Case study 2

Coastal Wind Farm

Asset Overview

Equity investment for the construction of a ~50 MW offshore wind farm in a non-OECD country 130 km from a major city.

Asset objectives
- Lifetime of 20 years
- Average annual energy generation of ~160 GWh/year

Estimated project impact
- Plant size : ~50 MW
- ~160 GWh/year clean electricity
- ~70,000 tCO_2eq/year emissions avoided
- 500 construction jobs
- ~130,000 people reached

Sector
- [x] Power generation (renewable)
- [ ] Power generation (other)
- [ ] Power transmission
- [ ] Other energy infrastructure
- [ ] Rail
- [ ] Water resources/network
- [ ] Airport
- [ ] Highway
- [ ] Telecommunications
- [ ] Data centres

Climate variables analysed
- [ ] Drought
- [ ] Precipitation
- [ ] Heat
- [x] Flooding
- [x] Wind

Finance type
- [x] Blended finance facility
- [ ] Private sector funding
- [ ] Government funding
- [x] DFI funding

PCRAM Methodology

	1	2	3	4
Steps	Scoping and data gathering	Materiality assessment	Resilience building	Economic and financial analysis
Objectives	Determine data sufficiency	Assessing asset resilience	Identifying resilience options	De-risk asset exposure to PCRs
Sub-tasks	Project initiation Project definition Data gathering and sufficiency	Hazard scenarios Impact identification Impact severity Risk quantification	Resilience options: Hard (Structural/Capex) Soft (Operational/Systems)	Cost/benefit analysis IRR comparison
Outputs	Initial climate study Critical components KPI selection (the 'Base Case')	Detailed climate study List of impacts and severity by component The 'Climate Case'	Revised climate study for new elements The 'Resilience Case'	Recommendations Value implications
Decision gates	Gate A Is data good and sufficient?	Gate B Are PCRs material to this asset?	Gate C What resilience options are available for this asset?	

Step 1: Scoping and data gathering

A series of asset objectives were compiled by reviewing the available asset data and the financial model in detail. Focus was primarily on downtime and energy yield.

Global and regional climate projection models were analysed and utilised to identify potential climate hazards in the area. Preliminary analysis determined exposure to coastal flooding caused by Sea level rise (SLR) (Figure 1), and a potential decrease in average daily windspeeds under various emissions pathways. Risks related to typhoons and temperature rise were deemed to be insignificant based on the preliminary analysis.

Climate data was matched to the asset objectives and these were shortlisted to focus on climate change events that affect energy generation.

Given the nature of the asset, being dependent on windspeeds, and the preliminary climate screening, this study focused on the materiality of wind and flood risk, acute flood events and chronic changes in SLR and windspeed, to the windfarm and its primary supporting infrastructure. The downstream infrastructure was excluded from the assessment.

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Step 2: Materiality assessment

Analysis of long-term trend (2070-2100 vs. 1985-2015) for each of 9 Global Circulation Models (GCMs).

The predominant trend is a slight increase in daily mean wind speed, but there is significant disagreement and uncertainty between the 9 models.

The scenarios are statistically similar, with a range for difference in long term average wind speed from -0.1m/s to +0.6m/s. As compared to the long term average wind speed at the turbines on site of 7.3m/s, this equates to a range of around -1.5% to +8% in wind speed.

The primary focus then became the downside and quantifying this in terms of impact on the investment.

When analysing wind speed sensitivity, there are many factors that influence an energy model. After analysis and recreating the original energy model used at the time of investment, it was determined that the sensitivity ratio for the project was such that average wind speed changes within 3% would linearly impact energy output. As a result, a simplified analysis of the windspeed was utilized to compare the impact of a change in long term average windspeed on the investment case.

The result was determined to be negligible with a 0.1% drop in yield annually.

Analysing the impact of SLR and storms

A key risk typically affecting near-shore and offshore windfarms are storm events and SLR. Combined scenarios of SLR projections, tidal factors and storm surge, indicated that it was projected the flood plane would rise by 2050. When considering local wave patterns and a 1 in 100 year storm surge by the year 2050, the flood elevation was determined to be less than the critical elevation of the primary landside substation and other infrastructure. It wasn't until after the useful life of the asset under the chosen climate scenario that the critical elevation is projected to be breached in the 1 in 100 year storm event.

Prior to the PCRAM analysis the primary substation, a critical single point of failure for the asset, had in fact been placed far inland and raised well above the natural ground elevation and therefore out of the floodplain as a resilience measure.

Since the substation was deemed to be well adapted for flood risk, for the purposes of the case study, the CCRI team decided to test a fictional scenario where no investment in raising the substation was made.

In order to do this, an estimate was made to the cost of raising the substation, allowing a comparison to be made against two scenarios; 1. The current asset 2. Where no investment in resilience had been made.

Step 3: Resilience building

In this case study, we are starting with a resilient asset as the primary point of failure and has been moved out of the flooding zone. Therefore, the analysis centred on the resilience option that had already been made to raise the substation.

Step 4: Economic and financial analysis decrease in chronic windspeed

The windfarm was determined to have minor exposure to physical climate risks related to wind, both chronic and acute, under multiple chosen climate scenarios which provide an equal likelihood of a chronic decrease in wind speed of 1.5% or an increase of 8%.

Substation flooding

The windfarm developers decided to raise the substation to higher ground for resilience at a cost of <1% of total development cost.

A recalculation to the baseline taking out this capex was conducted and then three flood scenarios built in assuming a major flood event in years 1, 10 or 20. It was assumed the substation – if not relocated – would have been shutdown for 6 months with no energy production during the wet season, between October to March. It was also assumed that each flood event would result in the substation having to be replaced at a cost of ~10% of total development cost with a 2% inflation rate built in over the 20 year period, same as operating and maintenance cost inflation rate assumption.

Keeping the debt/equity ratio the same as the baseline model, the inflation adjusted financial benefit in investing in resilience options for the IRR (at 75% probability level for estimated energy production) ranges from:

- 113 basis points for a flood in year 10
- to 60 basis points for a flood in year 20

This can be referred to as a resilience premium.

To simulate a less resilient asset the following steps were undertaken:

Step 1 Subtract cost of raising substation at project initiation (CAPEX)

Step 2 Model a flood event w/ loss of substation (three separate scenarios modelled year 1, 10, 20)

- Shutdown 6mo (no energy production) in wet season from September to February
- Add substation rebuild cost, ~10% of total development cost, in same year as flood event

Step 3 Compare IRR between Raised substation vs. Unraised substation

The cost-benefit analysis of implementing resilience measures shows a material upside compared to the cost of not implementing such measures. This helps demonstrate the significant benefit of investing in resilience.

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Lessons learned

In applying the PCRAM methodology to this case study, the following lessons have been learned:

- The physical climate risk assessment for this case study has not included an end-to-end climate change risk assessment, technical due diligence, detailed drought risk or the compound effects of a prolonged drought followed directly by an extreme rainfall or flood event.
- It was found that the original design included some PCR considerations for example raising the substation to higher ground for resilience.

Glossary

- **Climate projection** – The simulated response of the climate system to a scenario of future emission or concentration of greenhouse gases (GHGs) and aerosols, generally derived using climate models. Climate projections are distinguished from climate predictions by their dependence on the emission/concentration/radiative forcing scenario used, which is in turn based on assumptions concerning, e.g. future socioeconomic and technological developments that may or may not be realised (IPCC 2018).
- **Climate base cases** – Base case evaluations are a part of scenario analysis, which helps decision-makers visualize and compare the most realistic outcomes for a business. With foresight into all possible outcomes, an organization can greatly improve its financial planning and modelling, allowing management to make decisions with confidence.
- **GWh/year** – Gigawatt hours per year (a measure of power)
- **m3/s** – Cubic metre per second (a water volume flow rate)
- **Functional resilience measures** – non-structural modifications to operating policies to alleviate the impacts of climate change.
- **Structural resilience measures** – physical or hard modifications in order to alleviate the impacts of climate change.
- **Internal Rate of Return (IRR)** – A metric used in financial analysis to estimate the profitability of potential investments. Annual return that makes the net present value (NPV) equal to zero or is the annual rate of growth that an investment is expected to generate.
- **P50** – 50th percentile or central estimate