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1. CLIMATE CHANGE RISK ANALYSIS

1.1 Overall Approach

This analysis was performed based on data from the web-based tool *ThinkHazard!* developed by GFDRR (Global Facility for Disaster Reduction and Recovery) in partnership with the World Bank Group and various other international and national institutions active in the field of climate change research and analysis[1].

Country climate-fact-sheets developed by the KfW Development Bank and the German Climate Service Center (GERICS)[2] were also used, as these provide information about future climate change at country level based on the climate change projections presented in the 5th Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC)[3].

The area of focus of the climate change risk analysis is the area of Cañadon Seco, in the region of Deseado, in the province of Santa Cruz.

Low to high emissions scenarios as developed by the IPCC were considered to obtain the most likely levels of risk.

Level of confidence however remains medium on average given the uncertainty of climate projections for the risks considered.

1.2 Summary of Risk Assessment

1.2.1 Key Climate Change Risks Related to the Project

The main risks to the project area, related to climate change, are likely to be:

- Floods (mainly due to changes in precipitation patterns and increased frequency of extreme weather events);
- Tsunami (i.e. worsened consequences of a potential tsunami due to climate-change induced sea level rise);
- Wildfire (increased risks of forest or bushfires due to prolonged periods of drought).

Potential change in wind patterns was also assessed as part of this analysis since this could have an impact on the productivity of the wind farm.

In this chapter, these risks are assessed for the long term (by convention, a time horizon of 2050 has been used), and are compared to the current risks.

All the abovementioned risks were estimated as low for the Project for short and long-term with the exception of wildfire risk. Wildfires at the project location have currently a high likelihood of occurrence, which will increase on the long-term due to expected increase in temperature and variance in rainfall,

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[1] The Global Facility for Disaster Reduction and Recovery (GFDRR) defines itself as "*a global partnership that helps developing countries better understand and reduce their vulnerability to natural hazards and climate change. GFDRR is a grant-funding mechanism, managed by the World Bank that supports disaster risk management projects worldwide. Working on the ground with over 400 local, national, regional, and international partners, GFDRR provides knowledge, funding, and technical assistance.*" (www.gfdrr.org/)

[2] As per its official website presentation, "*The Climate Service Center Germany (GERICS) was initiated by the German Federal Government in 2009 as a fundamental part of the German high-tech-strategy for climate protection. Since June 2014, GERICS has been a scientific organizational entity of Helmholtz-Zentrum Geesthacht – Zentrum für Material- und Küstenforschung GmbH.*" (www.climate-service-center.de/)

[3] As per its official website presentation: "*Created in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP), the objective of the IPCC is to provide governments at all levels with scientific information that they can use to develop climate policies. IPCC reports are also a key input into international climate change negotiations. The IPCC is an organization of governments that are members of the United Nations or WMO.*" (www.ipcc.ch/)

added to the aridity of the region. However, the vegetation at the location of the plant is of relatively limited density (low-lying shrublands typical of Patagonian steppe environments). We have assumed that a wildfire on this type of vegetation would have limited potential to impact the project facilities. Moreover, according to data provided by YPF, processes are in place to respond to emergency situations, including fire. Therefore, no additional mitigation measures are proposed as such risks are observed to be appropriately controlled with adequate emergency procedures.

1.2.2 Risk Rating Methodology and Results

1.2.2.1 Methodology

Risks induced by climate change may have diverse impacts on the production capacity and working conditions of a wind turbine.

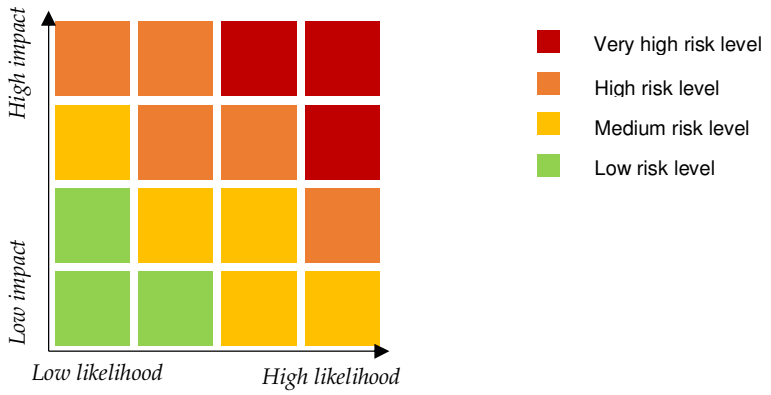
Four levels of likelihood and impact have been set based on information coming from reputable databases using combined (low, medium and high emissions) IPCC climate scenarios (see Table 1-1).

Table 1-1 "Likelihood" and "impact" definition for the analysis

Likelihood	Impact
Very high likelihood: the event already occurred or is very likely to occur according to available *scenarios, ceteris paribus*.	**Very high impact**: potentially disruptive consequences on activities.
High likelihood: the event is likely to occur following the current trend.	**High impact**: potential significant consequences on activities and operations of the site (high operational or commercial impact).
Medium likelihood: the event may occur according to available projections, but depending on the development of other linked phenomena, that might be more or less likely to occur.	**Medium impact**: potential consequences on activities and operations of the site (e.g. operational impact without significant commercial impact).
Low likelihood: the event is not likely to occur according to available projections.	**Low impact**: low consequences on the activities and operations of the site ("business as usual").

The overall risk level is obtained by combining the likelihood and the impact as illustrated in the risk matrix presented in Figure 1.1.

Figure 1.1 Risk level definition according to impact and likelihood



1.2.2.2 Key Results for Cañadon Leon Project

For this Project, the following overall risk levels (considering likelihood and magnitude of impact) were obtained (see Table 1-2).

Table 1-2 Level of current risk and of risk in 2050 with likelihood and impact levels

	Current		2050		Current	2050
Risk	Likelihood	Magnitude of impact	Likelihood	Magnitude of impact	Overall risk level	
Flood	Low	Medium	Low	Medium	**Low**	**Low**
Tsunami	Medium	Low	Medium	Low	**Low**	**Low**
Wildfire	High	Low	Very high	Low	**Medium**	**Medium**
Change in wind patterns	-	-	Low	Medium	**-**	**Low**

The following sections provide a more in-depth discussion of likelihood and impact for each risk.

1.3 Topic-by-Topic Assessment

1.3.1 Floods

Coastal Flood

There is a current high likelihood of coastal flood[4] in the region of Deseado where the Project is located. This risk is expected to increase with the long-term raise of the sea level due to climate change.

Global mean sea level rise depends on a variety of factors, and estimates for 2100 range from ~20 cm to nearly 1 m which is negligible compared to the lifetime of the Project[5].

The Project being located at approximately 10 km from the coast and between 190 and 300 m above sea level, it should not be affected by risks of coastal floods.

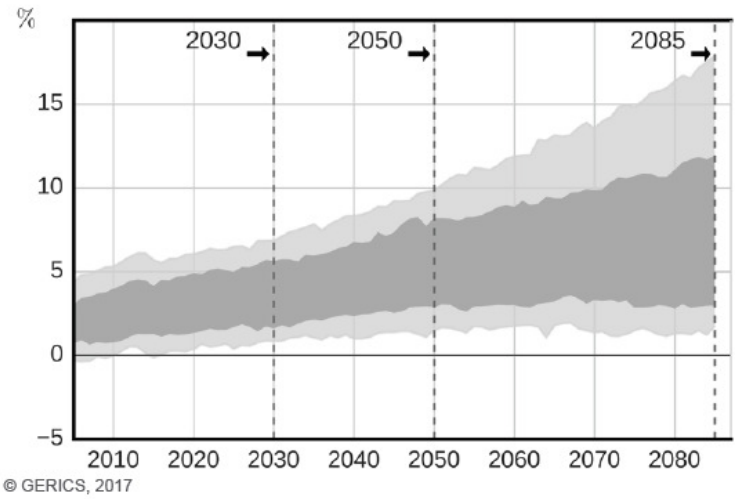
Heavy Rains

Heavy rain events are also expected to increase from +3% to +8% in intensity at the horizon 2050 (likely range considering all model simulations from IPCC AR5) compared to reference period from 1971 to 2000 (see Figure 1.2).

[4] http://thinkhazard.org/en/report/4816-argentina-santa-cruz-deseado/CF

[5] IPCC, 2013

Figure 1.2 Projection of possible development of heavy rains intensity



**Dark grey: likely range (central 66%)*
Light grey: very likely range (central 90%)

The frequency of heavy rainfall is expected to increase by 12% by 2050 compared to reference period from 1971 to 2000[6]. This increase in intensity and frequency of heavy rainfalls will have little effect on the flood likelihood.

River Flood

The likelihood of river floods in the region of Deseado is classified as low[7].

In southern Argentina, model projections are inconsistent in changes in rainfall. The present likelihood is projected to increase on the long term due to the effects of climate change but remains low.

Combining the three previous flood causes, the flood **likelihood** is assessed to be **low for both short and long-term** due to non-proximity to river or coast and a low change in rain patterns.

The **magnitude of impact** can be considered as **medium**. Indeed, wind farms are not very sensitive to flood in general, but the electrical grid infrastructure might be affected, potentially causing electrical disruption.

> The **flood overall risk level** is **currently low** and projected to **stay low** on the **long-term** (2050) due to the low likelihood in the area of the Project and a medium impact.

1.3.1.2 Tsunami

Although likelihood of tsunamis is not expected to be impacted by climate change, the magnitude of impact related to tsunamis is however projected to increase. Indeed, the areas at risk of tsunamis will increase as global mean sea level rises and "even minor sea-level rise […] poses greater risks of tsunamis for coastal communities worldwide"[8].

[6] From Climate-Fact-Sheets, Updated Version 2015; Argentina; Helmholtz-Zentrum Geesthacht Zentrum für Material-und Küstenforschung GmbH, GERICS, May 2018

[7] http://thinkhazard.org/en/report/4816-argentina-santa-cruz-deseado/FL

[8] https://www.sciencedaily.com/releases/2018/08/180815141444.htm

In the area of the Project, tsunami **likelihood** is classified as **medium** according to the information that is currently available. This means that there is more than a 10% likelihood of a potentially damaging tsunami occurring in the next 50 years[9]

The Project being located at around 10 km from the coast and between 190 and 300 m above sea level, the **magnitude of impact** of a potential tsunami is considered as **low**.

> Despite a slight rise of sea level, the **tsunami overall risk level** is **currently** considered as **low** given the limited impact on the Project location and will be considered as **low** for the **2050 horizon** as well.

1.3.1.3 Wildfire

The likelihood of wildfires occurring in the region of Deseado is currently classified as high. This means that there is 50% likelihood occurrence every year of a weather propitious to significant wildfire[10]. However, according to data provided by YPF, processes are in place to respond to emergency situations, including fire. Therefore, no additional mitigation measures are proposed as such risks are observed to be appropriately controlled with adequate emergency procedures.

In this type of extreme fire weather events, elevated temperatures combined with strong winds and wind born debris may weaken the integrity of infrastructure.

Future climate projections suggest a likely increase in daily temperatures and greater variability in rainfall. This is likely to increase the frequency of occurrence in the region of weathers propitious to fires. In areas already affected by wildfire hazard, the fire season is likely to increase in duration, and include a greater number of fire events. Climate projections also indicate that there could also be an increase in the severity of fire. Wildfire **likelihood** is therefore classified as **very high** on the **long-term**.

According to satellite views and data collected on site, the area of the Project is mainly composed of shrublands with a low density of vegetation which would reduce the **magnitude of impact** to a **low** level in case of potential fire.

> **Current wildfire overall risk level** can be considered as **medium**. In the **long-term** the likelihood will increase with climate change and therefore the overall risk level will also be **medium**.

1.3.1.4 Change in Wind Patterns

The wind turbine model selected for this Project is the GE 4.2-117 which is a model specifically designed by General Electric to withstand extreme weather events such as typhoons[11]. Therefore, it should not be impacted by very high wind speed events.

Nevertheless, a significant increase or reduction of the annual average wind speed can directly impact the productivity of the plant since current wind turbines operate within a defined range of wind speed (up to 57 m/s for the GE 4.2-117). **Magnitude of impact** is assessed as **medium** for the Project and its commercial model.

The likely range of projected change in annual mean wind speed indicates almost no change by 2050 compared to reference period from 1971 to 2000. The very likely range is from -4 to +4% (see Figure

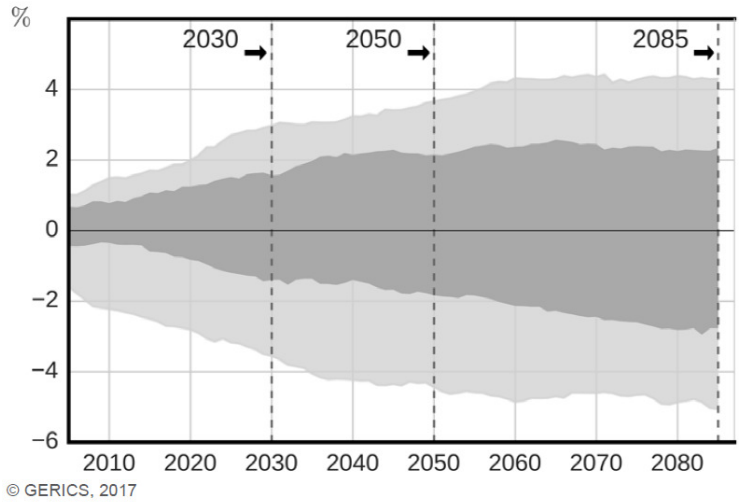
[9] http://thinkhazard.org/en/report/4816-argentina-santa-cruz-deseado/TS

[10] http://thinkhazard.org/en/report/4816-argentina-santa-cruz-deseado/WF

[11] https://www.ge.com/reports/riders-storm-ge-building-wind-turbine-can-weather-violent-typhoons-hurricanes/

1.3)[12]. Confidence in these figures is medium. The **likelihood** of significant change in annual mean wind speed can be therefore considered as **low**.

Figure 1.3 Projection of possible development of wind speed



**Dark grey: likely range (central 66%)*
Light grey: very likely range (central 90%)

Change in wind speed regularity and wind speed extreme values might also have an impact on the productivity of the wind turbine. However, no further information was available to draw conclusions on impact on productivity.

> Potential impacts on the wind farm's productivity have been identified but no significant changes (inferior to 4%) are expected in the annual average wind speed. **Long-term change in the wind speed overall risk level** can be considered as **low** at country level.

1.4 Mitigation Measures Proposed

No high risk was identified for the wind turbines through this climate change risk assessment.

This is largely related to the fact the Project is not located in an area with high natural hazards exposure such as floods or tsunamis and given wind turbines are generally engineered to be resilient to physical risks.

The wildfire risk is the only risk classified as medium overall. Its very high likelihood on the long-term is due to expected increase in temperature and variance in rainfall, added to the aridity of the region. However, the vegetation at the location of the plant is relatively low in density and composed of shrublands. We have assumed that a wildfire on this type of vegetation would not seriously threaten the project installations. Moreover, according to data provided by YPF, processes are in place to respond to emergency situations, including fire. Therefore, no additional mitigation measures are proposed as such risks are observed to be appropriately controlled with adequate emergency procedures.

[12] From Climate-Fact-Sheets, Updated Version 2015; Argentina; Helmholtz-Zentrum Geesthacht Zentrum für Material-und Küstenforschung GmbH, GERICS, May 2018