How multi-technology PPA structures could help companies reduce risk

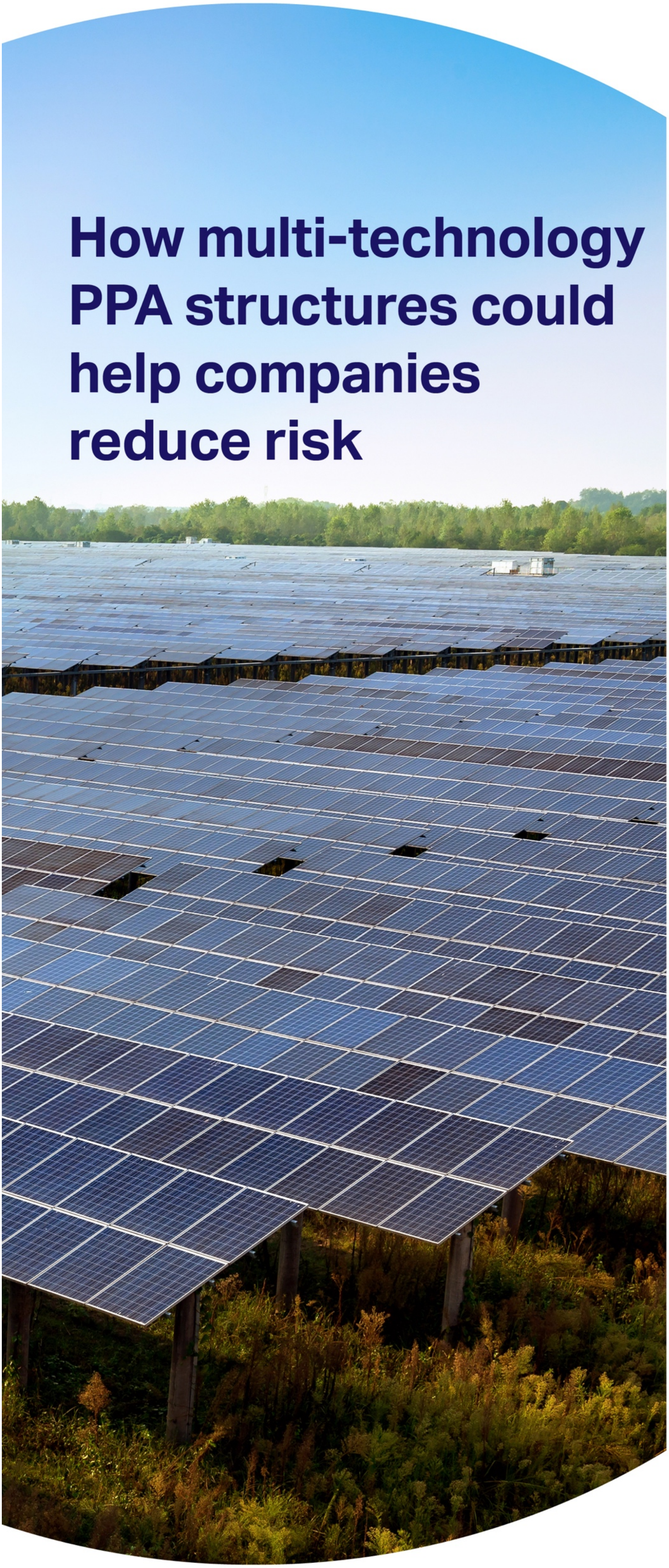

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Table of contents

Introduction

This paper builds on previous WBCSD reports on corporate power purchase agreements (PPAs): *Corporate Renewable Power Purchase Agreements: Scaling up globally* (October 2016) and *Innovation in Power Purchase Agreement Structures* (March 2018). These reports cover the opportunities corporate PPAs offer, the obstacles that corporate buyers and developers face as they plan and negotiate PPAs, as well as innovations in corporate PPAs as the market grows and evolves. This paper adds an additional focus to the previous publications and discusses a particular type of PPA – a multi-technology PPA – and the manner in which developers and corporate buyers may increasingly be using it. We hope this will support continuing innovation in the way companies purchase renewable power for their operations.

As outlined in the first report – *Corporate Renewable Power Purchase Agreements: Scaling up globally* – PPAs usually focus on a company purchasing electricity (whether actually or notionally) from an off-site renewable electricity project via a PPA (a corporate renewable PPA). This paper focuses on what we term multi-technology PPAs (MT PPA). By that, we mean a PPA that covers multiple projects using different technologies (such as wind, solar, biomass, geothermal or hydro).

A variety of technology combinations are possible for corporate renewable MT PPAs. In order to maintain focus, we have limited this paper to the technologies with a variable generation profile: wind and solar PV. It is equally possible to consider a combination of these technologies with storage technologies (e.g. on-site battery storage or hydro assets). For this paper, we have also maintained the focus on off-site PPA structures and have not included on-site behind the meter solutions (such as on-site solar PV).

There is relatively limited public evidence of MT PPAs to date. The risk discussion in this paper draws from actual transactions that the co-authors have worked on in markets such as the United States. Although MT PPAs are not yet common, WBCSD is interested in the potential use of MT PPAs to solve identified market needs. Particularly, corporate buyers have shown increasing interest in firm or shaped PPA offerings in recent years (that is, rather than be exposed to a project's variable generation profile, the corporate buyer can rely on a firm profile over a given time period – whether physically or via a financial hedging product). In this paper we explore whether combined technology solutions can offer a firmer generation profile in comparison to a single technology and hence reduce exposure to risks, now or perhaps in the future. This may make them a viable alternative to other existing risk mitigation tools.

The focus of this paper is how MT PPAs may impact particular risks related to variable renewable generation within PPAs. As such, we first provide background on those risks and how corporate PPAs are addressing them. We then analyze how MT PPAs may impact those risks. Finally, we highlight how MT PPAs influence other relevant legal aspects.

Key PPA risks related to variable generation patterns

For background on corporate PPAs, common features and risks, please refer to the previous WBCSD reports mentioned above. In this section, we focus on key risks related to variable generation patterns that are relevant to assessing whether a MT PPA approach offers benefits to either the sell side or buy side. Adopting the terminology from our previous reports, those are balancing risk, shape/profile risk and volume risk.

Balancing risk – This concerns the risk of exposure to power system costs that arise when an asset's forecasted generation is different from its actual generation. The rules relating to the potential liability of an asset's exposure to power system costs differ markedly between markets. For example, the level to which power system operators pass system-balancing costs through to a party that is responsible for grid feed-in or off-take differs between jurisdictions – with some operators imposing strong price signals. Similarly, whether a system operator uses a single price or different prices for imbalance fees or compensation – depending on whether a party has gone over or under its nominated position – is equally a policy decision that impacts risk exposures.

The more an asset contributes to the power system's imbalance, the higher the imbalance cost. And the more the generation profile of an asset correlates with the market-wide generation profile of its technology, the more the asset's imbalance correlates with the overall power system imbalance, resulting in higher imbalance costs. In short: asset generation profile and location matter when quantifying an asset's imbalance risk.

Shape or profile risk – This captures the fact that hour-to-hour generation will be variable depending on wind speed or solar irradiation, even if the overall volume over a sufficient period of time equals the estimated volume. Against this generation profile, the demand profile of a corporate buyer is likely to be flatter, with a pronounced variation between business and non-business days.

Volume risk – This risk captures the variable generation of an asset over a period of time (usually a longer period than when discussing shape or profile risk). This variability derives from variations across that longer time period, such as higher than expected wind over one year or lower solar irradiation levels due to a poor summer.

Many corporate buyers receive green certificates alongside the purchase of electricity to prove its renewable nature. In addition to the risks explained above stemming from the variable electricity generation of wind and solar technologies, corporate buyers also manage the lack or excess of green certificates that results from the variable renewable electricity generation. This particular risk is not further explored in this paper.

Risk impact on PPAs

Corporate buyers are increasingly interested in understanding the range of mitigation tools available to address these risks. We outline some of these below, along with a discussion of how a key stakeholder – lenders to the project – view them.

Risk	Mitigation tool	Summary	Costs	Bankability of project
Balancing risk[1]	Outsourcing of risk to a third party	Depending on the market and how the PPA is set up, the imbalance risk for a physical PPA can sit with either the seller or the corporate buyer. It is common to pay an appropriate third party (such as a utility or wholesale market trader) to manage the risk. For example, in some markets the buyer's agent for delivery of electricity can be the balancing responsible party for the asset and also manage the imbalance risk. A third party can include the asset within a much larger asset group and thereby reduce likely exposure to imbalance costs.	Fees are payable to the third party managing the risk. Costs might also depend on the asset's generation profile and location and the quality of the information shared by the asset owner with the third party.	Considered a bankable structure. Low risk for project. Structure has been used.
Balancing risk	Sell-side management of risk	Alternatively, a large enough developer may have access to balancing tools within its wider group and hence offer to manage this risk (i.e. not outsource to a third party). The developer would most likely arrange for electricity deliveries to be nominated to the corporate buyer or its agent.	Where the seller manages the risk, the overall cost under the PPA will account for a risk premium.	Considered a bankable structure. Low risk for project. Structure has been used.

[1] Balancing risk is directly relevant to a physical PPA structure. In case of a virtual PPA, the cost of managing imbalance risk is equally relevant as the seller will account for such costs when negotiating the price it needs to obtain under a PPA.

Shape and/or volume risk	Buy-side management of risk: Physical PPA	For 'as-produced', physically sleeved PPAs, the corporate buyer is responsible for the impact the variability of the electricity production may have on its overall demand position. For shape risk, if the sun did not shine or the wind did not blow, then the corporate buyer would need to procure the near-term reduction in volumes to meet its demand requirements. Similarly for volume risk, the corporate buyer will take a view on the asset's likely generation on a probability basis when determining how to hedge any residual demand volumes required over a longer time period. Usually, the corporate buyer uses its utility supplier as a sleeving agent to manage the variable volumes from the PPA as part of the wider management of the corporate buyer's electricity demand.	Fees are payable by the corporate buyer to the sleeving agent. The scope and cost are dependent on commercial arrangements between the corporate buyer and the sleeving agent but can include management fees and, potentially, top-up fees when it is necessary to purchase replacement volumes on the market. The corporate buyer will likely experience and pass on a higher cost to accept this risk (in comparison to a large electricity trader directly contracted by the seller). Also, the cost will depend on the share of renewables in the market. In a renewable-dominated market, prices tend to be higher at moments with less renewable production. Thus, for the hours where the PPA does not cover the buyer's demand, the market price might be higher than average prices, leading to a higher cost when purchasing additional power.	Considered a bankable structure. Low risk for project. Structure has been used.

Shape and/or volume risk	Buy-side management of risk: Virtual PPA	Above can also be relevant for an 'as-produced' virtual PPA. The corporate buyer does not receive physical delivery of power. However, it has financially locked in a price for the variable renewable generation. The corporate buyer will need to manage the financial impact of the contracted variable generation in the PPA when it buys additional power for its overall electricity requirements. For example, an electricity supplier to the corporate buyer could provide this by accounting for the value of the electricity the buyer has already 'hedged' under its corporate PPA when determining how to manage the buyer's overall position.	Fees are payable for management of the corporate buyers' overall electricity demand price exposure.	Considered a bankable structure. Low risk for project. Structure has been used.
Shape and/or volume risk	Sell-side management of risk: Physical PPA	The seller commits to provide a firm shape or volume over a given time period (such as, a determined volume per hour and hence also per year or a minimum and/or maximum generation guarantee). For a physical PPA, this could involve the seller contracting an agent that can nominate and deliver the agreed firm volume notwithstanding the variable generation of the asset. Alternatively, a seller could seek to absorb the risk itself or within its wider group by setting firm deliveries at a conservative level. For volume risk in particular, a seller may consider the risk of under-delivery over a longer time period financially manageable. The delivery of renewable energy certificates (over a longer time period) matching the firm volumes proves the overall renewable nature of the electricity.	Costs depend on the level to which the seller outsources the risks. For a physical PPA with a delivery agent that manages the risks, fees for this risk management would be payable on a per MWh basis. Where the seller manages the risk itself, the overall cost of the PPA will account for the risk premium.	More dependent on deal-specific and market-specific factors. Likely acceptable to lenders if seller outsources risk to a creditworthy delivery agent and if alternative delivery agents offering similar services are available. The approach of the seller absorbing the risks and not wholly outsourcing them will require more consideration by lenders.

Shape and/or volume risk	Sell-side management of risk: Virtual PPA	Similar issues are relevant for a virtual PPA where the seller commits to a firm volume that is used for financial settlement under the PPA. The seller can either (i) outsource this risk by entering in a parallel financial hedge with a third party (such as a trader) to manage the commitment of financially settling against a firm volume; or (ii) seek to absorb the risk by setting firm deliveries at a conservative level where the risks of under-production versus the firm financial settlement volume are financially manageable.	Costs depend on the level to which the seller outsources risk. Where the seller manages the risk itself, the overall cost of the PPA will account for the risk premium.	As above.

How can MT PPA structures mitigate those risks?

This section discusses how MT PPAs may impact the risks mentioned above. The approach taken under a MT PPA may equally impact other risks also assigned under a PPA. We discuss these later in this paper (see Other risks specific to MT PPAs).

The table below lists each of the risks discussed in the previous section and considers how MT PPAs may impact them.

Risk	PPA with multiple technologies
Balancing risk	If different technologies connected to the grid in the same balancing zone can be managed as a single group for balancing purposes and the assets' forecast errors are not strongly correlated, then the resulting multiple-project effect could reduce the exposure to imbalance costs. This could impact the commercial terms of a PPA: if the effect reduces exposure to imbalance costs, then it may also reduce the fees for managing that risk via a third party or the developer itself (which in turn could influence the pricing under the PPA). A considerable effect is expected with bigger portfolios of different projects.
Shape and/or volume risk	Solar and wind generation tend not to be correlated. Hence the amount of time both wind and solar assets produce insufficient power for the corporate buyer to cover their demand tends to be less than that of single technology type assets. Similarly, a combination of wind and solar can reduce the exposure to years of extreme generation (both on high and low sides) and hence volume risk. As a result, market exposure is expected to reduce compared to a single technology PPA. The extent of this benefit depends heavily on the correlation between the production profiles of the assets, the relative size of the different assets and the specific power system dynamics. In principle, this effect also holds for a PPA combining multiple renewable assets of the same technology, as long as their physical characteristics lead to different generation profiles (e.g. a wind farm in the North of a market area combined with a wind farm in the South). Where the corporate buyer is accepting and managing shape and/or volume risk, then a MT PPA may influence the corporate buyer's approach to that risk and the cost it assumes it will incur to manage it. For example, the MT PPA could be on an 'as-produced' basis, but the net impact of the variable generation of the multiple projects is such that the corporate buyer considers the cost of managing the overall variable generation to be less expensive compared to an 'as-produced' single technology PPA. This insight will influence price discussions with the sleeving agent (if used). Where the seller is accepting and managing shape and/or volume risk, a MT PPA may enable the seller to more easily offer some form of a firm or shaped commitment under the MT PPA, as the risk and cost of managing this (either directly or via a trading party supporting the seller) is manageable.

The explanations above show that MT PPAs may offer a form of alternative mitigation to some of the risks relevant to a corporate PPA. However, whether that is accurate or relevant depends significantly on the actual effect of different technology combinations on balancing, shape and volume risk. The key influencing factors are:

- Individual asset generation profile and geographical location, i.e. its correlation with the market-wide generation profile of its technology type;
- The correlation of generation profiles and forecast errors within the MT PPA;
- The correlation of combined generation profiles (i.e. wind and solar) with the demand profile of the corporate buyer;
- How 'sharp' imbalance costs are (that is, how potentially expensive exposure to imbalance risk is);
- How 'sharp' shape and volume costs are (that is, how potentially expensive it is to be exposed to intra-day and seasonal swings in power market prices).

It is thus necessary to quantify the actual effect on balancing, shape and volume risk for each individual asset and MT PPA. With the availability of historic weather data for specific sites, a dedicated power market model can estimate cost effects into the future. As market rules, market shares of different generation technologies and power prices change over time, these estimates can guide decision-making, but are uncertain.

Analysis

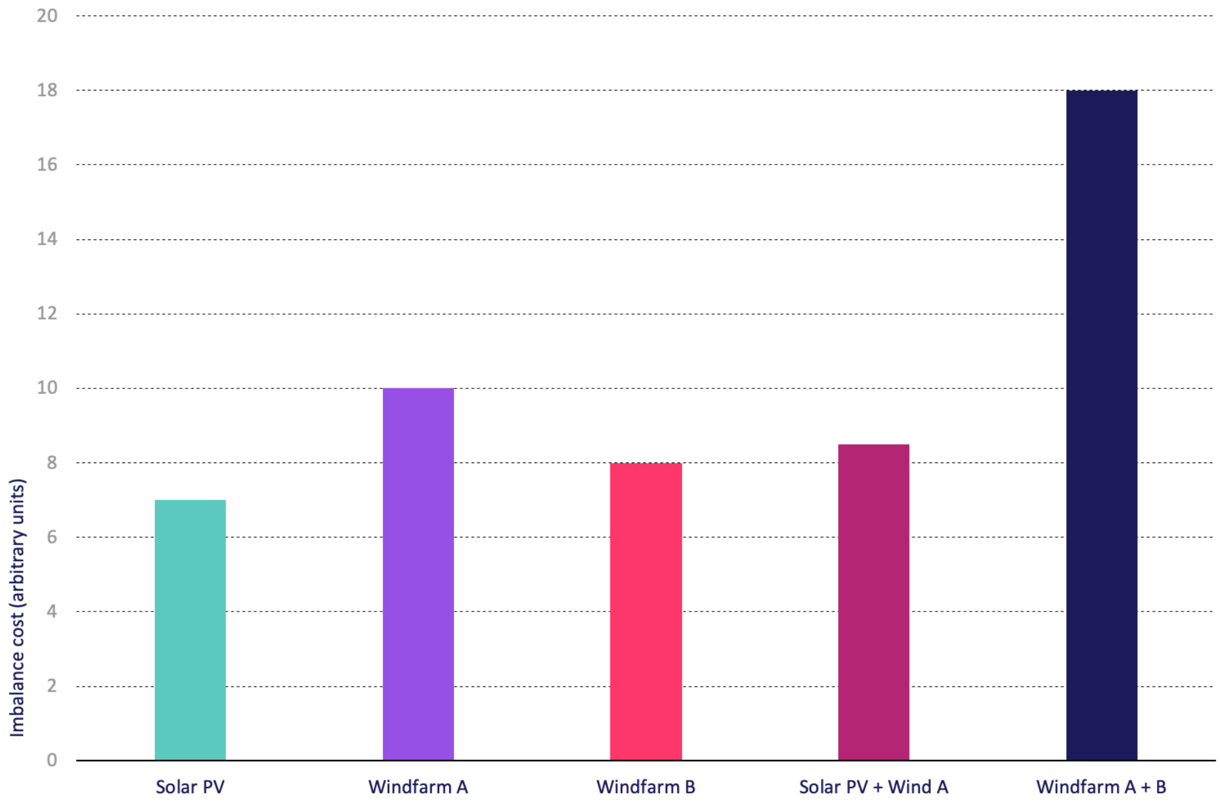
This section analyses the manner in which wind and solar technologies can impact the risks above when considering their generation profiles as part of a MT PPA. The extent to which they can do so is crucial to the value that a MT PPA may offer compared to a single technology PPA. In practice, local circumstances will always highly influence these impacts.

Balancing risk

An asset's imbalance costs are dependent on market rules, imbalance prices as well as on the deviation of the actual generation from the forecasted one. For renewable assets, the reasonable but limited accuracy of renewable generation forecasts largely causes this deviation. Yet, the asset's characteristics also play an important role: one individual site may see more (local) weather fluctuations than another site. As such, some renewable assets may follow an imbalance pattern that is typical for most renewable assets in the market and other renewable assets may show less typical behavior.

In a MT PPA the total imbalance cost of all assets is a combination of the individual asset's imbalances. Figure 1 explains this further: When combining assets that have highly correlated generation profiles and forecast errors (e.g. two identical turbines standing close to one another), the imbalance cost equals the sum of the individual imbalance costs. If generation profiles and forecast errors are not correlated (such as a wind asset and a solar asset), the imbalance cost is closer to the average of the two individual imbalance costs.

Figure 1: The balancing risk of uncorrelated assets (e.g. solar PV and wind) vs the balancing risk of two correlated assets (e.g. two wind turbines in the same location) (indicative example)

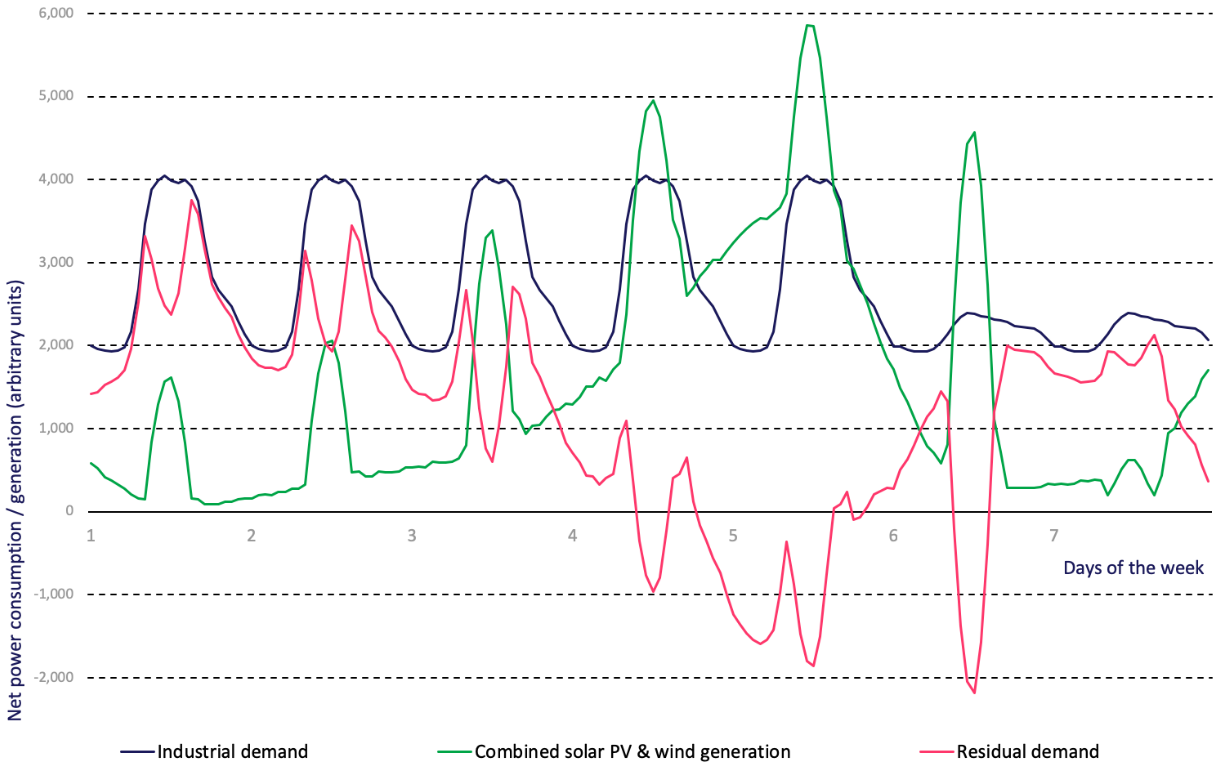


As discussed in the previous section, sellers or corporate buyers can outsource balancing risk to a third party that absorbs and manages the risk for a fee. It is arguable that an approach across several solar and wind assets could form the basis of a more nuanced understanding of the likely imbalance exposure over time. This could, in turn, support a more focused discussion with the seller or corporate buyer asking the third party to reduce the fees for the risk management. As such, exposure to imbalance costs (or the fees to manage that risk) can impact price discussions between a seller and a corporate buyer.

Shape risk

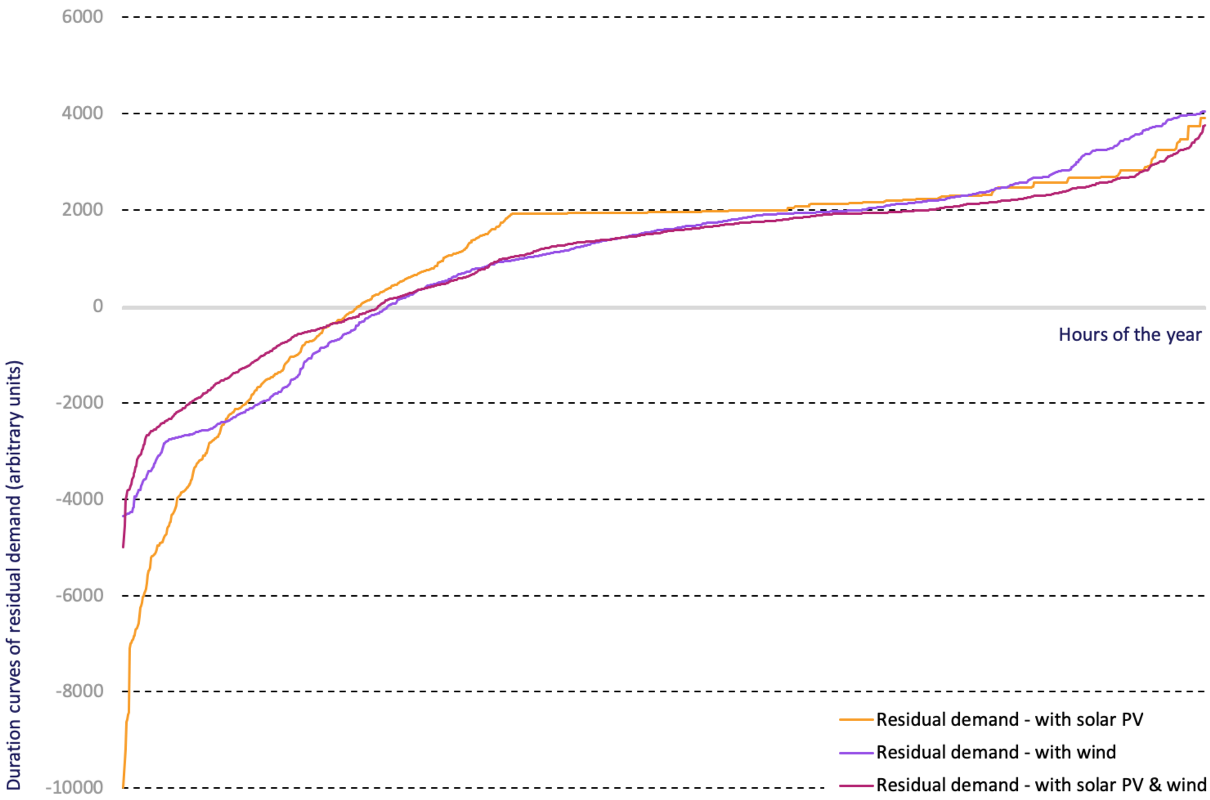
Shape risk captures the fact that the hour-to-hour generation will be variable depending on wind speed or solar irradiation, whereas the demand profile of a corporate buyer is likely to have a different shape (for example, a relatively stable demand profile over business hours). Figure 2 shows the residual demand curve of an industrial corporate buyer with a MT PPA using both solar and wind technologies.

Figure 2: Residual industrial demand derived from a typical industrial demand with a solar PV and wind MT PPA (indicative example)



The corporate buyer seeking to minimize shape risk tailors the contracted amount of renewable generation to its demand profile in an effort to reduce the number of hours in which it needs to purchase / sell additional power as well as to reduce the volume that it needs to purchase / sell. Figure 3 shows the duration curve of three residual demand profiles: solar only, wind only and solar and wind combined. The pink line (solar and wind combined) is generally closest to the X-axis, meaning that the corporate buyer needs to buy / sell less additional power with a MT PPA. Note that this analysis is based on stochastically derived average profiles; in reality, wind and solar production profiles are location specific and residual demand curves can deviate significantly from the example shown here.

Figure 3: Duration curves of residual demand with a solar PV PPA, a wind PPA, and a solar PV & wind MT PPA (indicative example)

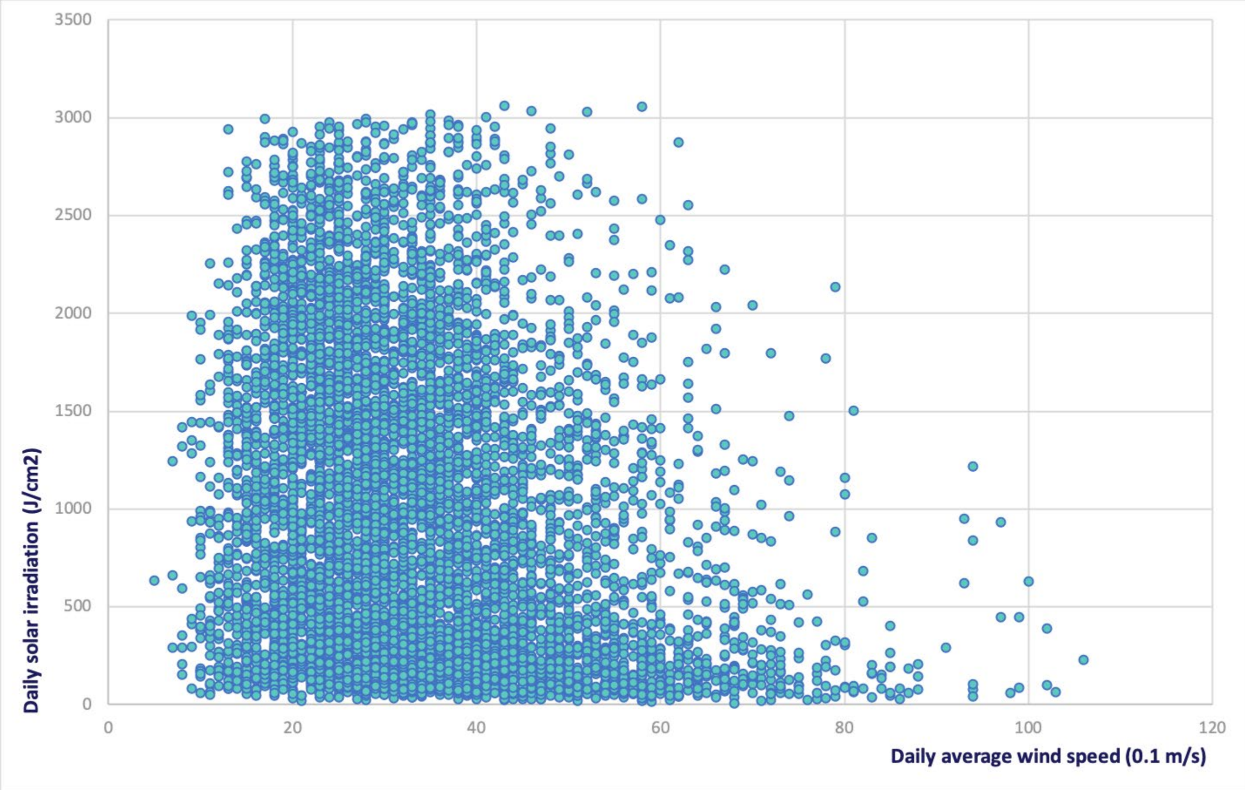


Volume risk

As discussed above, a relevant question is whether a MT PPA can (over time) hedge the volume risk of solar and wind technologies due to their weather dependency.

Figure 4 shows that wind speed and solar irradiation tend to not be correlated. If they were correlated, the graph below would show a clear pattern (e.g. a linear correlation as the shape of a linear line). As a result, a combination between both wind and solar by itself reduces the exposure to years of extreme generation (both on high and low sides) and hence volume risk. It is worth highlighting that this impact arises over time, meaning several years. As such, a combination of wind and solar projects may reduce volume risk over longer terms.

Figure 4: Daily measured wind speed and solar irradiation from 2000-2018 in De Bilt, central Netherlands (Source: KNMI)



Note: Wind speeds below 4 m/s have been removed as only low generation will occur below this speed.

It is necessary to consider the impact of this high-level finding compared to the risk appetite of a corporate buyer and the existing risk mitigation tools available. For example, although a corporate buyer considering an 'as-produced' PPA with solar and wind projects may have a lower volume exposure on average, the buyer would need a sophisticated understanding of the risks involved. That may not be the case. In practice, a corporate buyer would usually seek to have the volume and shape risk managed by its usual electricity supplier or would seek to have the seller manage those risks. In that scenario, the value of this volume risk analysis lies in whether a more sophisticated analysis of volume risks associated with a MT PPA could form the basis of negotiating lower fees for the management of the risk.

Other risks specific to MT PPAs

The table below highlights legal aspects that different types of MT PPAs discussed above could influence. Our experience and the discussions in this paper inform the table.

PPA element	PPA with multiple technologies
Price	To the extent that the impacts on imbalance, volume and shape risk discussed above exist, then there is potentially an impact on the price under a MT PPA. In essence, the extent to which a multi-technology approach reduces the costs incurred by either party to manage these risks may create the potential for a different price point.
Performance	Technologies such as wind and solar are mature. As such, performance requirements under a MT PPA (such as mechanical availability warranties) are likely to be substantively similar to what would have been available under a single technology PPA. However, one area to explore is the development of a portfolio availability warranty, with consequences for the seller only where the total average availability of the portfolio breaches agreed levels. Whether that will be appropriate will depend on the purpose of bringing together multiple technologies under one PPA. As explained above, the geographical diversity of projects in a MT PPA may provide suitable risk mitigation. If, for example, the generation of a wind project in the North of a market area is crucial to risk mitigation, then the mechanical availability of that asset may be more important than other assets in the MT PPA. In this instance, using a simple average availability measure across all assets in the MT PPA would not be appropriate.
Project-specific issues	Building on the above, a key MT PPA structure question is how to deal with issues related to individual projects. For example, should the loss of key permits or licenses for an individual project potentially lead (if not cured) to the entire MT PPA being in default or just that portion of the PPA? Some MT PPAs do treat multiple projects as a single asset. However, others can provide for partial termination or extended cure regimes (under which it is possible to replace a project).
Change in law	While there may be different issues for different technologies arising from changes in law, the usual approach to managing changes in law still applies. However, when the change in law only relates to a specific technology or project, the choice of the PPA structure will influence how the change in law affects the MT PPA overall. For example, if it is not possible to resolve the impact of a change in the law for a particular technology and project, should that lead to the potential termination of that aspect of the MT PPA or of the entire MT PPA?

Sellers and corporate buyers investigating a MT PPA would also want to explore the impacts of different asset maintenance schedules, different curtailment requirements (if the assets are located in different grid zones) and different applicable network losses.

Conclusions

Combining multiple technologies with variable generation profiles can reduce imbalance, shape and volume risk. The extent to which multiple technologies can do so is highly dependent on specific factors, such as:

- Individual asset generation profile and geographical location, i.e. its correlation with the market-wide generation profile of its technology type;
- The correlation of generation profiles and forecast errors within MT PPAs;
- The correlation of combined generation profiles (i.e. wind and solar) with the demand profile of the corporate buyer;
- How 'sharp' imbalance costs are (that is, how potentially expensive exposure to imbalance risk is);
- How 'sharp' shape and volume costs are (that is, how potentially expensive it is to be exposed to intra-day and seasonal swings in power market prices).

Assuming that it is possible to identify multiple projects and technologies that can make an impact on one or more of these risks, the key question remains whether that is sufficient to alter existing approaches to managing these risks. Existing risk management tools have the advantage of being relatively simple. That is, in most cases, one party takes on the risk for a fee (or a risk premium reflected in the price under the PPA). For a corporate buyer not focused on the intricacies of managing the underlying risks, this may be the easiest solution as long as the overall cost of the PPA remains acceptable.

However, in a world where government financial support for renewables is decreasing, the pressure on sellers to find mutually acceptable prices for new projects is increasing. Any tool that can reduce price pressures in such discussions will be useful – including MT PPAs with variable technologies such as wind and solar as well as controllable renewable generation such as hydro or biomass. In conclusion, the most likely near-term value of a MT PPA is where well-structured, multiple projects reduce risks and thereby underpin discussions on reduced fees or risk premiums for managing such risks.

Exploring the potential value of MT PPAs requires greater engagement by the parties involved with the nature of the underlying risks and the probabilistic assessment of their impacts. For example, where a corporate buyer is negotiating with its electricity supply utility on the costs of managing shape and volume risk, assessing the value of a MT PPA approach in such discussions will require the corporate buyer to have access to strong modeling capabilities, ideally using market modeling with numerous historical weather years (wind speeds, solar irradiation), which forecast future years based on historically seen weather patterns. The corporate buyer will want to understand historical weather data and expected generation for each asset, the tools used for forecasting generation and their expected accuracy, the applicable balancing market rules and expected prices as well as expected spot market prices. This understanding and analysis will be necessary to challenge the assumptions underpinning proposed risk management fees.

Finally, it is necessary to assess the bankability of MT PPA structures on a case by case basis. For example, where a seller uses inherent risk mitigation under a MT PPA to underpin absorbing more shape or volume risk, lenders will want to focus on the seller's assessment and management of that risk. It will likely be acceptable to have the seller outsource risk management to a creditworthy third party (or for the seller to have access to sufficient depth of risk management tools internally). However, where the project absorbs the risk itself, it will be necessary to model the downside financial risks and, if material, manage them.

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REscale brings together leading companies representing the full renewable energy value chain to accelerate deployment of renewables and the transition to a low-carbon electricity system. REscale members share the ambition to scale up renewable deployment beyond average growth.

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To find out more about REscale, the Corporate Renewable PPA Forum and previous reports, visit our webpage or contact:

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