

20 July 2020

Georgina Woods  
NSW Coordinator,  
Lock the Gate Alliance

Dear Ms Woods,

In response to your request for considerations regarding climate change with respect to the proposed Narrabri Gas project I have noted several gaps in the project documentation that you may wish to raise with the Independent Planning Commission.

The most obvious question is the reason climate change exacerbation of environmental hazards been omitted from the 'Hazard and risk assessment report, Appendix S' of the Environmental Impact Statement? GHD offers **climate change** modelling, impact analysis, risk and vulnerability studies as a standard service and is a founding member the Infrastructure Sustainability Council of Australia (ISCA) which requires climate impacts to be analysed in project ratings. So it's very odd that this report makes not a single mention of 'climate change.' Inclusion

Following on from the above. Appendix S makes reference to bushfire risks, but does not include climate change impacts in the analysis of risk. Climate change will tend to increase the probability of days when bushfires are possible. I have attached a report I have produced considering the projections from one of the CORDEX international climate models downscaled to the area which suggests a 150% increase in the probability of bushfire conditions under IPCC's Representative Concentration Pathway 8.5, which is the current global emissions trajectory. This would have an impact on estimated bushfire ignition probability of 1 in 70 years notes in the document titled "Question to Santos - Email of 2 September 2019"<sup>1</sup>, in principle raising the probability to 1 in 28 years – i.e. climate change could results in a reasonably high probability of the project starting a bushfire during its lifetime.

While Appendix S refers to management plans regarding fire-fighting, and plant management the analysis again fails to consider the ability of the facility and its staff to cope with a pyro-cumulus events which show clear trends to increase in parts of Australia (Dowdy et al 2019)<sup>2</sup> under various climate models. Such events are considered unfightable fires.

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1

<https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-6456%2120200611T033526.639%20GMT>

<sup>2</sup> <https://www.nature.com/articles/s41598-019-46362-x>

With regard to the above I would draw your attention to the recent guilty plea by the US based Pacific Gas and Electric (PG&E) for causing the death of 84 people during an ignition caused during 2018 fires in California. It may be worth checking that the company's insurance extends to cover such outcomes if climate change impacts have not been considered.

With regard to subsidence risk, again there is no reference to climate change in Appendix S. Climate change can exacerbate drought conditions which can cause subsidence in clay soils. According to various mapping, this area does have soils which are susceptible to subsidence. In the attached EasyXDI report, the subsidence risk will proximately double over the next 30 years under the models used. This would have a bearing on risks associated with subsidence - pipe cracking and so forth – which should be re-calculated in light of climate change.

Extreme Temperatures: In Appendix S, table 2.11 notes that the risk analysis has been conducted 25 degrees Celsius. It would have been useful to see an analysis under severe temperature conditions above 40°C or even approaching 50°C. For example, at these temperatures electronic systems can fail to operate (in the same way that mobile phone stops working if left in the sun). It would be important to demonstrate that the safety measures specified for all hazards would occur if there were a failure of electronic control systems in extreme temperatures.

Finally I would suggest that including climate change is now a rather mainstream expectation for infrastructure development. For example the NSW State Infrastructure Strategy for 2018-2018<sup>3</sup> states:

*NSW's future prosperity depends on its ability, and willingness, to get the maximum economic and social benefit from existing and new infrastructure assets. To do this, good practices need to be applied to infrastructure planning, assessment, procurement, construction and management:*

- *to meet rising demand for public services*
- *to support longer term plans for jobs and housing prepared by the Greater Sydney Commission and the Department of Planning and Environment*
- *to anticipate and respond to megatrends, including taking advantage of opportunities generated by technological transformation and managing threats such as climate change.*

I trust these observations assist you in your considerations of the relevance of climate change to the proposed development.

Kind Regards

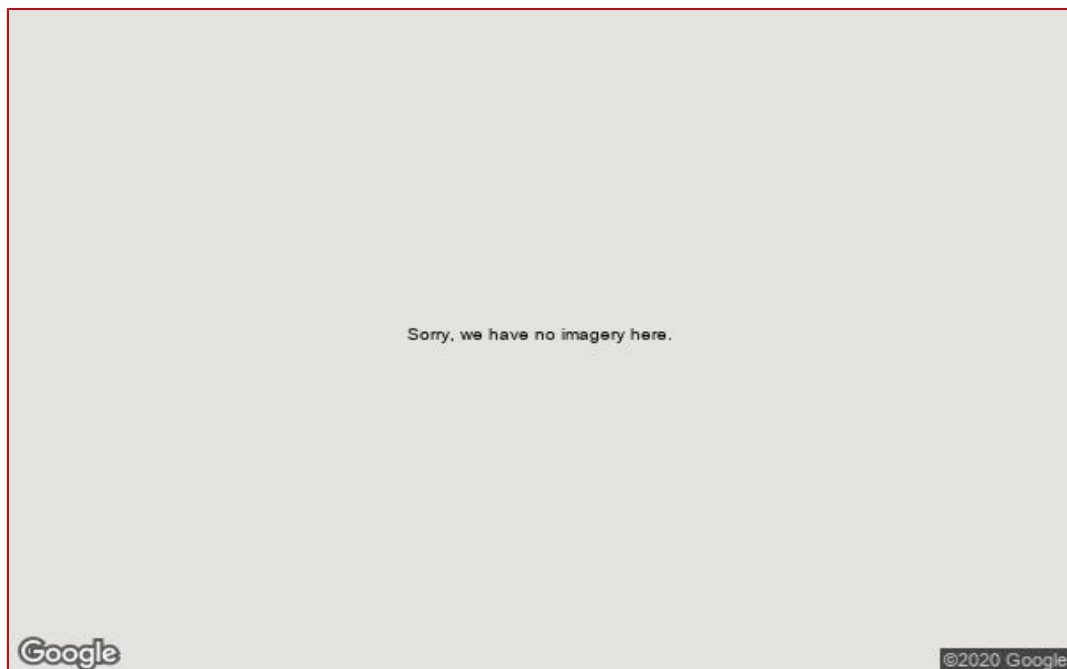
Dr Karl Mallon, Director of Science, Climate Risk p/l

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<sup>3</sup> [https://insw-sis.visualise.today/documents/INSW\\_2018SIS\\_BuildingMomentum.pdf](https://insw-sis.visualise.today/documents/INSW_2018SIS_BuildingMomentum.pdf)

# CLIMATE RISK ANALYSIS REPORT

Prepared for: [karl@climaterisk.com.au](mailto:karl@climaterisk.com.au)  
Jacks Creek, Australia  
Sunday, 19 July 2020



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# CAVEATS

## 1 IMPORTANT INFORMATION

### 1.1 What Products and Services on this Site do and do not do.

The Products and Services on this Site send information to the Climate Risk Engines operated by Climate Risk P/L that process this information and return results. Generally, users select or create Representative Assets which are synthetic representations of a real or hypothetical asset which may include real estate properties, infrastructure or other physical objects. Information about this Representative Asset is processed together with other relevant information such as location, age or value.

The Climate Risk Engines integrate the information sent to it with information from a large number of national and international datasets from government institutions, universities and private companies to provide a generalised model of how climate change may affect a number of physical risks to the Representative Asset, all else being equal. The physical risks covered by the analysis will be displayed where the results are presented (on a Site or in a Report).

However, the Climate Risk Engines do not provide a forecast, prediction or projection based on any real or planned asset. The analysis does not purport to 'cover the field' of all potential risks associated with climate change nor to address coincidence or correlation between such risks. For example, extremes of precipitation and flooding may be coincident with extreme wind-storms which can damage a building making it more vulnerable to damage. The Climate Risk Engines do not necessarily take into account the impact of any actual built infrastructure, modifications, adaptations or resilience-building measures (public or private) that have been, or may be, applied that reduce (or exacerbate) the relevant hazard. The representation is made in relation to the availability or coverage of insurance to a real or planned asset.

### 1.2 No forecast or prediction

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### 1.3 No financial advice

The information presented does not comprise, constitute or provide, nor should it be relied upon as, investment or financial advice, credit ratings, an advertisement, an invitation, a confirmation, an offer or a solicitation, or recommendation, to buy or sell any security or other financial, insurance, credit or lending product or to engage in any investment activity, or an offer of any financial service. This information does not purport to quantify risk to the subject land, infrastructure, buildings or other physical assets or any part thereof, nor make any representation in regards to the saleability, mortgageability, insurability, or defects, of any subject property, nor its suitability for purchase, holding or sale. The Modelling Outputs presented are provided with the understanding and expectation that each user will, with due care, conduct their own investigation and evaluation of any real or planned asset at a specific location.

## **1.4 Exclusion of liability**

To the extent permitted by law we and our data and analytic suppliers will not be liable for any loss or damage, whether in contract, tort (including negligence), breach of statutory duty or otherwise, even if foreseeable, arising under or in connection with use of or reliance on any information, data or content obtained via our services, including (without limitation) the modelling outputs presented.

## **2 Scientific Limitations**

The information presented has been generated using an expert selection of the scientific methods and computational modelling techniques available at the time of creation. However, at any time there are known limitations of which you should make yourself aware. These are constantly refined and updated and are clearly specified on the Site.

### **2.1 Scope of Modelling and Scenarios**

Science is not able to definitively predict the exact range or rate of future global warming; or the scale and rate of change of atmospheric and oceanic processes that may be hazardous, including temperatures, precipitation, wind and the rise in sea levels that result from this warming. Many variables will determine society's continuing rate of emission of 'greenhouse gases' (including political, regulatory, technological and behavioural factors), and how the Earth's natural systems respond. However, we can estimate a range of potential impacts across what mainstream science considers to be a plausible set of scenarios for future ocean and atmospheric behaviour. The scenarios used are specified in the relevant Scenarios sections of websites and reports where the Climate Risk Engines are used.

### **2.2 Scope of Financial Modelling**

The Climate Risk Engines compute a number of financial indicators based on the concept of Annual Average Loss (AAL) which is the computed financial loss in a future year due to the damage to component elements of an asset and the cost of their replacement and/or consequential costs such as compensation payments of lost income.

The model is also uses an associated interest rate to calculate the extent to which the diversion of funds to cover Annual Average Loss, would represent a reduced ability to make repayments on the financing (e.g. mortgage) property with a commensurate reduction in principal that can be borrowed. This is a useful indicator of a potential difference in value caused by climate change.

# TABLE OF CONTENTS

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<b>1. INTRODUCTION</b>	<b>6</b>
<b>2. ANALYSIS SETTINGS</b>	<b>7</b>
Your Asset Details	7
Your Archetype Details	8
<b>3. ANALYSIS RESULTS</b>	<b>13</b>
Introduction	13
XDI Asset Rating	14
Percentage of Value at Risk (VAR%) : All Hazards	15
Failure Probability: All Hazards	17
Vulnerability Diagnostics	20
Hazards Breakdown: VAR% and Failure Probability	23
Riverine Flooding	23
Coastal Inundation	24
Forest Fire	25
Soil Subsidence	26
Extreme Wind	27
Extreme Heat	28
<b>4. METHODS USED FOR ANALYSIS</b>	<b>29</b>
Stress-Test Approach	29
The Climate Risk Engines	29
A Representative Asset Archetype	30
Included Hazards	30
Mathematical Analysis	30
Hazard Exposure	30
Vulnerability Analysis; Damage and Failure Thresholds	30
Weather Data	31
Climate Change Modelling	31
Scenario Run Data	31

# 1. INTRODUCTION

This EasyXDI report provides you with insights into the risks to, and resilience of, the type of asset you selected, at the location you placed it, under the extreme weather and climate change scenarios applied at [www.EasyXDI.com](http://www.EasyXDI.com).

The results are based on computationally testing the material and design specifications of your selected asset type and its component elements against a range of extreme weather impacts such as flooding, coastal inundation, heat, forest fire, subsidence and extreme wind. This analysis utilises a combination of public and commercial data.

This analysis is powered by proprietary Climate Risk Engines that combine engineering data and local hazard maps with a statistical interrogation of historical weather and climate model projections to provide a financial analysis of future risk.

The results are a Technical Insurance Premium (TIP) expressed as a percentage of the replacement value of asset – referred to as the Percentage of Value At Risk (VAR%). This is effectively the forward looking annualised average cost of damage that would be caused by climate change and extreme weather. (See Analysis Results for further detail).

It's important to note that these results apply to a Representative Asset based on a selected type (called an Archetype), pre-constructed in EasyXDI, against which a range of future climate scenarios are tested.

You may have chosen to customise some of the features of this Representative Asset in the settings tab on [EasyXDI.com](http://EasyXDI.com). These will be displayed in the 'Analysis Settings' section of this report as 'customised' or 'default'. EasyXDI Archetypes include assumptions about design specifications and materials used in major elements including electrical, civil, mechanical and engineering components. This helps provide insights into an asset's vulnerability to different hazards.

Please note, though these results can be useful, they cannot be taken as indicating actual future risks as they are not testing a real asset, only a Representative Asset. This analysis uses scenarios which are only one possible view of the future and models which are themselves a representation of the climate change. Specific emissions scenarios and climate models used are listed below in Analysis Settings.

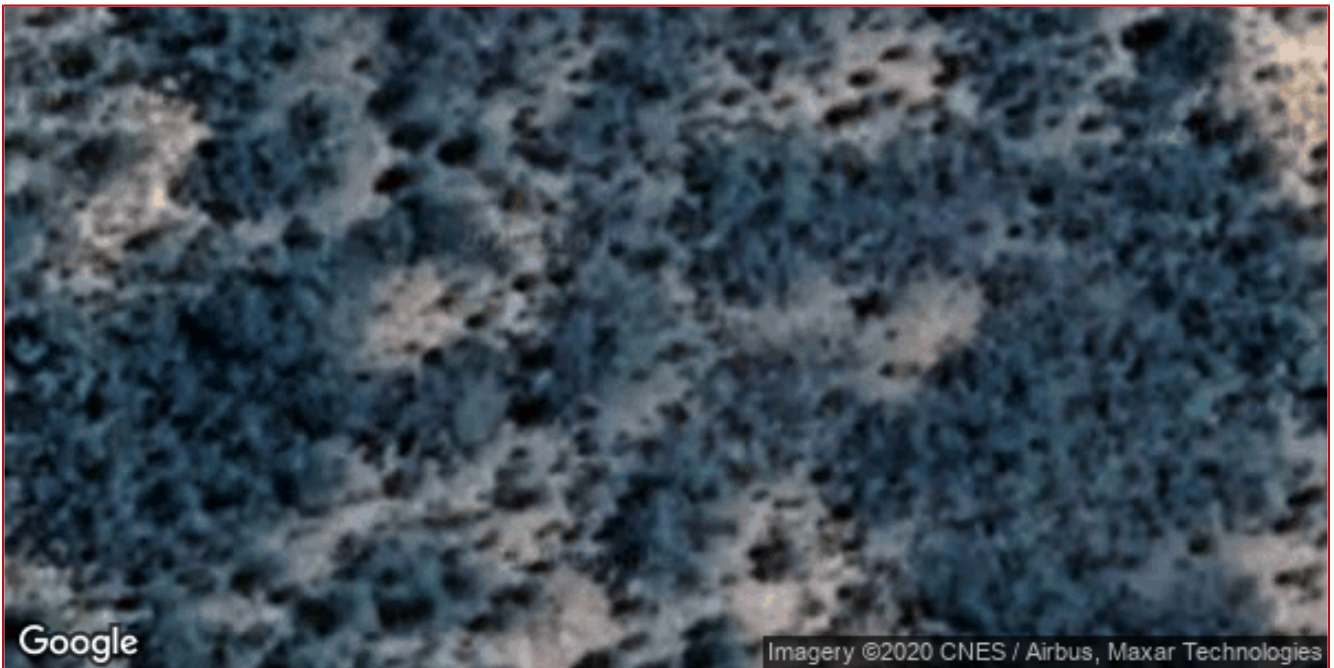
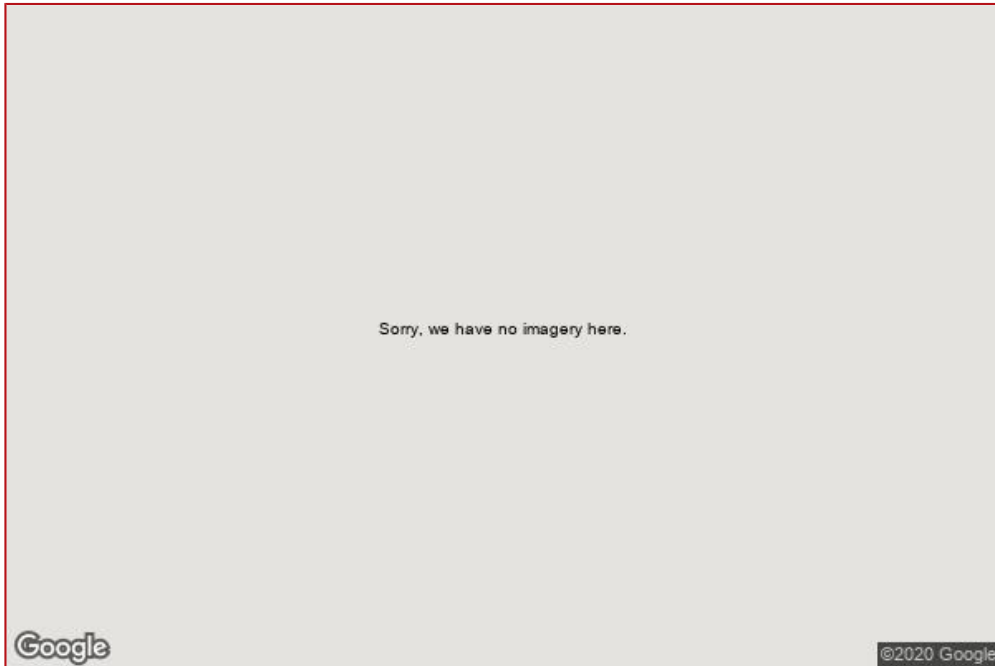
This report is based on a standard Representative Asset. Deeper insights are possible using more detailed asset-specific data, where available. Other XDI products and services including the testing of adaptation options and cost benefit analysis are available. If this report identifies significant risk that you wish to investigate further please contact us at: [info@xdi.systems](mailto:info@xdi.systems).



## 2. ANALYSIS SETTINGS

### 2.1 YOUR ASSET DETAILS

Address: Jacks Creek, Australia  
Lat long: -30.58333N,149.65000E  
Elevation: 266.6 (m)



## 2.2 YOUR ARCHETYPE DETAILS

EasyXDI uses predefined archetypes to represent the materials and design specifications of an asset. Archetypes assume things such as construction materials, wind speed thresholds, floor height above ground and build year to inform the asset's vulnerability when exposed to a hazard.

It is possible to change many of attributes of the archetype using the 'Customise' tab on EasyXDI website.

If you have already done this, it will be displayed below as 'customised' or 'default' (if you have made no changes).

It's important to note that the archetype specifications define a representative asset and cannot therefore be taken as the specifications of your actual asset.

### Your Archetype

The asset archetype you have chosen is: Transformer

### Design Specifications

	DEFAULT SETTINGS	CURRENT SETTINGS
Build year	1990	1990
Heat threshold (c)	42	42
Wind speed design threshold	1 in 500	1 in 500
Forest fire protection	none	none
Foundation design	normal	normal
Asset lifetime	50	50
Floor height above ground (metres)	0.5	0.5
Elevation above sea level (metres)	266.6	266.6

## Elements and Materials

ELEMENT	DEFAULT SETTING	CURRENT SETTING
Access	Reinforced Concrete	Reinforced Concrete
Civil	Reinforced Concrete	Reinforced Concrete
Electrical	Electrical Components	Electrical Components
Electronic	Electrical Components	Electrical Components
Information	Electrical Components	Electrical Components

## 2.3 CLIMATE SETTINGS

### Climate and Hazard scenarios

HAZARD	DATASET	DETAILS
Riverine flooding	Not Calculated	<b>Reason:</b> No flood risk in this location.
Coastal inundation	Projection	<b>Description:</b> Global Sea Level <b>Source:</b> Haigh-et-al-2014
	Bias correction	<b>Description:</b> Global Sea Level <b>Source:</b> CSIRO_Recons_gmsl_yr_2015
	Context data	<b>Land rise (Glacial Isostatic Adjustment):</b> drad250.1grid.ICE5Gv1.3_VM2_L90_2012-global <b>Maximum annual tide height:</b> CANUTE-global
Heat Failure	Projection	<b>Description:</b> Annual maximum temperature <b>Source:</b> DSITI <b>Dataset:</b> DSITI <b>Domain:</b> QLD-10
Forest fire	Projection	<b>Description:</b> Fire weather index (HDW-daily) <b>Source:</b> CORDEX <b>Dataset:</b> MPI_CLMcom <b>Domain:</b> CORDEX-AUS-44
	Context data	<b>Tree Cover:</b> treecover2010_blurred-global <b>Urban Density:</b> urban_areas-global

Wind damage	Projection	<b>Description:</b> Annual maximum wind gust speed <b>Source:</b> CORDEX <b>Dataset:</b> MPI_CLMcom <b>Domain:</b> CORDEX-AUS-44
Soil movement due to drought	Projection	<b>Description:</b> Annual total precipitation <b>Source:</b> DSITI <b>Dataset:</b> DSITI <b>Domain:</b> QLD-10
	Context data	<b>Soil Clay Content:</b> CLYPPT_M_sl5_250m_ll_06_16-06_16

The Climate Risk Engines stress test assets using emissions scenarios modelled by international climate research groups based on the Representative Concentration Pathways published by the Intergovernmental Panel for Climate Change (IPCC). The scenario used in this analysis, RCP 8.5, provides a high greenhouse gas emissions trajectory which is most consistent with current global emissions behaviour, trends and the business-as-usual outlook.

**Sea Level Rise:** This analysis uses a sea level rise projection is based on Haigh 2014, which is 1.5m sea level rise above 1990 levels. This sits between IPCC (2013) projections and those used by the U.S. Government's NOAA extreme sea level rise scenarios for 2100.

**Climate Parameters:** The projections for climate parameters covering temperatures, precipitation, forest fire and wind are sourced from the results of a range of General Circulation Models (GCM) and Regional Concentration Models (RCM) developed by international research agencies and published as part of the Coordinated Regional Climate Downscaling Experiment (CORDEX).

**Bias Correction:** Historical weather data may be used to adjust climate model data to align with known local weather behaviour and statistics.

## 3. ANALYSIS RESULTS

### 3.1 INTRODUCTION

This section shows the financial impacts of extreme weather and climate change on the representative asset, using two key indicators: Percentage of Value At Risk (VAR%) and Failure Probability (FP).

Based on these two indicators, XDI provides an overall Asset Risk Rating, Maximum VAR% and Failure Probabilities for all hazards (aggregated) and for each individual hazard. Vulnerability Diagnostics on the component elements of the asset archetype provide further insights into failure modes. These can be customised within EasyXDI online if required.

#### Percentage of Value At Risk (VAR%) - using Annual Cost of Damage

The Percentage of Value At Risk (VAR%) is the annual cost of damage (also called Technical Insurance Premium) caused to an asset by extreme weather, expressed as a percentage of a single asset's replacement cost, specified for a 1 year period with no discounting of the TIP or the asset replacement cost.

Because the replacement value of the actual asset replacement will vary, EasyXDI converts the cost of damage to a percentage of the Value At Risk (VAR%) rather than provide a dollar figure.

Therefore:

$$\text{Percentage of Value At Risk (VAR\%)} = \frac{\text{Technical Insurance Premium}}{\text{asset replacement cost}}$$

#### Failure Probability (FP) - the probability of an event occurring that will stop the asset working

Failure Probability is the annual probability of an event occurring that will cause the asset or its components to stop working. This can occur due to physical damage or due to the asset stopping working without damage. Eg.: an airconditioner might fail because the ambient temperature exceeds the operational threshold of its electronics.

Failure probability is an important indicator because of the consequences related to the asset failing to operate.

This is especially true for productive assets such as business premises or critical infrastructure where there may be significant lost income or customer disruptions when the asset stops working.

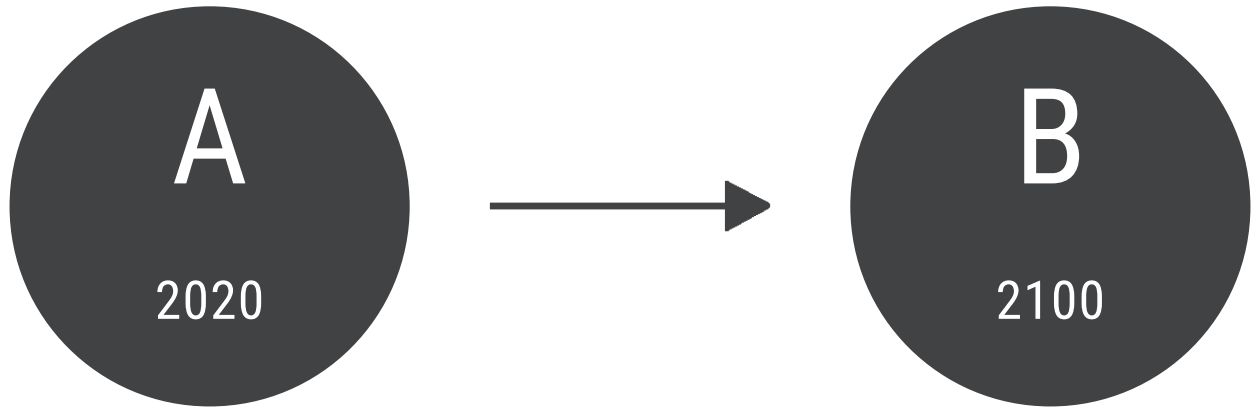
The mechanisms by which an asset or its component elements are caused to fail by a hazard are further explored in Vulnerability Diagnostics.

For more information see Section: Methodology.

## 3.2 XDI ASSET RATING

Using VAR% as an indicator on the possible availability and affordability of insurance, EasyXDI creates a Risk Rating associated with the chosen asset type at its selected location now and at the end of the asset's lifespan.

A representative asset (building: Transformer) at the selected location has a Medium XDI Risk Rating over the expected asset lifetime (ending 2100). The highest level of risk (%VAR) is reached in 2100.



XDI ratings are calculated from the Value At Risk % (annual average cost of damage divided by asset replacement cost) as follows:

- A** **Low Risk = %VAR < 0.2**  
May be insurable at reasonable cost.
- B** **Moderate Risk = 0.2 < %VAR < 1**  
May lead to higher insurance costs.
- C** **High Risk = %VAR > 1**  
Insurance may be high cost or unavailable unless adaptation actions are undertaken.

The XDI ratings follow the Federal Emergency Management Agency (FEMA) designations that are used for pricing a large number of Insurance premiums in the USA. XDI has used FEMA's probability method and extended it to include a wider set of hazards. The XDI Rating results therefore provide an insight into the possible longer-term availability and cost of insurance. For any real asset, availability and costs should be obtained from a commercial insurance provider.

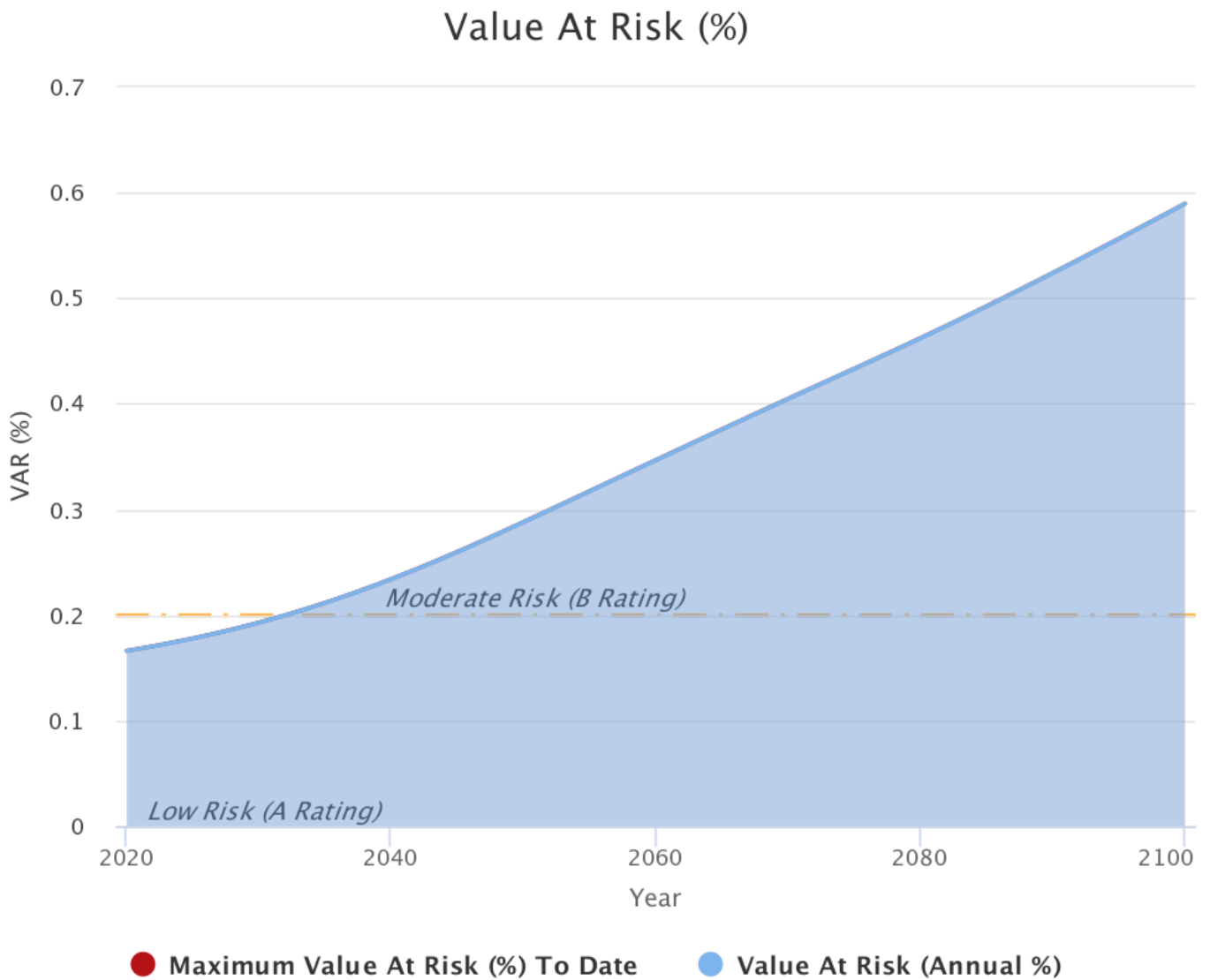


### 3.3 PERCENTAGE OF VALUE AT RISK (VAR%) - ALL HAZARDS

This section shows maximum and annual VAR% for all hazards.

#### Maximum Value At Risk (VAR%)

This chart shows the contribution of each hazard to the Maximum VAR% and the contribution each hazard makes to VAR% for each year.



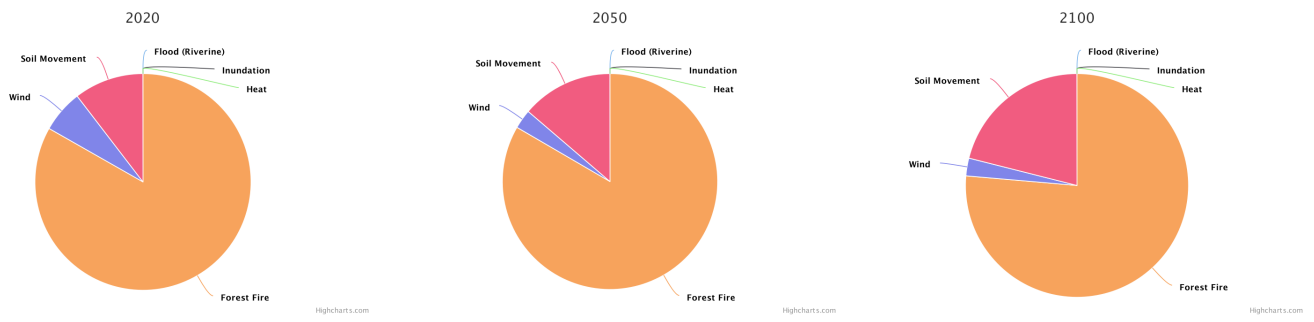
Highcharts.com

Starting in 2020, the Max VAR% shows the highest VAR% reached up to a given date. This can be thought of as the record reached by an athlete, which stays unchanged until the record is broken and pushed higher. Max VAR% is an important reference for stress testing an asset, because climate models may not be accurate at assessing the precise time at which climate indicators increase or decrease. This chart alerts the user to the maximum VAR% that has been seen up until that date. This number may be the most appropriate to use for adaptation planning.

Note that downward fluctuations sometimes appear due to climate model outputs, which VAR% follows. In some cases, model outputs are aggregated into 20 year blocks, in which case curve-fitting is used to interpolate and extrapolate the annual behaviour.

## Pie Charts for Annual VAR% by hazard for 2020, 2050, 2100

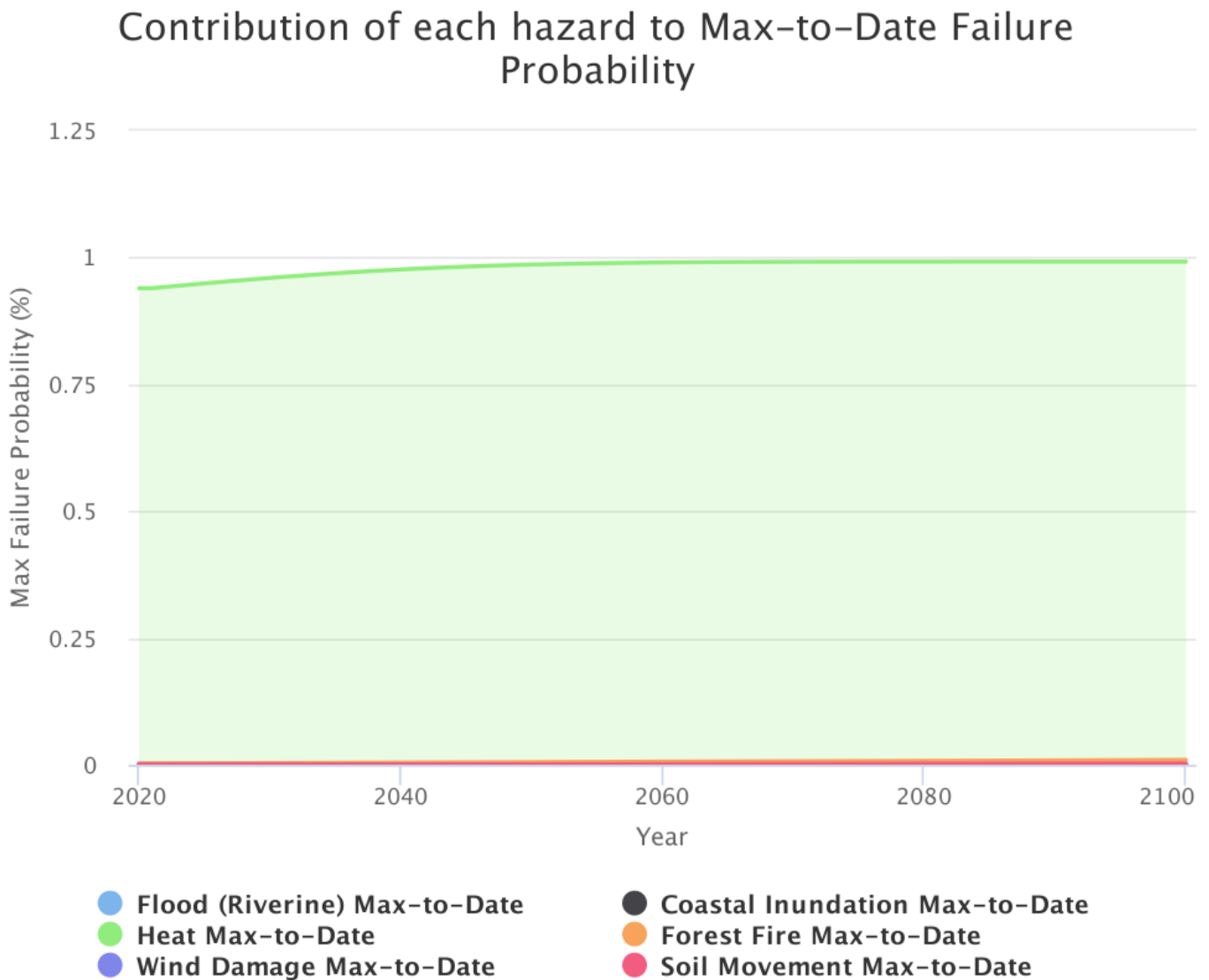
These charts show annual VAR% divided into each hazard for three time periods.



## 3.4 FAILURE PROBABILITY - ALL HAZARDS

### Maximum Failure probability to date

This chart shows the contribution of each hazard to the Maximum Failure Probability.



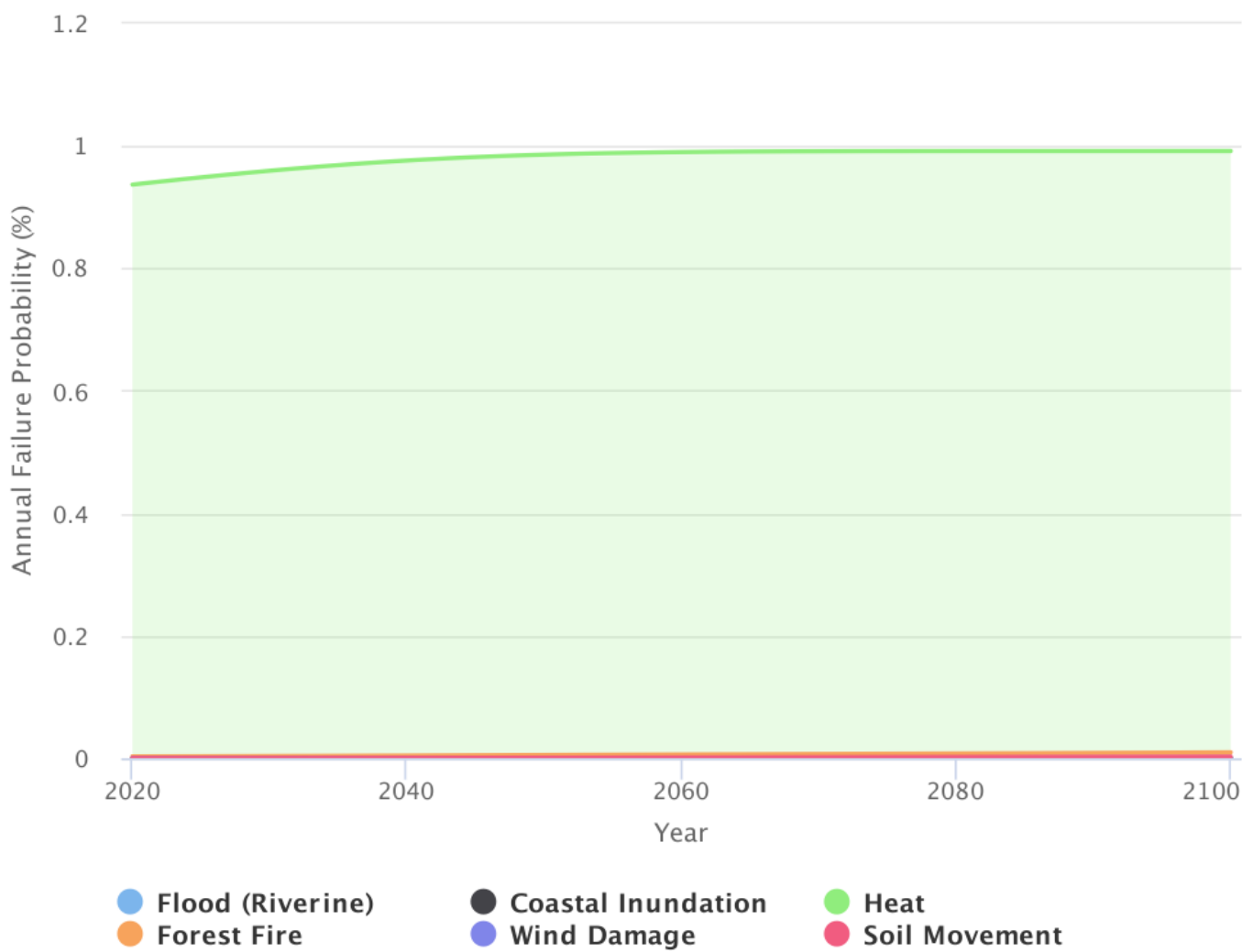
Highcharts.com

Starting in 2020, the Max Failure Probability shows the highest FP reached over the period. This can be thought of as the record reached by an athlete, which stays unchanged until the record is broken and pushed higher. Max VAR% is an important reference for stress testing an asset, because climate models may not be accurate at assessing the precise time at which climate indicators increase or decrease. This chart alerts the user to the maximum VAR% that has been seen up until that date. This number may be the most appropriate to use for adaptation planning.

## Annual Failure probability to date

This chart shows the contribution each hazard makes to the annual failure probability.

### Contribution of each hazard to Annual Failure Probability

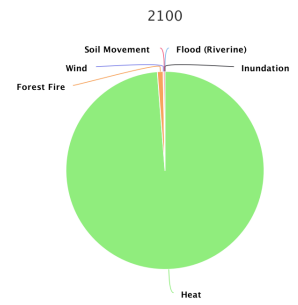
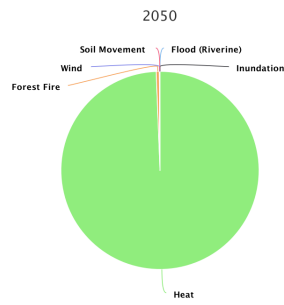
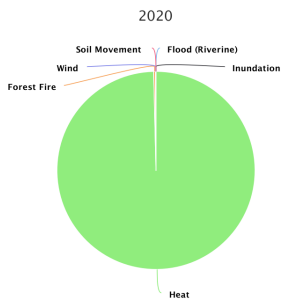


Highcharts.com

Note that downward fluctuations sometimes appear due to climate model outputs. In some cases, model outputs are aggregated into 20 year blocks, in which case curve-fitting is used to interpolate and extrapolate the annual behaviour.

# Pie Charts for Annual FP by hazard for 2020, 2050, 2100

These charts show annual Failure Probability divided into each hazard for three time periods.



## 3.5 VULNERABILITY DIAGNOSTICS

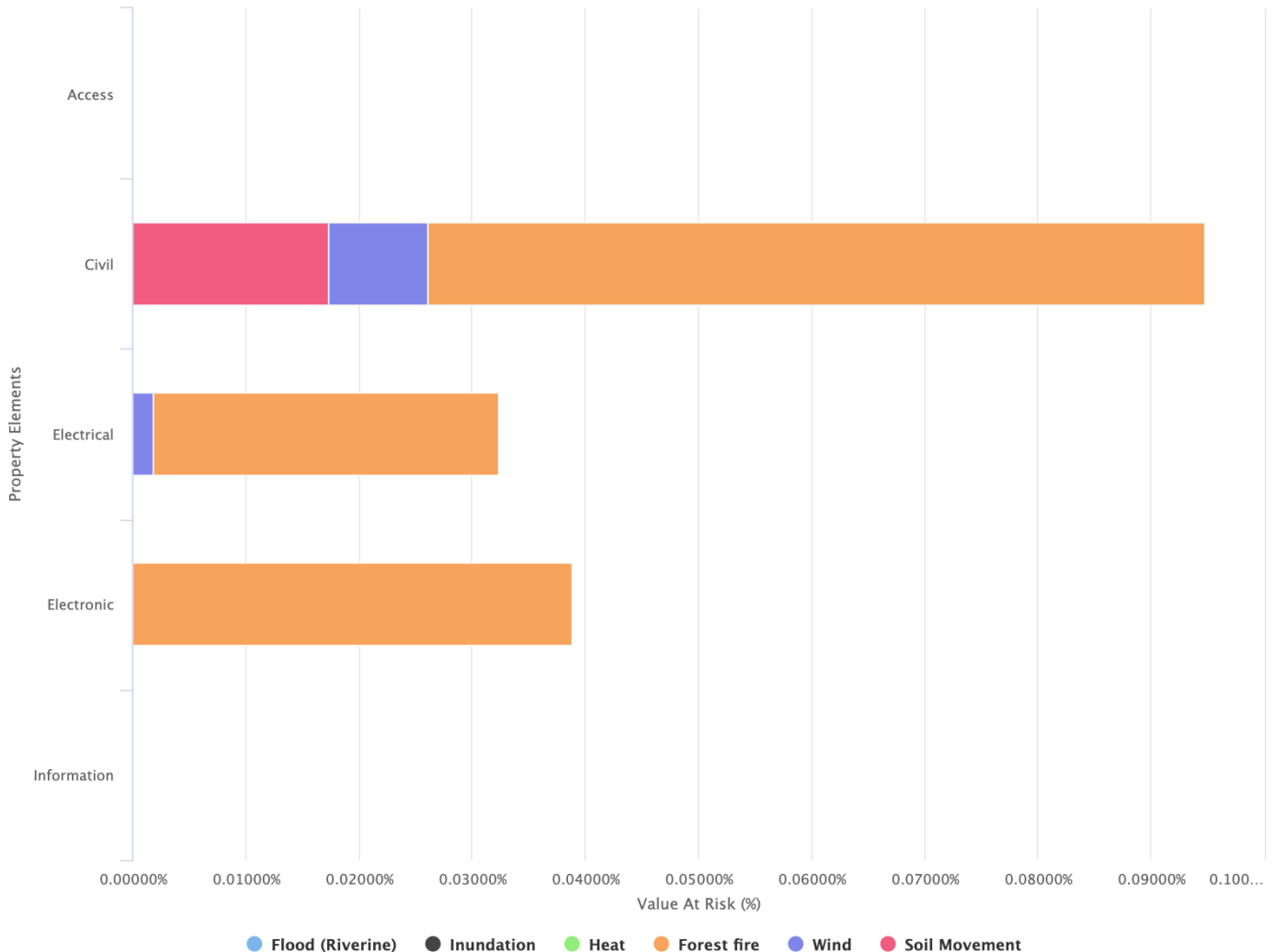
This section helps to understand which material elements of the asset archetype are failing and why. The graph shows hazard impacts (colour coded) on each of the construction elements in the archetype for three time periods.

The Y Axis lists all of the construction elements analysed for hazard impacts. The X Axis quantifies each hazards contribution to the composition percentage of the the hazard impacts for each of the elements.

Diagnosing vulnerability helps decision makers to fine tune maintenance, schedule upgrades, or plan for adaptation.

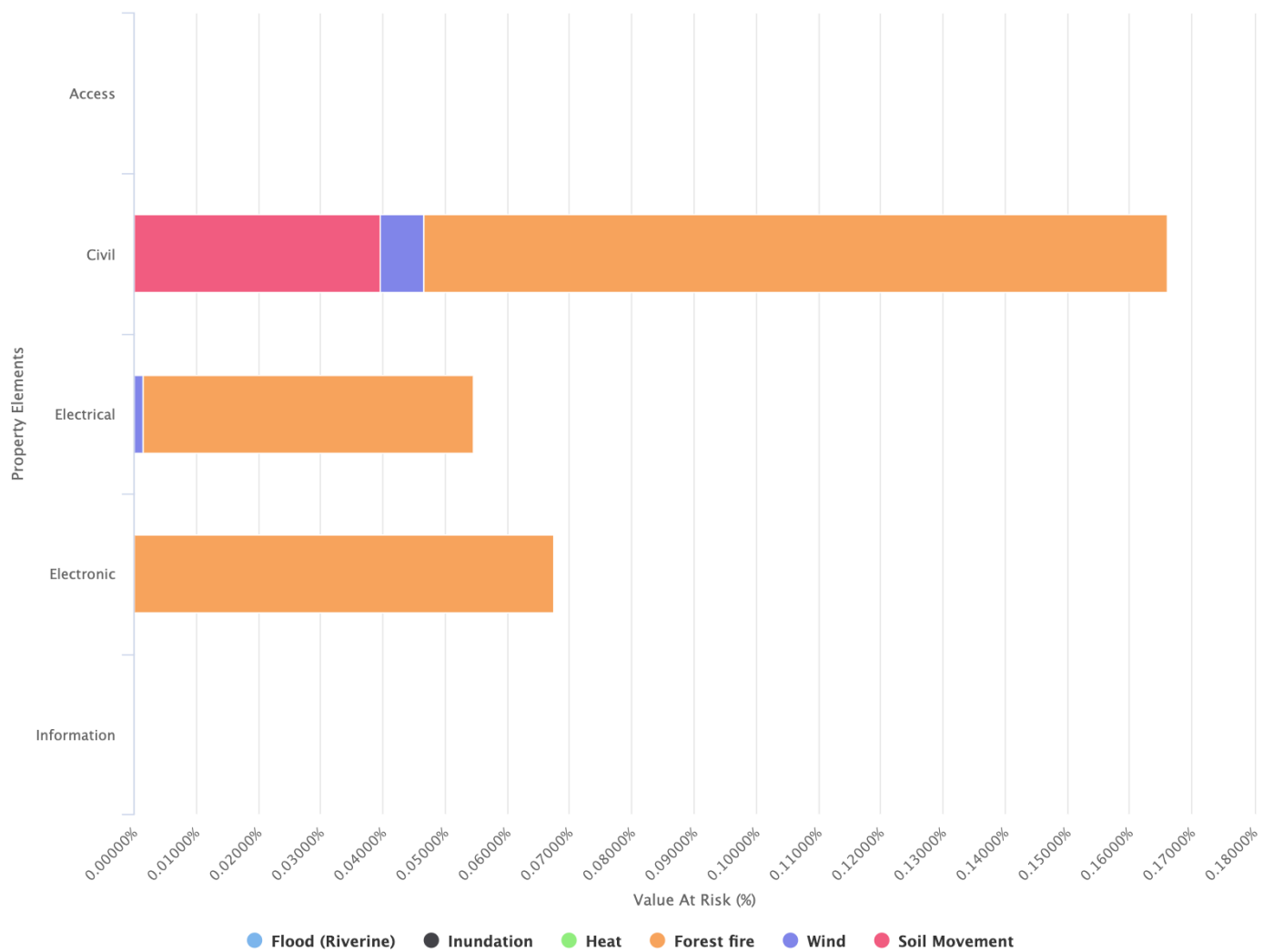
### Current year

Vulnerability per Hazard by Element: 2020



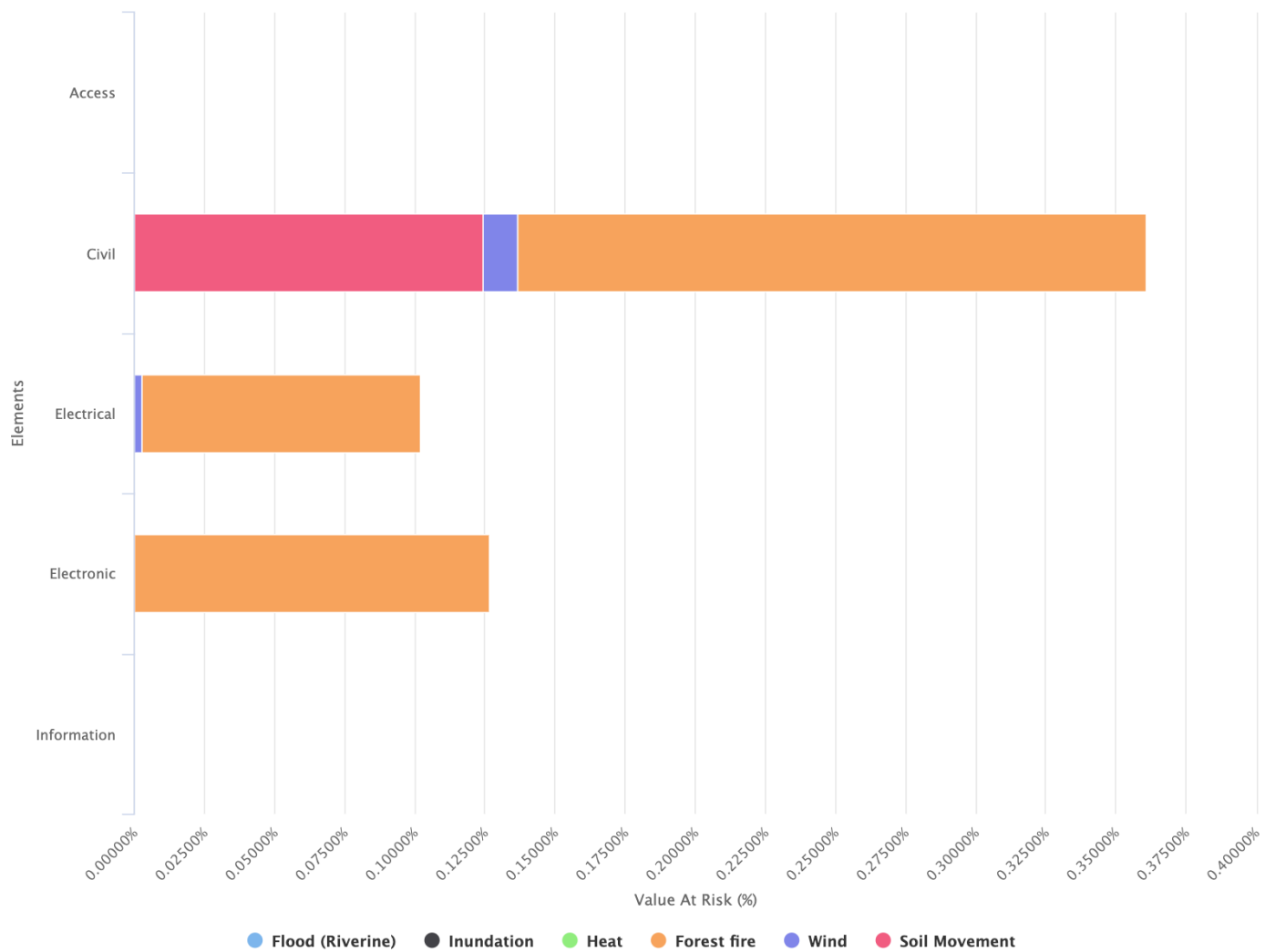
Highcharts.com

Vulnerability per Hazard by Element: 2050



Highcharts.com

Vulnerability per Hazard by Element: 2100



Highcharts.com



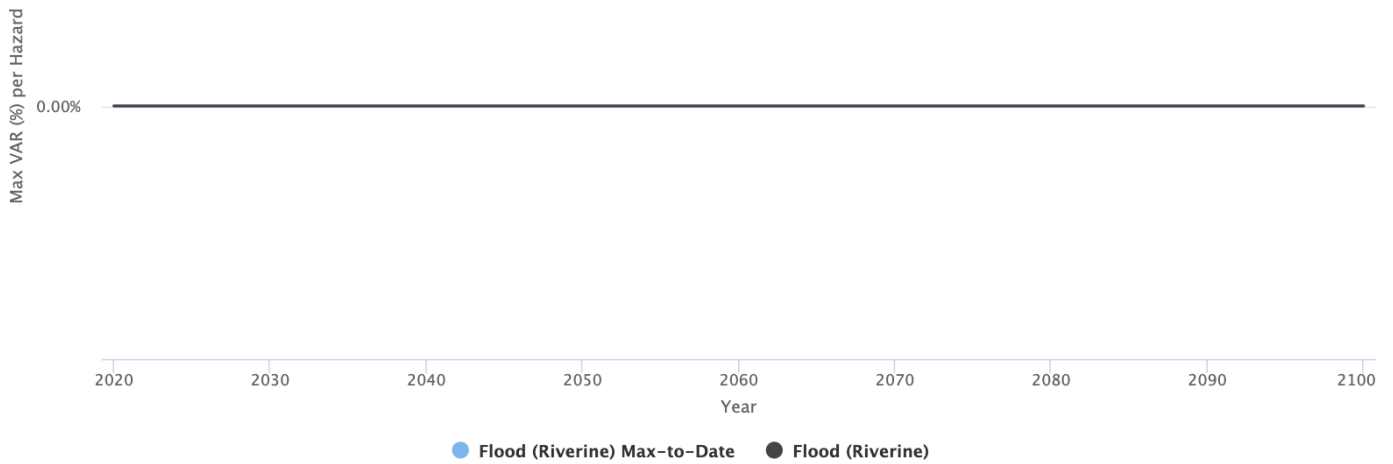
## 3.6 HAZARDS BREAKDOWN

This section displays key indicators for each hazard analysed on the asset archetype.

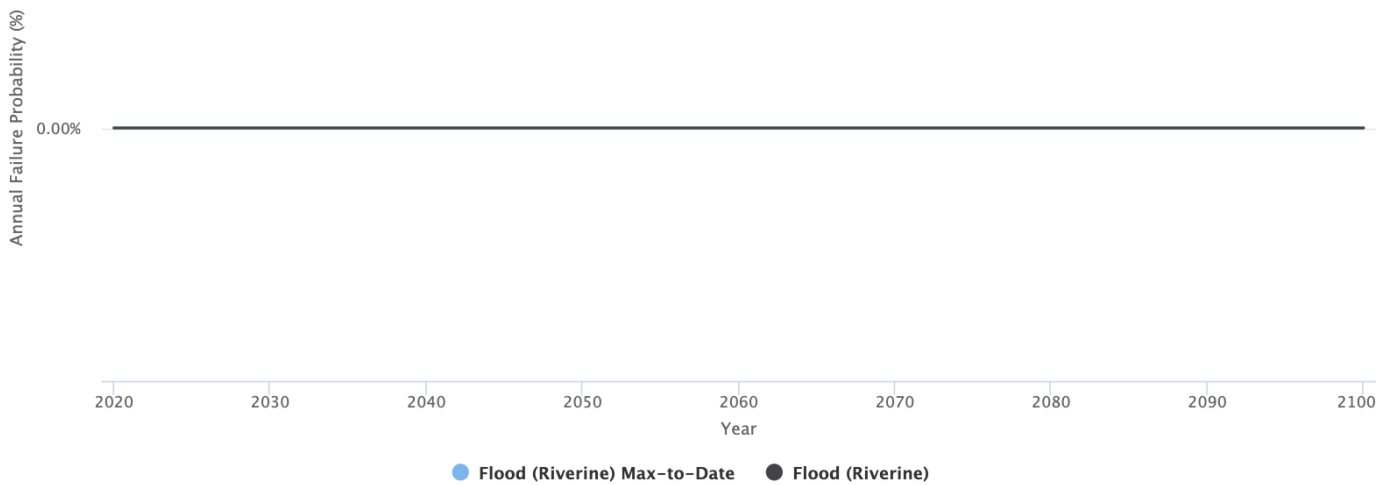
### Riverine Flooding

VAR% and FAILURE PROBABILITY (MAXIMUM + ANNUAL)

Contribution of each hazard to Max-to-Date and Annual Value At Risk (%)



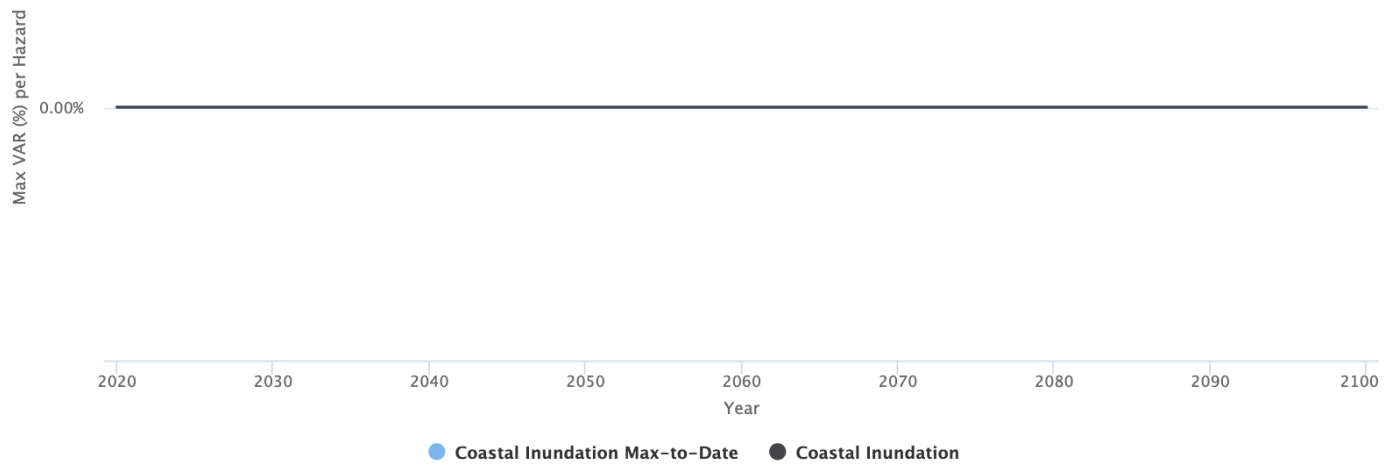
Contribution of each hazard to Max-to-Date and Annual Failure Probability



# Coastal Inundation

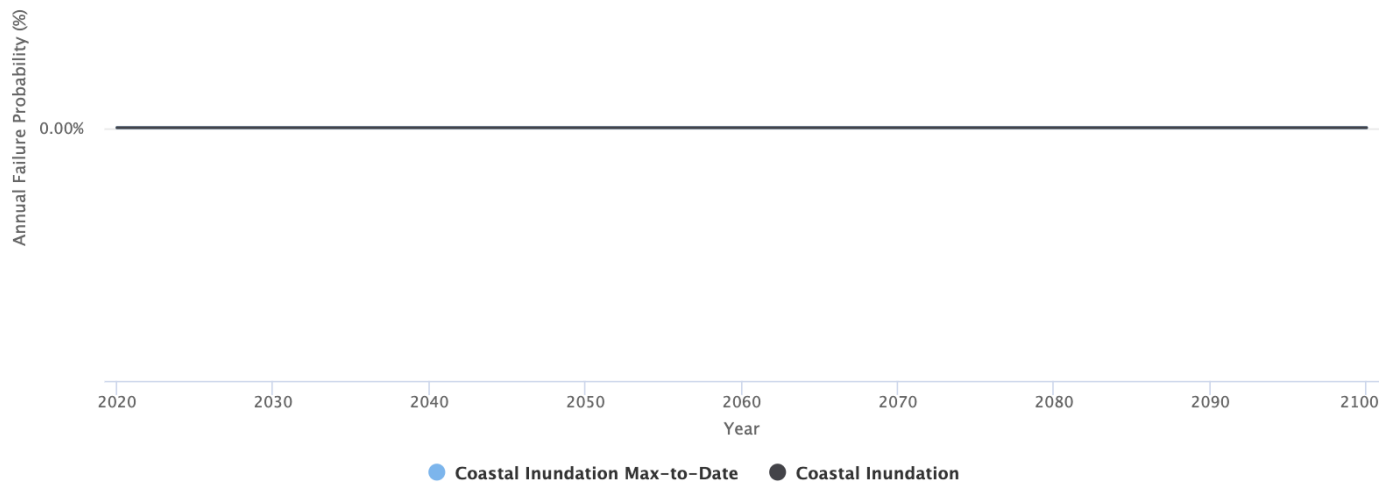
## VAR% and FAILURE PROBABILITY (MAXIMUM + ANNUAL)

Contribution of each hazard to Max-to-Date and Annual Value At Risk (%)



Highcharts.com

Contribution of each hazard to Max-to-Date and Annual Failure Probability

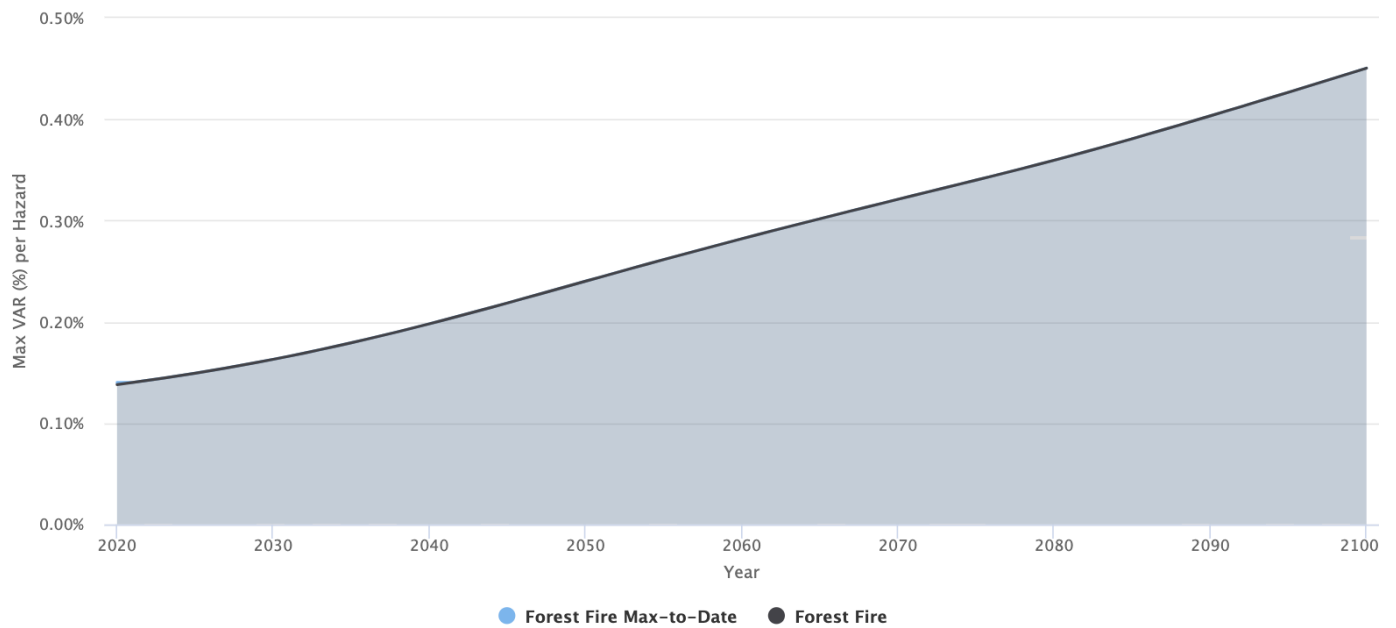


Highcharts.com

# Forest Fire

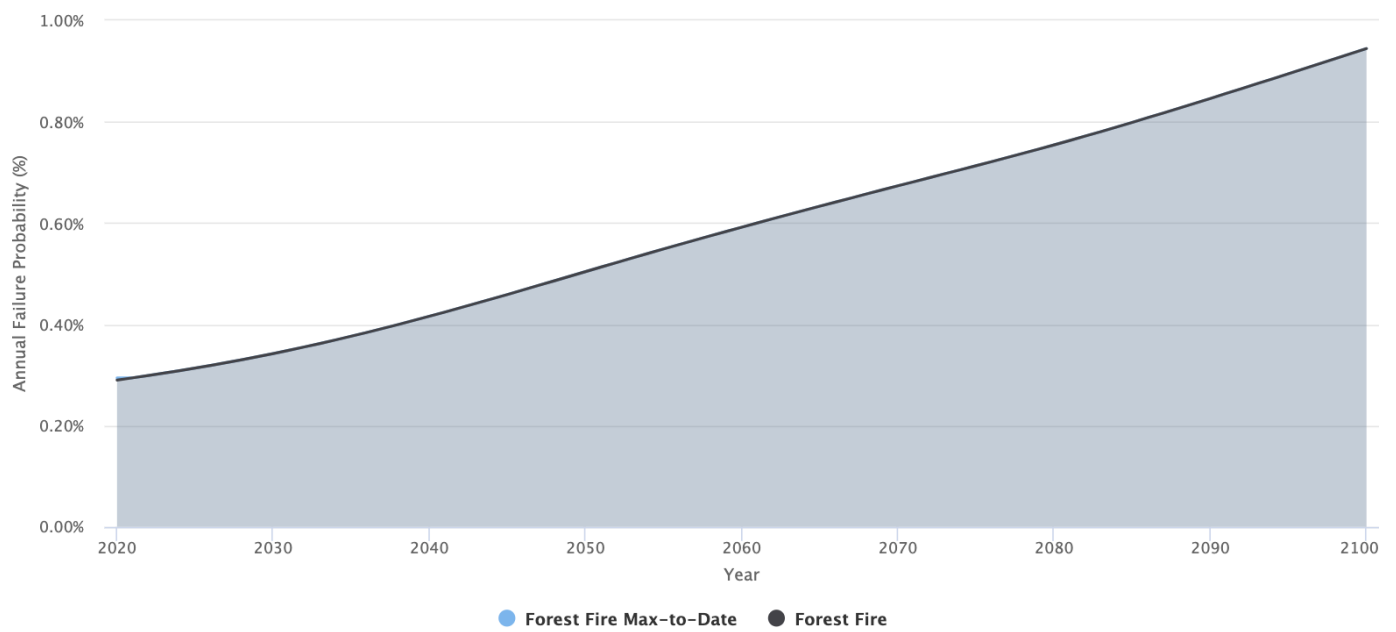
## VAR% and FAILURE PROBABILITY (MAXIMUM + ANNUAL)

Contribution of each hazard to Max-to-Date and Annual Value At Risk (%)



Highcharts.com

Contribution of each hazard to Max-to-Date and Annual Failure Probability

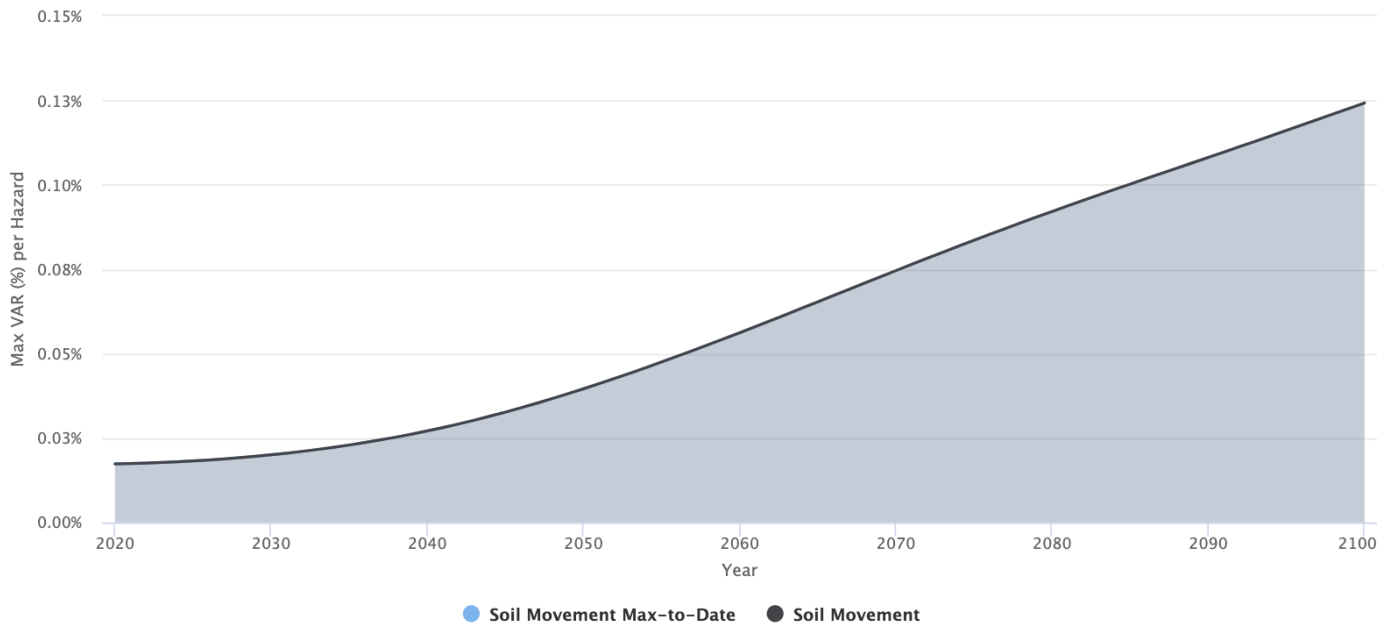


Highcharts.com

# Soil Subsidence

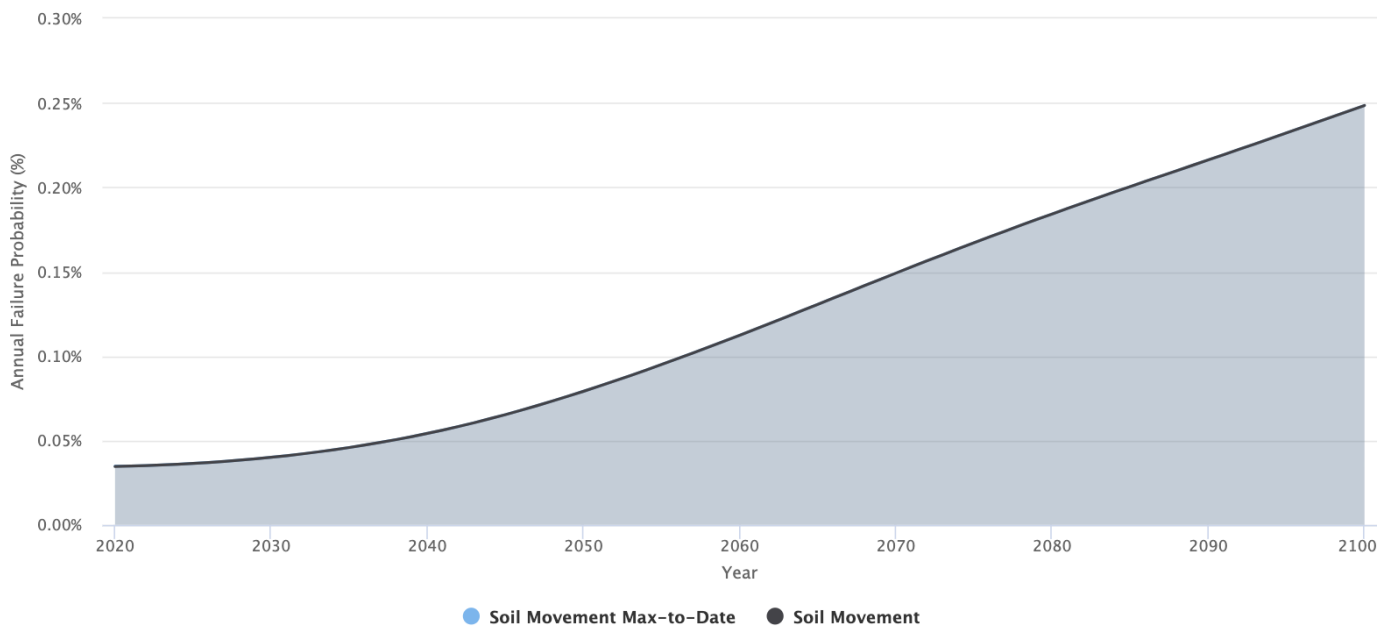
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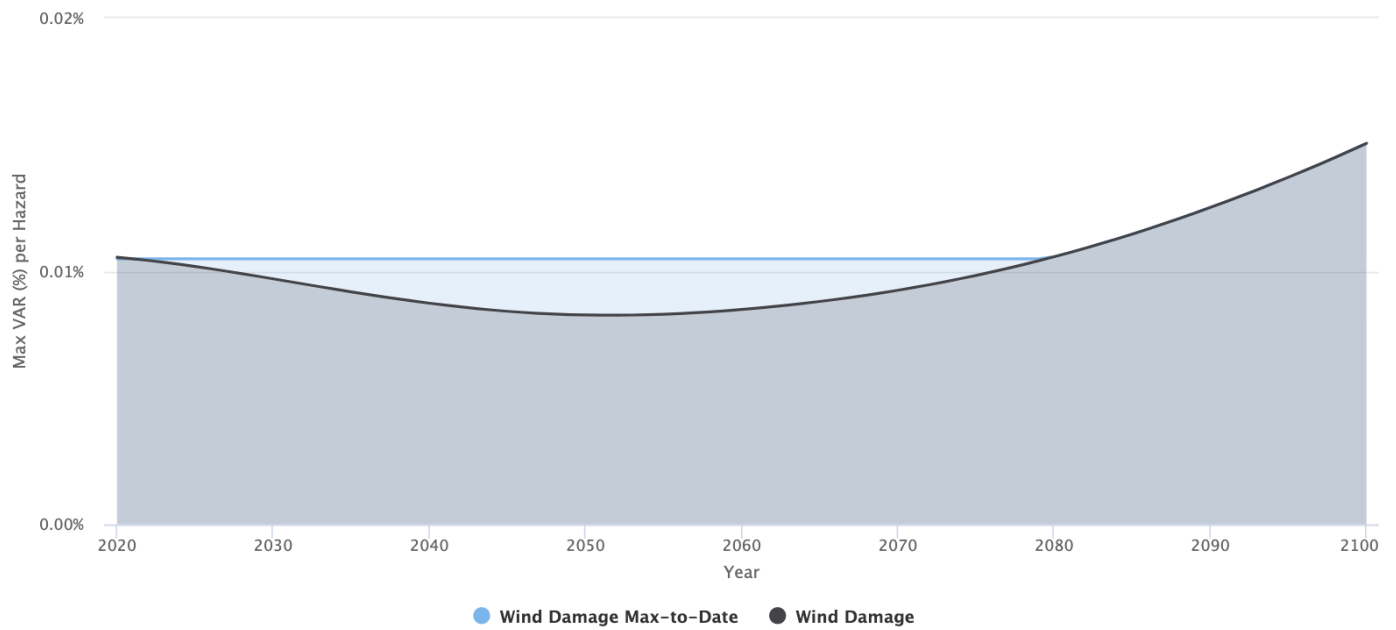


Highcharts.com

# Extreme Wind

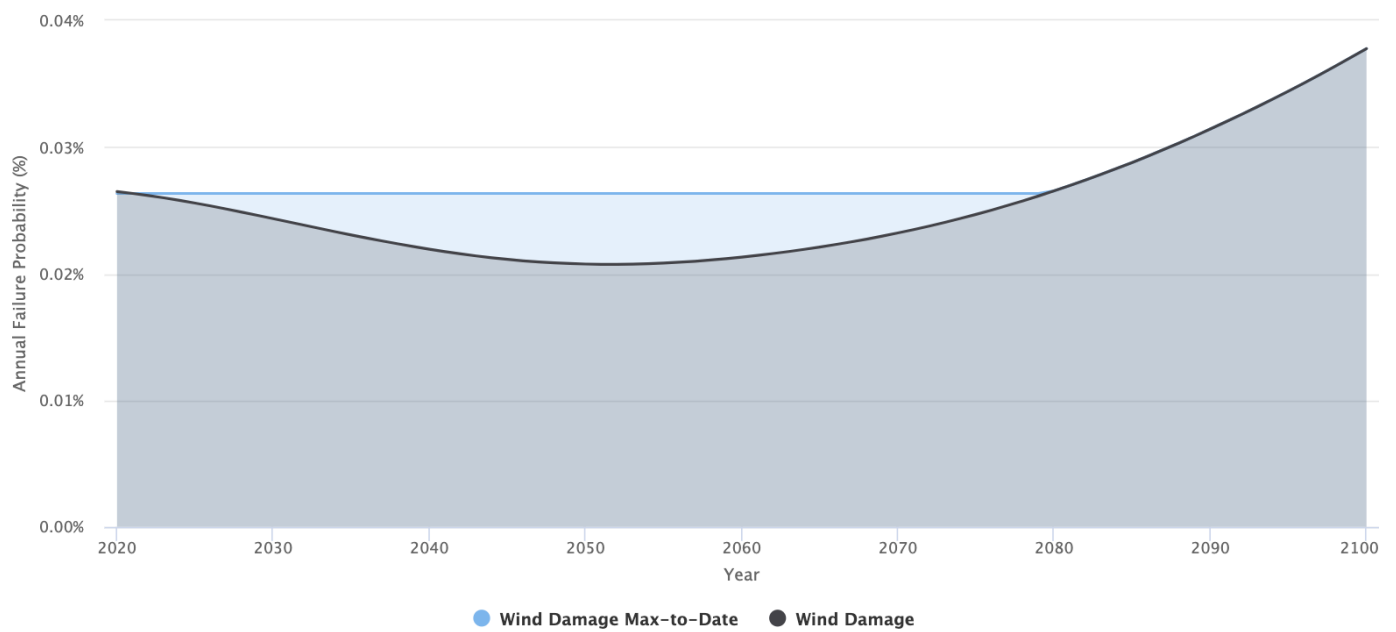
## VAR% and FAILURE PROBABILITY (MAXIMUM + ANNUAL)

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Highcharts.com

Contribution of each hazard to Max-to-Date and Annual Failure Probability

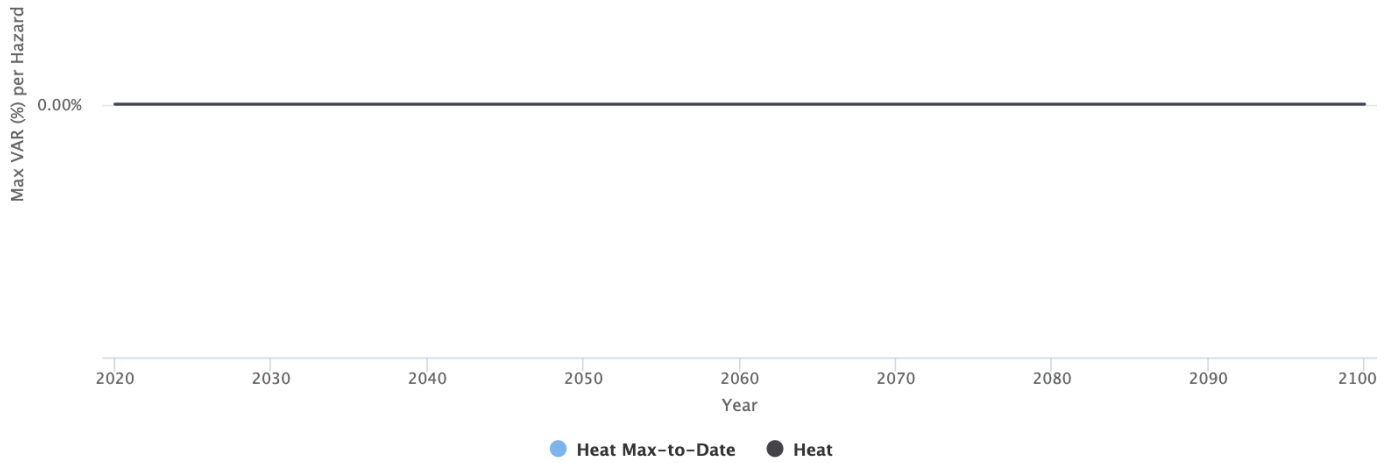


Highcharts.com

# Extreme Heat

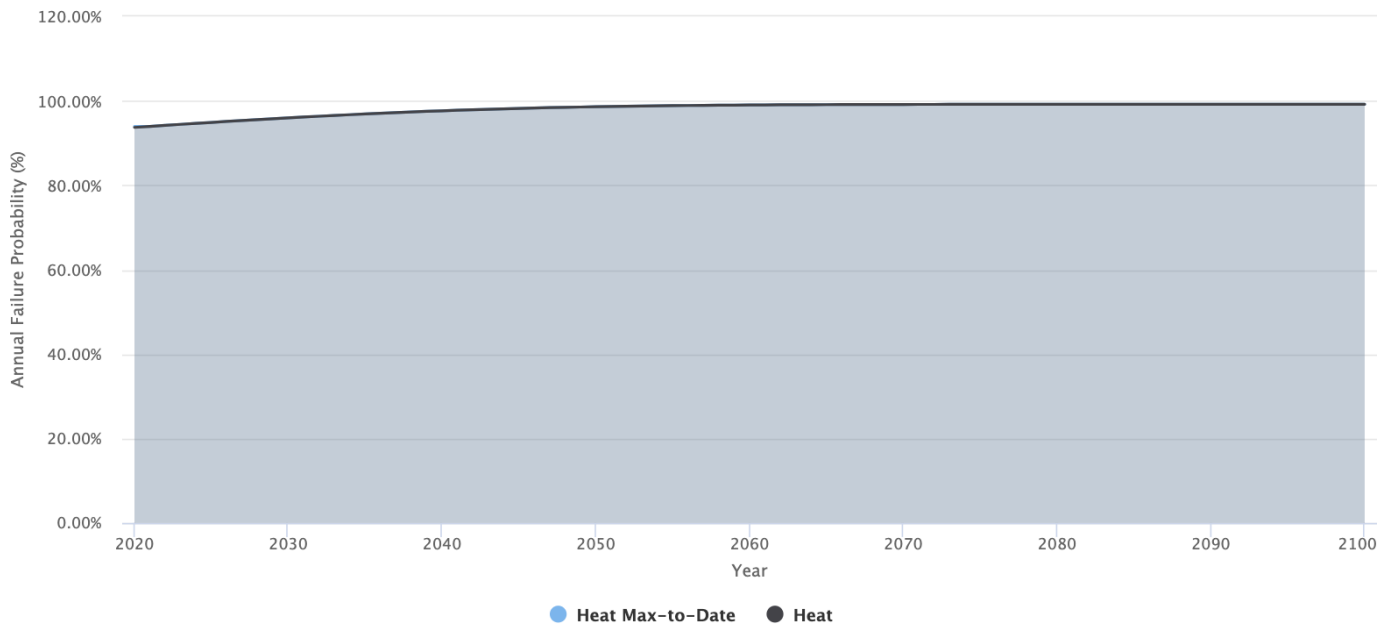
## VAR% and FAILURE PROBABILITY (MAXIMUM + ANNUAL)

Contribution of each hazard to Max-to-Date and Annual Value At Risk (%)



Highcharts.com

Contribution of each hazard to Max-to-Date and Annual Failure Probability



Highcharts.com

## 4. METHODS USED FOR ANALYSIS

This analysis covers riverine flooding, coastal inundation, forest fires, extreme wind, soil movement due to drought, and extreme heat. It does not cover flash flooding (pluvial), coastal erosion, grass fires, land slip, cyclones, hail or heat impacts.

Results have been generated using purpose-built software running on an array of high-speed servers provided by Climate Risk Pty Ltd. The Climate Risk Engines assess climate impacts by placing a pre constructed asset 'Archetype' at the address entered. Using the design specifications and materials typical of the Archetype, the Climate Risk Engines compute the threshold at which its various key components would fail if exposed to hazards such as flooding, soil subsidence and forest fires.

Using this information, the annual probability of damage being caused by such events is calculated by (a) gathering a range of data on forests, soils, floods, elevations, tides, and waves, (b) coupling this with long term data from local meteorological stations, and (c) adjusting future probabilities to account for changes in parameters such as heat, precipitation, wind and humidity from global climate change models.

### Stress-Test Approach

This analysis uses an IPCC greenhouse gas emission scenario that follows business-as-usual (RCP8.5). Specific models are selected to 'stress test' each hazard - thus a model that tends to predict a drier future is used to consider drought, and a model which predicts a wetter future is used to test flood risk. This selection process avoids masking risks or diluting impacts through averaging an ensemble of models, however results should be interpreted as a stress-test, not a mean or median projection

Multi-model ensemble analysis is available from XDI upon request.

### The Climate Risk Engines

The Climate Risk Engines are purpose built to compute hypothetical future risks to a modelled asset archetype designed to represent individual property and infrastructure assets. The system enables each such an asset to be stress-tested against a wide range of extreme weather and extreme sea events typical of its location. A range of future-looking scenarios can be applied that are consistent with different greenhouse gas emission scenarios, atmospheric sensitivity, adaptation pathways, building standards and planning regimes.

The Climate Risk Engines combine engineering analysis with statistical analysis of historical weather and climate projections, and probabilistic methods for financial analysis of risk and value. It's important to note that these results apply to a synthetic Representative Asset Archetype under a range of future scenarios. The results cannot therefore be taken as representations of the actual future risks to, or value of, a real or planned property or infrastructure asset.

## A Representative Asset Archetype

Initially the system creates a synthetic representation of an asset that is based on nominal industry archetypes, but may include some customisation by the user. This representative asset type could be selected and tailored to represent a real asset at the same location – such as a house, road or phone tower – or be created as an entirely hypothetical asset being placed in that location.

## Included Hazards

Weather and climate change are not hazards in themselves. Rain is not a hazard, but flooding is. Drought is not a hazard, but contracting soils and moving foundations can be. Therefore, quite apart from just climate and weather data, the Climate Risk Engines analyse a range of damage causing hazards including riverine flooding, coastal inundation, forest fires, extreme wind, extreme heat, and soil movement due to drought.

## Mathematical Analysis

The extreme weather and climate risks to an asset will depend on its exposure and vulnerability to each hazard, as well as the current and future severity and frequency of the hazard that may alter with climate change. How each of these are handled by the Climate Risk Engines is discussed below.

## Hazard Exposure

To understand if the Representative Asset is exposed to a hazard or not, contextual information about each location is gathered by the Climate Risk Engines. This may include information about the soils, tree cover, topology, elevation, flood plains, local tides or waves. Data is gathered on these contextual features from national and international sources selected on the basis of scientific methods used, accuracy, spatial resolution, completeness and the standing of the institution that has generated the information. The organisations from which data have been used are set out in the appendix of this document.

## Vulnerability Analysis; Damage and Failure Thresholds

Each asset is tested for its ability to withstand the hazards to which it is likely to be exposed for each future year. The system tests both failure thresholds and damage thresholds.

A damage threshold is breached when an asset is affected by a hazard such that it is broken or excessively weakened. Examples might be flood waters damaging an electrical control system, or a wind-storm blowing the roof off a house.

A failure threshold is breached when an element of the asset prevents the asset from performing its function. For example, when the roof is blown off in a storm it is both damaged and it fails to protect its occupants from the weather. However, it is possible to have failure without damage, for example an electrical control system that exceeds its operating temperature in a heat wave may stop the asset working, but there will be no damage (when the temperature drops it will start working again).



## Weather Data

To establish the precise probability that a hazard will exceed the coping threshold of an asset or element, information about the causal weather or climate indicators may be needed, for example the likelihood of flooding is linked to the likelihood of extreme precipitation.

The Climate Risk Engines have access to data from 100,000 weather stations around the world. Internal algorithms are used to select which stations to use when testing an asset, based on proximity, data quality, duration and completeness. In some cases, the Climate Risk Engines may use a combination of data from more than one station or gridded data sets made by national meteorological centers. Satellite data has become an important source of weather data and this too may be accessed for computations, though the climate change influence on a weather data base-line has to be handled very carefully.

## Climate Change Modelling

Changes in the composition of the atmosphere due to greenhouse gas emissions will change how the atmosphere and oceans behave. Therefore, the historical weather station statistics need to be adjusted to allow for climate change.

The Climate Risk Engines have access to a large number of data sets from the Coupled Model Inter-comparison Project (CMIP) in which participant organisations model the atmosphere under various Representative Concentration Scenarios (RCP). At a whole of atmosphere scale the General Circulation Models (GCMs) have a resolution down to about 100km<sup>3</sup>.

With downscaling, Regional Climate Models (RCMs) include local topology and land surface information to provide weather parameters at higher spatial resolutions - between 5km<sup>3</sup> and 50km<sup>3</sup>.

For some locations, users can select the GCM/RCM they wish to apply to the analysis of the Representative Asset, otherwise the Climate Risk Engines will select by default the most appropriate climate modelling to use based on: the models available in the region; the 'skill' of the model in capturing typical weather behaviour in a certain region; the range of parameters included or reported; the spatial resolution; and how the results of the model fit within the ensemble of other models for the region.

## Scenario Run Data

In this analysis data from CORDEX is used. CORDEX models are selected based on resolution, currency and relevance the hazard of interest. The model selected for each hazard is specified in the results.

## 5. CONCLUSION

This EasyXDI report has provided an XDI Risk Rating and a calculation of Percentage Value At Risk based on your choice of a Representative Asset, the location selected and the future climate change scenario used. Though insurance is a private contractual arrangement, these results can help understand whether such an asset might have problems accessing affordable insurance now or in the future.

You may wish to undertake a new analysis with changed settings that consider improved resilience - for example by changing design specifications or the choice of materials used in the Representative Asset.

If you wish to undertake detailed diagnostic analysis, plan adaptation actions, explore the impacts of hazards in more detail or assess large numbers of assets, please contact our team at [info@xdi.systems](mailto:info@xdi.systems)

### CONTACT XDI

Since 2006, organisations have turned to our team to help them analyse the physical impacts of climate change to their business operations. XDI's analysis is underpinned by the Climate Risk Engines, developed through extensive commercial engagement with industry and government

If this report identifies significant risk, XDI can provide more detailed analysis through other XDI products and services. Please contact us for more information: [info@xdi.systems](mailto:info@xdi.systems)

All XDI products are powered by Climate Risk Engines. To find out more see [www.climateriskengines.com](http://www.climateriskengines.com)