# Technical Task - PPA Performance

Please complete this task in a Jupyter notebook and send it over at least 48 hours before the interview so we have a chance to review. You will be asked to go through your logic and findings in the interview. Feel free to decide if you would be more comfortable going through a slidedeck or the notebook itself.

Please note this is a new technical task so if anything is unclear or requires more guidance then please get in touch with the recruiter who will forward any questions across. Do not worry about getting everything right, we are more interested in your ability to write readable code and your approach to the concepts introduced. This task is intended to take 2-4 hours to complete so if you find yourself running over then please feel free to describe what you would do if you had more time.

## Background

Heads up! This concept may seem a little confusing at first but don’t worry if you don’t fully understand. Try following through the questions using the hints and hopefully parts will make sense.

A [Power Purchase Agreement](https://en.wikipedia.org/wiki/Power_purchase_agreement) (or PPA) is a contract between a generator (e.g. a solar/ wind farm) and another party (e.g. Octopus Energy). It is one way suppliers buy power (the other being buying on the [wholesale market](https://www.ofgem.gov.uk/energy-data-and-research/data-portal/wholesale-market-indicators)). A generator, especially renewables such as wind, can generate intermittently so it is not a guaranteed source of power. Most PPAs Octopus sign are to take 100% of the generation export volume of a site at a fixed PPA rate [£/ MWh] between two dates (for example, a PPA might state that between 01/01/2021 and 31/12/2021 Octopus will take 100% of any electricity generated at a solar farm at a rate of £100/MWh).

The fixed rate agreed between two dates is calculated using live forward ([definition](https://en.wikipedia.org/wiki/Forward_curve)) market prices at the time of the contract. For example, in 2022 electricity markets have gone up **A LOT,** therefore PPA rates agreed in 2022 have also gone up **A LOT**.

However, the rate offered in a PPA is usually at a discount to the forward market price. This is because spot (at actual delivery, [definition](https://www.investopedia.com/terms/s/spotprice.asp#:~:text=What%20is%20Spot%20Price,or%20sold%20for%20immediate%20delivery.)) power prices are [inversely correlated](https://www.sciencedirect.com/science/article/pii/S0140988319303470) with generation. For example, on a low-wind day there is a lack of electricity in the grid and so power prices are usually high. This is also the time we expect to receive less generation from a (wind) ppa site. As we would have expected seasonal generation, we need to buy back the difference between the seasonal forecast and actual generation at higher prices. This discount is changing as the mix of UK generation evolves.

**(MOST TRICKY PART!)** There is the risk that if the market falls then the PPA generation loses its value. A way to de-risk the contract is for Octopus to immediately ‘sell’ the equivalent value of power into the wholesale market and ‘buy’ it back at the time of delivery at spot prices. By doing this, if the market drops then Octopus can offset the reduction in PPA value by ‘buying’ back the equivalent value at a cheaper price. On the other hand, if the markets rise then Octopus would not benefit. This is the concept of hedging ([definition](https://www.investopedia.com/terms/b/buyinghedge.asp)) and a great way to manage risk. For this reason, it is important to be able to value volume forecasts.

In the following exercise you will be asked to do two things:

1. Calculate a technology cannibalization discount
2. Calculate the trade value of a PPA site forecast through its life cycle

## Task 1 - Calculating a PPA Discount

This question is around calculating the discount between wind-generation and the ‘baseload’ (or average) price. This discount is used to price a wind PPA contract as it is the expected loss in value.

The following datasets are provided:

* National wind generation data, (see *2018\_2022\_national\_wind\_forecast\_data.csv* and *2018\_2022\_national\_wind\_generated\_data.csv*, which contains the national wind day-ahead forecast and national metered generation respectively)
* Price data (see 2018\_2022\_spot\_price\_data.csv)

Questions:

1. What discount should be applied to wind generation compared to a baseload (average) price?
   1. **Hint**, calculate an average (mean) price and compare it to an average price that is weighted by wind generation. We suggest using monthly averages (as a granularity level) to smooth noise but also allowing trends to be noticed. Feel free to use [day-ahead](https://www.nordpoolgroup.com/en/the-power-market/Day-ahead-market/)/ [imbalance](https://www.elexon.co.uk/knowledgebase/what-is-the-system-sell-price-and-the-system-buy-price/) prices or forecast/actual generation. Bonus points if you can suggest why any might be better than others!
2. Can you spot any trends over time? What risks could this have for Octopus?
3. Can you spot anything else of interest?

## Task 2 - PPA trade performance

This question is around assessing the performance of a PPA contract. This is looking at a single 30 day period.

The following datasets are provided:

* Volume data containing long-term forecasts, short-term forecasts and actual generation (*volumes.csv*). The valid\_on\_date is the forecast\_date, except for actual generation.
* Price data containing forward prices, day-ahead prices and imbalance prices (prices.csv)
* PPA rate of **£162**

Questions:

1. What is the final value of the forecasts as they reached actual generation?
   1. **Hint**,
      1. Join the volume data to the price data on sensible fields.
      2. For every half-hour period, every time the forecast changes you would want to value that volume change at the current market price. You may want to calculate the forecast changes first before valuing.
      3. Continue this through any change in the long-term forecasts, through weather-forecasts and finally trade value the forecast error to actual generation at the imbalance price.
      4. Sum up the forecast value changes for each half-hour delivery period to get the total forecast value.
2. Calculate the profit/loss on the PPA during this period?
   1. If your answer in 1) was what the PPA could have been traded (sold) for in the market and the PPA rate agreed (to pay the generator) was £162 for the actual generation then simply calculate the difference.
3. How good was the initial forecast?
   1. Do you think this PPA would have been well hedged?
4. Can you identify any risks that Octopus need to manage?
   1. Think about how volumes and prices play a part.
5. Can you think of any ways of reducing risk?
6. Any other observations/ thoughts?