-term sustainable performance, based on the agency's experience with the industry and similar projects (the Fitch base case). This is also used as a common starting point for stress analysis and constitutes one of the references for surveillance over the debt's life.

Fitch makes certain adjustments to the sponsor's projections, where appropriate, based on its experience and the guidance of the TA. The adjustments aim to bring parameters such as production, degradation rate (for PV projects) and operating costs in line with expectations for the specific technology in similar environments and conditions.

Fitch uses the net P50 production forecast for its base case (which already includes a certain plant availability assumption) subject to, possibly, a haircut to reflect the uncertainty in energy production forecasts, as discussed in the *Revenue Risk – Volume* section of this report. The magnitude of energy production haircuts is driven by the assessment of *Revenue Risk – Volume*

for wind and solar projects, but will be determined on a case-by-case basis for hydropower projects.

In case of exposure to the risk of grid curtailment, Fitch reflects in its revenue projections the non-compensated curtailment that may affect the project on the basis of the considerations expressed by the TA in the transmission study.

In case of exposure to price risk, the Fitch base case will reflect price assumptions informed by the market advisor's base case or central scenario.

Rating Case

The rating case evaluates the resilience of the projected cash flows to a combination of stresses that together simulate a scenario of material underperformance, which is conceivable but not expected to persist during the life of the project financing. Fitch combines risk factors assessed in the individual stress cases and applies a combination of stresses that are most likely to affect the project's performance.

Typically, Fitch's rating case is based on a project's one-year net P90 electric output estimate, adjusted for a haircut to reflect the uncertainty in energy production assessments, as discussed above under *Base Case* and in the *Revenue Risk – Volume section* of this report. In its analysis of greenfield projects, Fitch may apply a consistent energy production haircut in the base and rating case. Energy production haircuts may be tempered in the base and/or rating case for operating projects, depending on their performance and characteristics. Credit may be given to the portfolio effect, if this is adequately supported in the energy production forecast.

We may adjust the rating case energy production scenario assumption to incorporate PPA contract terms that provide for lower sensitivity of period-specific revenue generation to actual period-specific wind production. An example of this is Brazilian wind projects, where some contracts recognize the variability of wind resource and allow for period-specific deficits to be offset by previous or future period-specific surpluses, which improves revenue predictability and leads Fitch to use the 10-year average P90 assessment as the rating case production scenario.

Stresses on production, curtailment, O&M costs, degradation rate (for solar projects) are run to assess the sensitivity of cash flow projections to common operating challenges. Base case stresses moderate potentially optimistic sponsor projections, based on Fitch experience, third-party assessments and peer comparisons. Rating case stresses may be increased over base case levels to reflect occasional or persistent stresses that could occur during the life of the project financing. Such stresses could be due to expiry of the operating contracts or warranties prior to debt maturity, forecast errors, unproven technology or less-experienced manufacturers, or more difficult access to the project or to spare parts and qualified contractors.

In case of exposure to price risk, the Fitch rating case will also incorporate adjustments to Fitch base case market price assumptions. Fitch sets its rating case price forecast based on the agency's internally generated market price forecasts, with due consideration given to the market adviser's base case and low case projections, available historical data or the projections of another third-party consultant, as relevant.

DSCR Evaluation

In evaluating projected financial performance, Fitch considers the overall profile of the DSCR. This profile consists of: the average of DSCRs over the life of the project; the degree that the minimum DSCR deviates from the average; and the magnitude and frequency with which DSCRs persist below the average. The DSCRs in the rating case reflect the levels of cash flow cushion available (on top of the transaction's internal liquidity available through reserve accounts) to mitigate other possible reductions in cash available for debt service.

Some examples of the type of risks that this cushion is designed to accommodate include:

- Uncertainty surrounding energy production forecasts, high volatility in the natural resource, curtailment risk;
- Uncertainty regarding the long-term performance of technology; and

- Uncertainty of O&M cost budgets.

The DSCR indicative ranges in this criteria report are a guide, not a prescription for achieving a specific rating. Fitch's rating seeks to quantify major credit risks as reflected in its projection of DSCRs under stress scenarios. However, the rating is also informed by qualitative factors previously discussed such as operation risk, debt structure and exposure to market power prices.

Metrics guidance is to be considered in the context of the project's merchant (if any) exposure at any point in time. Guidance for a project, which under the Fitch rating case derives some revenues from merchant sales (a "partially contracted project"), will be calculated by deriving a weighted average between metrics for fully contracted and fully merchant projects depending on the share of merchant revenues of total revenues under the Fitch rating case. A single threshold may be calculated for the whole period if the share of merchant revenues is very similar in all years or for selected distinct periods if the share of merchant revenues differs over the life of the debt. Rating case projections will be updated annually for monitored projects to reflect current views for expected pricing levels, which may change the metrics thresholds.

The rating of a project with a fully contracted period followed by a merchant one will reflect fully contracted metrics guidance for the initial period and fully merchant metrics guidance afterwards.

Break-Even Analysis and Individual Stresses

Break-Even Stresses

Break-even stresses run on Fitch's base case scenario allow Fitch to determine the level of stress that a project could absorb while producing the minimum cash flow to meet debt service payments just before the point of cash payment default, as reflected in DSCRs of 1.0x, and usually including drawings on debt service reserves. The results of the break-even analysis are benchmarked to the peer transactions.

Energy Production: Fitch investigates the resilience of transactions to extremely low production scenarios. For this purpose, the agency calculates the decline in energy production from the Fitch base case throughout the life of the debt as well as one-off declines. The results of the latter scenario can be interpreted as indicating the duration of a major outage that fully interrupts power output which the project is able to withstand while still fully servicing debt.

O&M Costs: Break-even analysis is also performed on operating costs and evaluated in terms of percentage increase throughout the life of the debt as well as one-off increases. The latter measure is intended to inform the project's ability to withstand the costs associated with repair works following a major outage or other unplanned restoration works.

The results of the break-even analysis on energy production and operating costs are particularly relevant for projects benefiting from lower modularity, such as offshore wind and CSP projects. Results are assessed in the context of the project characteristics (e.g. location, equipment redundancy, technology risk and insurance cover) and the Technical Adviser's opinion on the likely length of repair works and associated costs after key equipment failures.

Merchant Prices: When a project is exposed to price risk, Fitch will consider the market price decrease that a project can sustain and still meet debt obligations at a particular rating level. Fitch will give consideration to an investment-grade rating if the break-even power price falls below the minimum historical annual average price (in real terms), assuming that rating case financial metrics otherwise meet the appropriate quantitative threshold. Break-even analysis on merchant prices is performed by testing for the price at which the annual DSCR is at 1.0x, in any year of the debt's life, excluding drawings on reserves, which are not specifically structured to mitigate merchant risk exposure.

'A' ratings are associated with projects which break even without relying on the contribution of merchant revenues. 'BB' and 'B' category rated debt instruments are expected to at least break even at an annual price which has been exceeded on 80% and 60%, respectively, of annual observations, giving due consideration to protracted periods of consistently low prices.

Ratings may be constrained to sub-investment-grade in the event of limited meaningful historical data for a specific power market. Fitch's internal view and discussions with market consultants will inform the period of historical pricing that we deem most relevant to a project's pro forma financials on a case-by-case basis. Also, Fitch may set more demanding break-even tests, for example by requiring an investment-grade project to break even at a price lower than the minimum historical annual average price, depending on Fitch's view of future market dynamics and fundamentals.

Individual Stresses

The agency may also run individual stress cases on the project's key performance drivers to determine the level of exposure and sensitivity of the project's cash flow to individual events. The relevance of specific individual and/or combined stress scenarios depends on the project's characteristics and features.

Metrics

Financial ratio definitions are outlined in the *Infrastructure and Project Finance Rating Criteria* report.

Fitch generally regards DSCR as the most informative metric for analysis of renewable energy financings with fully amortising debt structures. Fitch recognises that financial structures without full debt amortisation do not readily lend themselves to DSCR metrics. In such cases, Fitch may create a hypothetical, fully amortising scenario for the outstanding debt over a reasonable length of time in accordance with the parameters of the base and rating case to generate comparable metrics for use in its rating decision. Fitch will also consider LLCR and PLCR ratios and net debt to EBITDA or cash available for debt service (CFADS) for financing structures with balloon or bullet debt structures.

Models

Fitch may use the following models in the analysis of renewable sector credits: GIG AST Model, Corporate Monitoring & Forecasting Model (Comfort Model) and third-party models. The *Models* section in the *Infrastructure and Project Finance Rating Criteria* provides a description of these models.

Rating Assumption Sensitivity

Renewable energy project ratings are subject to positive or negative adjustment based on actual project experience. Below is a non-exhaustive list of the primary sensitivities that can influence renewable energy project ratings:

Energy Output: Energy production levels that differ significantly and persistently from Fitch rating case assumptions.

O&M Costs: Operating costs that deviate from projections may indicate greater than expected cost volatility or a failure to properly estimate or fully capture relevant cost items

Price Risk: Projects exposed to volatile power and/or other commodity prices, can experience wide variations in cash flows that could persist beyond the short term.

Counterparty Credit Quality: Movements in the ratings of the key counterparties, such as an EPC contractor or revenue counterparty, can influence or constrain renewable energy project ratings.

Adverse Regulation Changes: Changes in regulations that have a negative impact on projects' cash flows.

Disclosure

Fitch expects to disclose the following items in its rating reports and/or Rating Action Commentaries (RACs):

- Key rating drivers and their assessment;
- Financial metrics;

- Peer analysis;
- Main analytical assumptions;
- Rating assumption sensitivity;
- Any variations from criteria.

Variations from Criteria

Fitch's criteria are designed to be used in conjunction with experienced analytical judgment exercised through a committee process. The combination of transparent criteria, analytical judgment applied on a case-by-case basis, and full disclosure via rating commentary strengthens Fitch's rating process and helps market participants to understand the analysis behind our ratings.

A rating committee may adjust the application of these criteria to reflect the risks of a specific transaction or entity. Such adjustments are called variations. All variations will be disclosed in the respective rating action commentaries, including their impact on the rating where appropriate.

A variation can be approved by a ratings committee when the risk, feature, or other factor relevant to the assignment of a rating and the methodology applied to it are both included within the scope of the criteria, but where the analysis described in the criteria requires modification to address factors specific to the particular transaction or entity.

Limitations

Rating levels discussed in this report relate to Fitch's international credit rating scale. Ratings, including Rating Watches and Outlooks, assigned by Fitch are subject to the limitations specified in Fitch's Ratings Definitions and available at https://www.fitchratings.com/site/definitions.

Data Sources

Key rating assumptions used in this report are based on the analysis of data received from issuers, arrangers, engineers, consultants and other third parties, and public information in addition to Fitch's analytical judgement. Fitch relies on these sources for the assignment of new ratings. In monitoring existing ratings, Fitch also relies on updated operational and financial reports in addition to or in lieu of updated third-party reports. See the *Infrastructure and Project Finance Rating Criteria* report for a discussion of the relevant information used in Fitch's analysis and rating decisions.

Appendix A — Rating Considerations Specific to PV and CSP Projects

Solar projects rated by Fitch largely fall in the 'BBB' category and some reach the 'A' category. Results observed by Fitch so far suggest solar power projects will have stable energy production and operating costs consistent with expectations. This is also in line with the views of renewable energy engineering firms consulted by Fitch.

The table *Key Rating Driver Assessments for Wind, Solar and Hydropower Projects* on pages 3–4 compares the attributes that Fitch considers in assessing the risk factors as 'Stronger', 'Midrange' or 'Weaker' for solar projects.

Operation Risk

Fitch attributes crystalline silicon (c-Si) panels, including monocrystalline and polycrystalline, a lower operating cost and performance uncertainty compared with other PV technologies based on approximately 30 years of operating history, mostly as a residential and distributed power source and with minimal scale-up risk due to their modularity. These technologies are considered to have strong operating attributes and, everything being equal, are likely to be subject to less severe degradation-rate stresses.

Thin film panel technologies, including amorphous silicon (a-Si), cadmium telluride (CdTe) and copper indium (gallium) diselenide (CIGS and CIS), are attributed a 'Midrange' cost and performance uncertainty because some of these technologies have a limited operating history at the utility scale. Harsher degradation rate assumptions are generally associated with projects utilising such technologies.

Parabolic trough technologies are the oldest operating CSP technology, dating back to the mid-1980s as a utility-scale electricity source, and Fitch attributes the technology relatively low operating cost and performance uncertainty. Power tower technologies have been available at the utility scale since the late 2000s, and due to their more recent utility-scale experience, Fitch considers that power towers display moderate operating cost and performance uncertainty. Dish-engine and linear Fresnel reflector technologies are attributed relatively higher operating cost and performance uncertainty because of their status as technologies that are currently under development.

Fitch expects actual operating costs of PV projects to exhibit modest variability. Major costs of PV projects are typically lower than those of other power projects due to the solid state nature of PV technology, which has no moving parts. Thin film panel technologies benefit from a shorter track record than c-Si panels and may be subject to higher cost stresses in the project's later years of operation to reflect the possibility of higher replacement costs. Major costs for CSP projects are usually more in line with a traditional thermal power project due to their complexity and various moving parts. Fitch considers it common industry practice for CSP turbines to be overhauled periodically based on usage and third-party engineering assessments. Fitch is likely to use higher stresses in its rating case for CSP projects than for PV plants, particularly in the case of less-established technologies, such as power towers.

Revenue Risk – Volume

Fitch views solar irradiation measurements collected on the project's site through high-quality and well-maintained equipment for a minimum of 12 consecutive months as strongest. Forecasts based on satellite data can be sufficient as the main data input for solar. Weaker datasets include poorly maintained or calibrated onsite data collection, solar satellite data that was created with older methodologies or from datasets collected in the past.

Topography complexity is generally less of a concern for solar projects, for which ground-based solar data collected within a few miles' radius of the actual project site is generally considered adequate. If the surrounding topography is predominantly varied, however, the presence of microclimates may be possible, in which case, based on the advice of the TA more localized data may be required in order to appropriately reduce estimation uncertainty.

From Fitch's experience, the vast majority of solar projects tend to perform close to, if not above, the P50 forecast. Most solar projects display natural resource volatility in line with midrange attributes. Well-designed brownfield solar projects in locations benefiting from

stable irradiation conditions are possible candidates for a stronger assessment of *Revenue Risk – Volume*. The energy production haircuts used in Fitch's analysis for solar projects tend to be 2%-3%, but can be zero for projects with a positive operating record.

Financial Analysis: Indicative Fitch Base and Rating Cases

Key performance variables for solar projects include energy output estimates, plant availability, operations and maintenance expenses (including major maintenance) and degradation rates.

Indicative Fitch Base and Rating Cases — PV Projects

	Fitch base case	Fitch Rating case
Energy production scenario	P50	1-year P-90[a]
Energy production haircut		
Stronger revenue risk – volume assessment	0%–2%[b]	Stress level expected to be equal to Fitch base case
Midrange revenue risk – volume assessment	2%–7%[b]	Stress level expected to be equal to Fitch base case
Weaker revenue risk – volume assessment	7%–10%	Stress level expected to be equal to Fitch base case
Annual panel degradation	0.3%–1.0%	0.3%–2.5%
Grid curtailment	Informed by third-party assessment	Stress level expected to be equal to Fitch base case
Availability	Informed by third-party assessment and peer analysis	Stress level expected to be equal to Fitch base case
O&M costs		
Stronger operation risk assessment	Informed by third-party assessment and peer analysis	Fitch base case plus 0%–5%b
Midrange operation risk assessment	Informed by third-party assessment and peer analysis	Fitch base case plus 5%–15%b
Weaker operation risk assessment	Informed by third-party assessment and peer analysis	Fitch base case plus 15%–20%

[a]Except for specific cases as discussed under *Rating Case* on page 11. [b]Ranges include lower bound number but not the one at upper bound.
Source: Fitch Ratings.

Net P50 and one-year P90 estimates typically include certain plant availability assumptions and Fitch base case and rating case availability assumptions will be informed by these, unless we consider these levels to be significantly different from Fitch-rated peer projects. Fitch's rating case availability assumptions for PV projects are typically in the 96% to 98% range. Availability levels are primarily dependent on the reliability of the technology and the quality of the maintenance services. Balance-of-plant (BOP) issues are not key drivers of project availability for solar PV projects.

Degradation rate assumptions in the rating case for c-Si panels are generally between 0.5%, in the case of particularly strong technologies, and 1%. O&M cost stresses may be more conservative than indicated in the table above, possibly also higher than 20%, depending on projects' characteristics, for example, use of technology with a limited operating track record, exposure to particularly harsh meteorological conditions, location in a country lacking a mature solar power industry or ageing equipment.

Indicative Fitch Base and Rating Cases — CSP Projects

	Fitch base case	Fitch Rating case
Energy Production Scenario	P50	1-year P-90[a]
Energy Production Haircut		
Stronger Revenue Risk – Volume Assessment	0%–2%[b]	Stress level expected to be equal to Fitch base case
Midrange Revenue Risk – Volume Assessment	2%–7%[b]	Stress level expected to be equal to Fitch base case
Weaker Revenue Risk – Volume Assessment	7%–10%	Stress level expected to be equal to Fitch base case
Annual Collector Mirror Degradation	0.1%–0.3%	0.2%–0.5%
Grid Curtailment	Informed by third-party assessment	Stress level expected to be equal to Fitch base case
Availability	Informed by third-party assessment and peer analysis	Stress level expected to be equal to Fitch base case
O&M Costs		
Stronger Operation Risk Assessment	Informed by third-party assessment and peer analysis	Base case plus 0%–5%b
Midrange Operation Risk Assessment	Informed by third-party assessment and peer analysis	Base case plus 5%–15%b
Weaker Operation Risk Assessment	Informed by third-party assessment and peer analysis	Base case plus 15%–20%

[a]Except for specific cases as discussed under *Rating Case* on page 11. [b]Ranges include lower bound number but not the one at upper bound.
Source: Fitch Ratings.

Fitch's rating case availability assumptions for CSP projects utilizing parabolic-through technology typically are in the 92%-94% range and are lower than for solar PV projects as BOP issues can be potentially highly disruptive in the case of CSP projects.

Rating case O&M cost stresses for parabolic-through CSP projects are generally 10%-20%. More conservative assumptions may be applied, possibly temporarily, depending on project characteristics, for example use of power tower technology, exposure to particularly harsh meteorological conditions, location in a country lacking a mature solar power industry or ageing equipment.

We analyse additional real estate risks, such as roof access and host maintenance, inherent in PV projects that are mounted on host structures, on a case-by-case basis depending on the design and legal considerations applicable to the specific project.

DSCR Evaluation

The DSCR indicative ranges in *Indicative Coverage Ratios Guidance for Fully Contracted PV and CSP Projects* and *Indicative 'BBB–' DSCR Profile for Merchant Revenue Structures* are a guide, not a prescription for achieving a specific rating and are to be considered in the context of qualitative factors previously discussed such as operation risk, debt structure and exposure to market price risk.

Indicative Coverage Ratios Guidance for Fully Contracted PV and CSP Projects

Technology	'A–' DSCR profile Rating Case	'BBB–' DSCR profile Rating Case	'BB–' DSCR profile Rating Case	'B–' DSCR profile Rating Case
PV (x)	1.40	1.20	1.10	1.00
CSP (x)	1.60	1.40	1.20	1.00

Source: Fitch Ratings.

Indicative 'BBB–' DSCR Profile for Merchant Revenue Structures

Technology	'BBB–' DSCR Profile Rating Case
PV (x)	1.60 or Higher
CSP (x)	1.80 or Higher

Source: Fitch Ratings.

Individual and Break-Even Financial Stresses

In addition to the other stresses discussed in the report, a stress specific to solar projects is:

PV Panels and Collector Mirror Degradation: Fitch may test for higher-than-expected annual degradation and for break-even degradation levels for the purposes of peer comparison.

Energy Production Scenario – P99: Fitch will assess a project's performance under a one-year P99. This scenario will be tested in a single year of transaction's life, all other assumptions in line with Fitch's base case. Investment-grade projects are expected to at least break even.

Appendix B — Rating Considerations Specific to Wind Projects

Ratings across wind projects rated by Fitch are relatively diverse: few ratings exceed the 'BBB-' level and many are rated in the 'BB' category, with some in the 'B' and 'CCC' categories. Downward rating migration of wind projects typically has affected projects whose actual energy production proved materially below original expectations, possibly in combination with operating costs that have significantly exceeded initial projections. The table *Key Rating Driver Assessments for Wind, Solar and Hydropower Projects* on pages 3–4 compares the attributes that Fitch considers in assessing the risk factors as 'Stronger', 'Midrange' or 'Weaker' for wind projects.

Operation Risk

Onshore WTG are generally considered to be proven technology. Offshore WTG are also generally considered proven although the technology is evolving, particularly in larger turbine sizes and new foundation designs. The TA's opinion is important in understanding the extent of incremental technology risks compared with more established technologies. The extent of modifications in the new models compared with the existing ones, the type and length of prototype tests and the ability of equipment suppliers to bring a new turbine model to market also have to be considered. Terms and conditions under the defect warranties and availability guarantees, as well as under the O&M agreements will be important considerations in assessing the extent to which the incremental technology risk is mitigated.

Fitch has observed on some onshore projects, however, that operating costs are underestimated, as they can grow faster than inflation, unless protected by fixed-price inflation-linked agreements. TA opinions and comparison to peer projects, subject to considerations for different contract terms, are particularly important in Fitch's analysis of cost projections.

Fitch understands from discussions with TAs that the risk of operating costs deviating from budget is similar for on- and offshore wind projects. Offshore projects are however more exposed to potentially large one-off costs in case of major BOP failures. Fitch tests this exposure through dedicated break-even analysis as discussed in the *Financial Profile* section. Offshore wind projects' shorter track record, exposure to weather risk and the more challenging operating environment are reflected in Fitch's financial analysis through more conservative assumptions for operating costs and availability compared with onshore wind projects. Fitch views strong equipment redundancy and a narrower project scope (for example the exclusion from the project's perimeter of the export cables) as important mitigation against the risk of one-off failures.

Fitch has observed a variety of WTG issues that negatively affect project availability. These range from temporary stand-still periods, due to adverse metrological conditions (e.g. icing on the blades) to technical failures, the most common of which relate to blades and gearboxes. The most serious technical issues usually occur soon after project commissioning. Projects in countries with a developing wind power industry may suffer from lower availability levels than those achievable by projects in Europe or North America due to more difficult access to spare parts or less experienced operators.

Revenue Risk – Volume

A minimum of two years of accurate onsite measurements, and often longer depending on site characteristics, is considered appropriate to provide a sufficient basis for a wind energy production forecast. Topography complexity requires the greatest attention for onshore wind projects, requiring measurements on the actual project site and from several masts. To the extent the aspect is given due consideration in the production estimates, Fitch understands that lack of onsite measurements is less of a weakness for offshore wind projects given their lower topography complexity.

Another aspect carrying particular importance for wind energy assessment is the correlation to a long-term reference. In Fitch's experience, meteorological stations or masts located in proximity to the wind project usually represent the most dependable sources of long-term correlation data. Conversely, the use of indexes or satellite data that was created with older methodologies appears to have contributed to inaccurate forecasts in the past for wind projects and Fitch considers such measures offer less certainty.

In Fitch's experience, very few, if any, wind projects are likely to present expected natural resource volatility levels in line with a Stronger assessment of this risk factor. Most projects are expected to fall in the 'Midrange' category. Projects that severely underperform expectations or are located in sites with particularly volatile wind conditions would be considered in line with a 'Weaker' assessment. The energy production haircuts used in Fitch's analysis of wind projects is generally 3%-7%.

Financial Analysis: Indicative Fitch Base and Rating Cases

Key performance variables for wind projects include energy output estimates, and operations and maintenance expenses (including major maintenance).

Indicative Fitch Base and Rating Cases — Wind Projects

	Fitch Base Case	Fitch Rating Case
Energy Production Scenario	P50	1-year P-90[a]
Energy Production Haircut		
Stronger Revenue Risk – Volume Assessment	0%–2%[b]	Stress level expected to be equal to Fitch base case
Midrange Revenue Risk – Volume Assessment	2%–7%[b]	Stress level expected to be equal to Fitch base case
Weaker Revenue Risk – Volume Assessment	7%–10%	Stress level expected to be equal to Fitch base case
Grid Curtailment	Informed by third-party assessment	Stress level expected to be equal to Fitch base case
Availability	Informed by third-party assessment and peer analysis	Stress level expected to be equal to Fitch base case
O&M Costs		
Stronger Operation Risk Assessment	Informed by third-party assessment and peer analysis	Base case plus 0%–5%[b]
Midrange Operation Risk Assessment	Informed by third-party assessment and peer analysis	Base case plus 5%–15%[b]
Weaker Operation Risk Assessment	Informed by third-party assessment and peer analysis	Base case plus 15%–20%

[a]Except for specific cases as discussed under *Rating Case* on page 11 [b]Ranges include lower bound number but not the one at upper bound
Source: Fitch Ratings.

Net P50 and one-year P90 estimates typically include certain plant availability assumptions and Fitch base case and rating case availability assumptions will reflect those, unless the underlying assumptions are considered to be significantly different from Fitch's in-house views and peer projects. Fitch's rating case availability assumptions typically are in the 95% to 97% range for onshore wind projects and 92% to 95% for offshore wind projects, in the absence of reliable availability warranties. Availability levels are primarily dependent on the reliability of the technology and the quality of the maintenance services. BOP issues are not key drivers of project availability for onshore wind projects, in Fitch's experience, but are potentially highly disruptive in the case of offshore wind projects.

O&M cost stresses may be more conservative than indicated in the table above, possibly higher than 20%, depending on projects' characteristics, for example use of technology with a limited operating record, exposure to particularly harsh meteorological conditions, location in a country lacking a mature wind power industry, or ageing equipment.

DSCR Evaluation

The DSCR indicative ranges in *Indicative Coverage Ratios for Wind Projects* are a guide, not a prescription for achieving a specific rating and are to be considered in the context of qualitative factors such as operation risk, debt structure and exposure to market price risk.

Indicative Coverage Ratios Guidance for Wind Projects

	'A-' DSCR Profile Rating Case	'BBB-' DSCR Profile Rating Case	'BB-' DSCR Profile Rating Case	'B-' DSCR Profile Rating Case
Fully Contracted	1.5	1.3	1.15	1
Fully Merchant		1.7 or higher		

Source: Fitch Ratings.

Energy Production Scenario – P99: Fitch will assess a project's performance under a one-year P99 scenario. This scenario will be tested in a single year of a transaction's life, all other assumptions being in line with Fitch's base case. Investment-grade projects are expected to break even.

Appendix C — Rating Considerations Specific to Hydropower Projects

This criteria annex gives guidance for rating reservoir and run-of-river hydropower facilities, but excludes pumped storage facilities as these do not generate net energy, despite many similarities in technology and operation. The table *Key Rating Driver Assessments for Wind, Solar and Hydropower Projects* on pages 3–4 compares the attributes that Fitch considers in assessing the risk factors as 'Stronger', 'Midrange' or 'Weaker' for hydropower projects.

Operation Risk

Hydropower plants use proven technology with a long operating history and established operating procedures. This makes operating costs predictable under normal conditions. The occurrence of major outages, due to technical failures or major floods, is unlikely but if these occur, the consequences can be severe, including extended periods of revenue loss, high repair and environmental costs and possible compensation to affected parties. Therefore operation in line with health and safety standards and good industry practice is paramount, and we will look for evidence from the technical adviser on the preventative processes and procedures.

Maintenance needs are well known and capital expenditures are limited, as the majority of capex is related to the initial groundworks. Throughout the project life only the electrical generation and control equipment require major overhauls, roughly every 20-25 years, at a small cost relative to the initial investment in groundworks. As such, O&M costs are largely concentrated in personnel, and less in the overhaul costs. Environmental costs can also be significant as many jurisdictions require permits for operating hydropower assets and these contain obligations to carry out local programs and environmental work.

Considerations specific to run-of-river hydropower plants include possible erosion and sediment build-up which may cause damage to turbines and civil structures. The prevalence of these issues may increase maintenance requirements.

Experienced staff are essential for the proper operation of hydropower plants. Many hydropower plants are remotely operated with limited on-site personnel. Large plants are more likely to have personnel on-site. For projects in remote locations retention of experienced staff on-site can be a challenge, and Fitch will pay particular attention to associated cost budgets and staffing levels.

Revenue Risk – Volume

As for wind and solar projects, Fitch expects to receive a resource report with estimates of P50 and P90 production levels. Hydrology assessments are based on river flow measurements or studies of rainfall, although the latter is considered much less accurate. Many major rivers are monitored for information on flooding, so long-term river flow data is typically available even for facilities under construction. Fitch considers 20-30 years a reasonable level of historical river flow data.

Existing hydropower facilities often have very long production histories due to the quasi-perpetual nature of the assets. If lacking a resource report, Fitch may rely on historical generation data over at least 20 years, and develop scenarios that approximate the P50 and P90 estimates based on the average and 10th percentile of historical generation data. We may remove outliers from the dataset if the production volume during the period was driven by factors unrelated to hydrology such as technical failures or curtailments.

In Fitch's experience few hydropower projects can reach a 'Stronger' Volume risk assessment due to the inherent volatility in water flows. Weather events can have a significant impact on production volumes. Of greatest concern is the effect of droughts, which can last for several years and can significantly reduce generation over a prolonged period. This is reflected in the typically high differential between P50 and P90. Typical hydropower projects would most likely be assessed as 'Midrange' or 'Weaker' for Volume risk, depending on the operating history and historical and/or expected resource volatility. To reach a 'Stronger' assessment, a hydropower plant would require a mechanism that fully mitigates hydrology risk such as availability-based payment mechanisms.

In its assessment of Volume risk, Fitch also considers the differences between the two main hydropower facility types: reservoir or run-of-the-river. Run-of-the-river systems production volumes are directly linked to water flows during the year. Seasonal patterns such as snow melts, rainfall seasons or other weather patterns need to be taken into account.

Reservoir-based systems are less directly exposed as reservoirs can smooth short-term fluctuations in water flows. However, generally reservoir capacity is not enough to compensate for significant seasonal variations. In addition, reservoir-based systems regularly have competing demands for water, such as for irrigation and drinking water, depending on the location of the project and on how developed the water management systems are in a particular region. Therefore Fitch analyses both types of facilities in a broadly similar manner and we expect that any differences in production patterns will be reflected in P50/P90 production estimates.

Fitch will also look for the TA's views on how the presence of reservoirs can smooth production volatility, considering also competing demands and operational challenges of the facility.

In some countries, hydropower projects may benefit from regulatory mechanisms that mutualise volume risk across a large number of facilities and guarantee the off-take of contracted volumes for each project, for example in Brazil. Consequently Fitch would assess the system-wide production forecast, using the system P50 and P90 for our base and rating cases respectively. However volume risk may not be entirely mitigated by this mechanism.

In Brazil, projects may be responsible for generation shortfalls below the contractual production level, paying the market price to PPA counterparty by way of compensation. In this case therefore Volume risk assessments would likely be 'Midrange'.

Revenue Risk – Price

Hydropower projects cover the whole spectrum of market risk exposure, ranging from projects selling energy at wholesale market prices to projects that are partially or fully insulated from price risk through PPAs or regulatory mechanisms. In the North American market Fitch has typically seen projects selling produced energy through marketers or directly into the local grid at the prevailing power price. Some hydropower projects benefit from capacity payments which ensure revenue stability. In general, merchant price risk for large reservoir-based hydropower facilities can be lower than for other renewables. This is because they have the ability to reduce production during low power price periods and increase production during times of peak prices.

In markets dominated by hydropower generating assets, regional hydrology patterns can drive electricity prices, creating a natural hedge: when hydrology volumes are low, hydropower plants produce less electricity but market prices rise. Fitch will assess the strength of this relationship based on historical data and the market adviser's views on whether the same pattern will prevail in the future.

This relationship could be inverted due to a mutualisation mechanism, similar to that in Brazil described above, as some projects may need to pay higher market prices during periods of reduced system production.

Fitch will carefully analyse payment mechanisms to identify possible price risk exposure in downside conditions and any mitigating features. Such features could include lower contracted energy levels, where the buffer is used to absorb system deficits, or insurance products that would allow projects to cap their exposure to system deficits and spot prices.

Financial Analysis: Indicative Fitch Base and Rating Cases

Key performance variables for hydropower projects include energy output estimates and operations and maintenance expenses (including major maintenance).

Indicative Fitch Base and Rating Cases — Hydropower Projects

	Fitch Base Case	Fitch Rating Case
Energy Production Scenario	P50	1-year P-90[a]
Energy Production Haircut	0–10%	Stress level expected to be equal or higher than BC
Grid Curtailment	Informed by third-party assessment	Stress level expected to be equal or higher than BC
Availability	Informed by third-party assessment	Stress level expected to be equal or higher than BC
O&M Costs		
Stronger Operation Risk Assessment	Informed by third-party assessment and peer analysis	Base case plus 0–5%
Midrange Operation Risk Assessment	Informed by third-party assessment and peer analysis	Base case plus 5–15%
Weaker Operation Risk Assessment	Informed by third-party assessment and peer analysis	Base case plus at least 15%

[a]Except for specific cases as discussed above
Source: Fitch Ratings.

Fitch believes that all energy production assessments carry with them a degree of uncertainty and potential for error. Therefore we will apply a haircut to the results of renewable energy production forecasts.

Unlike in other renewable projects, for hydropower projects the level of the energy production haircut is not linked to our assessment of Volume risk. Hydropower production forecasts typically have a lower level of uncertainty compared to wind projects based on long actual production histories and/or extended time series of river flow measurements. This means that, while the difference between P50 and P90 is typically wider for hydropower than for solar and wind farms, reflecting higher volatility, the accuracy of the forecasts is generally higher. A link to the assessment of volume risk, which takes into account the volatility of the resource, is not appropriate.

The level of the haircut will therefore be determined on a case-by-case basis after close examination of the resource forecast report. We would use a haircut at the lower end of the range if the project had a long and relatively stable production history, or for projects where historical volatility was not expected to continue, based on a well-argued technical adviser's opinion. Larger haircuts would be appropriate for projects that have shown historical volatility or for projects where production forecasts are based on shorter time periods of river-flow data, or where the forecast is not based on on-site measurements.

DSCR Evaluation

The DSCR indicative ranges in *Indicative Coverage Ratios Guidance for Hydropower Projects* are a guide and should not be seen as a prescription for achieving a specific rating and are to be considered in the context of qualitative factors previously discussed, such as operation risk, debt structure and exposure to market price risk.

Indicative Coverage Ratios Guidance for Hydropower Projects

	'A–' DSCR Profile Rating Case	'BBB–' DSCR Profile Rating Case	'BB–' DSCR Profile Rating Case	'B–' DSCR Profile Rating Case
Fully Contracted	1.5	1.3	1.15	1
Fully Merchant		1.7 or Higher		

Source: Fitch Ratings.

Sensitivity Analysis

Drought Break-Even: As hydropower projects are more exposed to low probability, high impact events such as droughts, greater importance will be placed on break-even analysis to

assess what level of drought could be withstood by the project. Fitch will establish a production level reflecting a severe drought informed by the TA's estimates, historical data and peer comparison. We will apply this production level (expected to be below the one-year P90 level) to the period of the lowest annual DSCR coverage in the Fitch base case. We then test for how long the project would be able to continue servicing its debt, taking into account all cash and liquidity available to the project. Investment grade projects should be able to withstand severe droughts for at least three years.