The Quant Foundry

# What to Look for In a Climate Risk Offering

With the wide adoption of the Paris Agreement on climate change in 2015 and strong commitments to limit greenhouse gas emissions by many states, the world has started to overhaul its use of natural resources. The impacts of climate change even under the best anticipated scenarios will be significant from increased frequency of acute weather events to the chronic long-term impacts on agriculture and the demands on businesses to adapt their business to enable the transition.

Many financial organisations on both the buy side and the sell side have signed up to voluntary disclosures such as TCFD, however there is an increasing push to implement regulatory measures such as scenario stress tests such as those from the Bank of England[1], the ECB[2] and recently guidelines from CFTC [3] in the United States. The regulatory land scape will require financial organisations to implement robust stress testing and risk assessment capabilities over short horizon to meet the current standards of the quantification of risks across their balance sheets. Achieving this will require the updating of existing data processes and the introduction of new models to reliably build scenarios across an organisation's exposures.

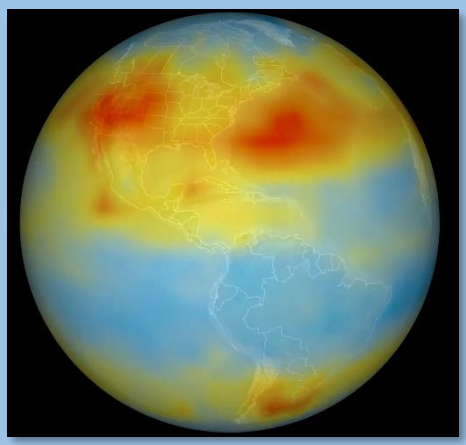
## Who Should Read This Note?

**Investors** looking for the right asset manager to provide best in class portfolio construction and justification for their asset management choices

**Asset Managers** looking to build a best in class portfolio construction and risk process

**CROs and Heads of Front Office Teams** for regulated financial companies looking to address the challenges of risk management and climate risk model governance

## The Challenge of Climate Risk



*The impact to climate will bring about enormous upheaval for every country in world. Even the most optimistic scenarios will create pressures on companies and nations to adapt.*

How to effectively measure the risks facing organisations and investors alike is how to forecast the impacts of climate change on the portfolio of assets. This has led to several organisations looking to implement a climate risk solution to address to help them guide investment choices and highlight the specific risks across their current portfolios. At the same time organisations such as the NGFS are engaging the research community to help build and define what the scenarios should look like across the industry.

The Climate Risk team in Quant Foundry is actively involved in the latest research to address climate transition and physical risks and have developed an offering, guidance and coherent quantitative solutions that enable banks / asset managers / insurers to quantify the physical and transition risks associated with climate change.

[1] Bank of England, Climate Change
[2] ECB Guide on Climate Related and Environmental Risks
[3] CFTC Managing Climate Risks in the US Financial System


E: enquiries+climate@quantfoundry.com

In this note we highlight what investors, assets managers and regulated financial institutions should look for as part of their modelling framework.

## Functionality Required for Risk Modelling

Risk modelling for climate change consists of several major components that are critical for an organisation to be able to make statements in its risk measurement (or asset allocation process).
Guidelines from the NGFS recommend investigating several different approaches to modelling and there is ongoing research and development to build more detailed models that can be downscaled to the company level. Each organisation will face the challenge of being able to collect, validate and integrate new data sets (such as details on plant and machinery, specific capital expenditure goals, business strategies). Having a defined data collection process and the relationships with clients to facilities the information gathering will be crucial for future risk forecasting.

*Energy Intensive industries will be significantly impacted by transition pathways planned to mitigate climate risks.*

### Quick Guide to Modelling Requirements

***Coherent Scenario Engine***
*that can combine impacts to energy use, Green House Gas Emissions, Configurable Climate pathways, with impacts to sectors, households, and land use capture. Capture the macro economic impacts from changes in GDP, rates, inflation.*

***Impacts to Land and Water Use**,*
*alongside adverse weather the chronic impacts to crop yields and water shortages will have significant impacts to nations' economies.*

***Company Level Modelling**,*
*organisations looking to be able to differentiate companies based on their current and future activities. Any model framework should be able to integrate the macro view with a company level view. Features should include, capture of **capital constraints**, predictions of **default probabilities**, **equity** valuations, **bond**, and **credit** prices.*

***Asset Level Modelling**,*
*impacts from severe weather, flooding, bush fires will need to be able to be assessed **mortgage portfolios** need an impact assessment and integration in current default models.*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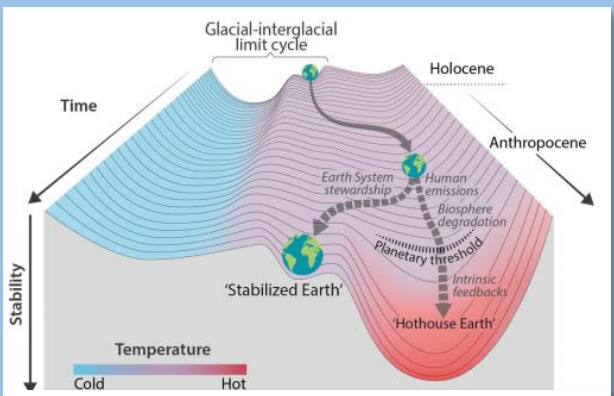
*Capturing the impacts from physical risk from direct damage and understanding the wider implications for each part of the world will be critical for everyone.*

## Steps to Assessing Climate Risks

As summary the most important feature is to have a framework that allows organisation to build scenarios that impact the global economy for all important outcomes that have an impact on the climate. This framework needs to be holistic and have means to predict the overall impact to Green House Gas (GHG) emissions from the modelled economic and technology any framework that cannot coherently produce this will give misleading numbers. More details can be found in section Coherent Scenario Engine and Future Energy Use Model and Model Should Capture Impact of Land and Water Resource Usage

The model design should be such that it allows the application of stress scenarios across all market and economic factors such as GDP, employment as well as impacts to markets such as equities, rates (sovereign, bank and corporate credit), commodities and foreign exchange as part of a long term simulation capability the model should also be able to capture the future volatilities across these markets. This is designed to facilitate both expected loss calculation from long term credit exposures but also to permit stress testing for credit and market risks. A holistic model should allow users to perform stress tests over the simulation time horizon. More details can be found in section Simulation Framework.

For organisations that wish to assess the impact to their portfolios at the individual company level a sensible model of each company needs to be implemented




*Path of potential temperature scenarios and the implications for the long-term climate. The ability of a scenario model to coherently capture these effects is central in meeting risk measurement requirements. Source: Steffen et al. (2018)*

## Coherent Scenario Engine and Future Energy Use Model

**The Coherent Scenario and future energy use model** is required to assess the global change in energy usage over the simulation horizon of the climate transition to meet GHG goals (eg. Net Zero by 2050). This will cover use of fossil fuels from coal, oil & gas. This will include modes of electricity generation for renewables and fossil plants.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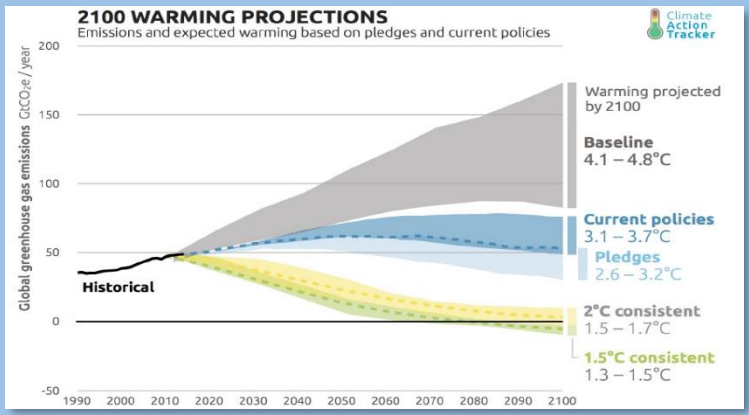
This model also needs to provide a use of energy across all economic sectors from residential energy use for heating and cooling and commercial buildings. The model should be able to describe both production methods and modes of consumption with genuine supply and demand balance in its product model. The underlying model framework must be able to give sensible economic predictions and forecasts of energy usage and integration with climate predictions. There are a number of ways this can be achieved through modelling, however for organisations that wish to put themselves on a path to provide detailed explainable scenario analysis would be best served using some of the Integrated Assessment Models (IAMs). These models have developed and utilised by universities and policy makers to help shape the future energy and emissions targets for example as part of the IPCC reports. Furthermore, the academic models have been subject to extensive peer review and hindcasting (the term used by IAM modellers for back testing). Using models that have not been extensively peer reviewed and subject to open scrutiny opens the increased likelihood of model risk and increased time and cost of model validation.




*A Model that can translate the implications of GHG pathways to tangible business insight is critical.*

## Model Should Capture Impact of Land and Water Resource Usage

As part of the need to build coherent scenarios the use of other natural resources should also be captured. Climate change will significantly impact water supplies for many countries having a significant impact on land usage and crop yields models that can anticipate potential land use will be needed to anticipate economic drivers for many countries where agriculture is a significant fraction of GDP. Furthermore, the ability to predict potential spikes in commodity prices & volatility across the world. This will play an important role in determining the frequency and severity of impacts around the world from crop yield reduction. This will be significant for estimating stress impacts from migration / conflicts. Coherent land and resource models would provide guidance to asset mangers on the relative impact each company may have compared to its peers.

*The ability to determine those regions of the world likely to be impacts by drought, flooding, crop failure will be important in understanding the wider scale national risks to each economy.*

Capturing and understanding these factors will play a significant role in quantifying an understanding sovereign level risk.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## Company Level Modelling

If the objective of the risk management (or from a front office perspective portfolio construction or loan approval) exercise is to capture the idiosyncratic risks for each company, the model applied needs to provide a sensible evolution for each company. ***Models that are not able to capture management actions such as changes in business capital expenditure or business strategies coupled with constraints on capital structure (eg. a simulated company arbitrarily raising capital based on macro-economic drivers) should be rejected as unrealistic***. Though it may not be possible to model all the attributes and revenue drivers for each company, those units that require significant capital costs to mitigate GHG emissions should be modelled. This would ensure that both their expenditure and importantly the environmental impact can be assessed over time to determine if a company is able to affect a transition.

- **Capture the impact of competition** in pricing driven from Carbon Tax Policy or emissions caps on expected earnings
- **Capture the impact via a stress analysis from customer value judgements** related to a company's environmental policies, companies that are regarded to be above the target average emitters
- The company framework needs to able to **capture the regional granularity of critical plant and machinery** and how this may be impacted in the event of an adverse weather hazard (Physical Risks).
- Ability to overlay **company specific stresses on revenue / earnings** as a model override, this can provide a means to assess the impact to adverse customer engagement with companies (lack of sales or **litigation**) if they fall short of relative / normative standards for environmental responsibility.

In terms of outputs that can be consumed by internal models (credit / market risk) the climate risk model should provide.

- Company impacts should be translated into impacts on **probabilities of default (PD)** and **loss given default (LGD)** for credit officers
- Estimate the values of a company's tradable securities including **equities, bonds and CDS**, this data should be made available for direct analysis or to be fed into existing credit / market risk engines.

To capture impacts at a company level will require specific analysis for each client

## Simulation Framework

The core of the simulation framework should consist of the following components.

- **Long term simulation** covering relevant exposures to 2050 and beyond to 2100. This would typically cover the duration of risks for most banks
- **Explainable Scenarios** – the ability to generate explainable forward simulated values across asset classes, covering equities, rates, FX, corporate and sovereign credit and commodities. This can be coupled with a detailed model of balance sheets for those companies classified as being more susceptible to transition risks.
    - **Facilitates Counterparty credit risk assessment**
    - **Potential Market Risk Scenarios**
- **Provide Input for Credit Models –** default scenarios under climate change risks may be significant for a large fraction of energy intensive companies, the scenario engine should provide estimates for probabilities of default (PD) and LGD estimates. The model could


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facilitate this in several ways providing raw input for models or be able to interface directly with internal rating models.
    - This input can be done for individual companies and assessments made at sectoral level. However, care must be taken for any aggregation model that cannot explain sectoral impacts carefully.
- **Provide Input for Market Risk Models –** Impacts from the stress analysis for abrupt onset scenarios can be relevant for market risk exposures.

*As an organisation's ability evolves understanding the size and extent to companies, properties and individuals will be crucial. Quant Foundry can help power your organisation onto the right pathway.*


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# About the Quant Foundry Climate Risk Solutions

Implementing climate risk measurement capabilities within an organisation is a monumental exercise and understanding where to start and what can be achieved realistically over what time frames given your starting point is not easy task either. Defining the goals of the business from the need to report on exposures to building an integrated risk solution to meet stress scenario construction and improved client advisory is only the start.

With the increasing desire for oversight from regulators for climate risk and increased demands from client's, organisations will need to justify investment and advisory choices and be able to defend the quantitative aspects of stress scenarios.

This will require an careful view of the long term investment into skills and capabilities in this space for a number of years, the urgency with which this needs to happen will transcend the normal time frames for regulatory change for most banks.

## The Steps in the Right Direction

Faced with the likely need to provide climate related stress testing on an ongoing basis for the foreseeable future from 2021 organisation that plan for the long-term solution makes sense.

### Step 1 - Classification and Exposure

With any new risk assessment defining how the risks may manifest themselves and hence your exposure is a starting point even if risks cannot be fully quantified or data and process are not fully formed. Our work on building a taxonomy of climate related risks will enable your organisation to identify items on your balance sheet that are exposed to climate linked risks. The taxonomy is coupled with our risk calculation capabilities providing coherence from the start of the process to whatever next steps you desire to take. Exposure in this case is linked to

The Exposure assessment exercise would be in the form of a consultation and assessments of exposures covering physical and transition risks to corporations, physical risks to mortgage portfolios, impacts to commercial real estate portfolios, exposures to climate linked sovereign risks.

This process of classification within the context of our robust quantitative capabilities provides a solid first step in the journey to building a best in class risk framework.

### Step 2 – Defining the Path to Risk and Opportunity Quantification

With a view of climate risk exposures across the organisation the next step is naturally to address these risks and adapt business strategies to identify opportunities, data, and capability gaps across the organisation. At this stage, many organisations will look to understand the costs of what can be achieved and timelines. Discussions across the organisation should start:

- **For the front office** on how to develop new client solutions and advisory, client management plans, new funding / loan structures and start the detailed understanding of how clients are going to address climate risks. For asset managers the ability to build and justify portfolios to address client requests and provide a clear motivation for your investment choices.
- **For risk teams** an understanding of their data and systems requirements driven by both the pressures from regulators and demands from customers as well as current existing


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capabilities from climate risk experts. This will lead to a clear path on how climate stress testing can be implemented within the organisation. Some organisations may in the first phase look to adopt a top down approach to stress scenario construction based on their current capabilities built for other regulatory stress testing programs (eg. CCAR, ECB, BoE etc). The need to have a clear and explainable causal explanation for each stress scenario is critical where historical data is missing (as is the case with climate linked stress scenarios).

For many organisations, the directions taken in Step 2 are critical, organisations looking to coherently integrate climate risk assessment across all their business lines will need to centralise and fix methodology design choices at this point.

The methodologies developed by Quant Foundry allow organisations to build coherent scenarios for global impacts of **transition** and **physical** direct risks around the world that include a direct link to GHG emissions embedded within the framework. These cover energy extractors (Coal, Oil & Gas), Utilities, Cement companies, heavy industry, transportation. It also covers the use of energy sources for commercial and residential properties a full description of the underlying model capabilities in included here[4]. This information is combined with a model to evolve impacts at individual company levels.

To address the challenged posed by physical risks we have partnered with XDI Systems who provide detailed property level risk analysis driven by detailed downscaled weather models combined with engineering structural models that allow a loss assessment for properties. This can provide direct forward-looking scenario impact analysis addressing mortgage portfolios but also corporate assets and provide a risk assessment and impact for critical infrastructure such as ports, road and rail links.

## Step 3 – Consolidation and Coherent Quantification of Climate Risks

Organisations that are looking to fully integrate climate risk assessments into their business models will need to engage the expertise across a wide range of disciplines utilising modelling techniques and methods that are not currently commonly used by financial organisations. For example models that incorporate the potential change in technologies, capital costs, expected revenues that can account for future business strategies that are coherently aligned with climate scenarios and can


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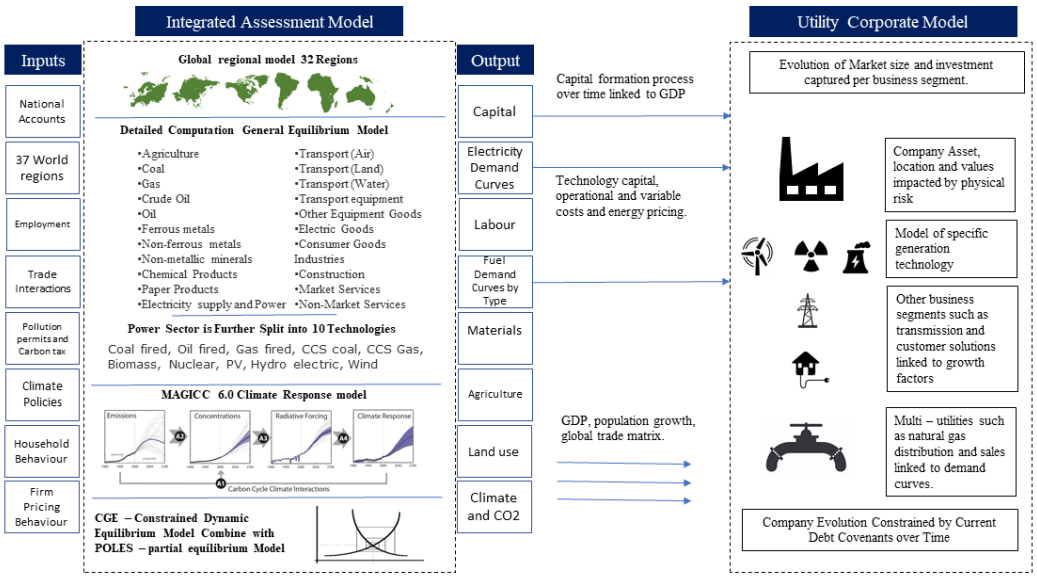


*Capturing the interplay of climate scenarios, GHG emissions, temperature changes and regional weather impacts to individual assets and global companies can be captured in our model framework.*

produce estimates of GHG emissions that are then coupled with models for physical risk do not currently exist within most organisations.

Quant Foundry's suite of modelling capabilities can provide your organisation with this capability along with world class expertise and understanding of climate risks and continuous involvement in research and development in this space. The model has been designed to permit a detailed description of the revenue generation capabilities and has been specifically designed to capture the impact of capital-intensive plant and machinery that companies may invest in to meet their climate targets.

The model uses a variety of economic factors across countries including GDP and population as well as sectoral output shares to predict demand for energy across a variety of sectors including residential, transport, industry, commercial, agriculture etc. It also utilises energy system data inputs.
This model drawn from research and development with the Quant Foundry team leverages models that have been developed for policy design (including the IPCC) provides a means to input government policy via levers such as carbon taxation and limits combined with detailed models for how companies would fair under competition going forward in time.

As a result, companies are encouraged to focus on capital expenditure that is designed to reduce GHG emissions. This may result in companies closing or making high carbon plant idle and to invest in new low carbon plant and technology to ensure targets are hit. Not to do so will result in significant negative financial consequences as well as investor and customer flight. Companies focused intelligently on the transitory journey will develop healthy revenue mixes and outperform those without an effective strategy.

Banks faced with making the decisions of which loans to grant, bonds to issue, equity financing deals to run etc., will need to be able to justify to their current and future customers why loan facilities may be limited or refused and develop a means to track the reasons for financing some companies to the


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stakeholders. The Quant Foundry model provides a clear impact view on both the financial risks and the GHG emissions for each company as it evolves over time.

## The Quant Foundry Climate Change Modelling Capability

The provider landscape is continually evolving as it stands there are only a few models in the commercial realm that provide the ability to make statements at a company level many of them do not factor in the rational management of companies going forward in time, this gives rise to unrealistic company exposures in time that nowhere near

QF has linked and customised a best in class Integrated Assessment model (that has been academically validated in hind casting studies and used as part of IPCC studies), this is then combined with a detailed model of the revenue generation capability for company's optimal transition path and thus measure the impact to their market capitalisation and credit rating. It also provides non-financial insight, such as technology mix.

The amalgamated model provides estimates of macro and micro-economic measures annually (macro and micro-economic pathways) between 2020 to 2050 (and beyond to 2100 if required) to meet CO2 emittance targets. Inputs include macro-economic information such as level of the carbon tax, energy demand, generation mix as well as micro-economic corporate financial information including revenue, EBIT, credit spread/rating, market cap, outstanding debt.

- The macroeconomic pathways project what the future economy is likely to look like and can be configured to provide views on GDP (or have updated views on GDP)
- whilst the microeconomic pathways provide insight into the performance of companies based on their ability to complete the necessary transition path a critical requirement on sell side.

Essentially, the model comprises of two principle components. The first being an overall CO2 emission allowance, set at a country / nation state level. Secondly, each company can then be allocated a specific allocation of that emission allowance. To survive and prosper, a company will need to meet or fall short of its allocation.

## For Asset Managers

With our detailed risk model and revenue forecasting model QF4CM has the ability to provide insights into the construction of a portfolio and can be used as part of an optimisation process across equities and bonds. As an understanding of the choices made by regional governments becomes clearer the impacts of those scenarios and how companies may be able to adapt will become clearer.

The QF4CM model has the power and insight to highlight those companies that can adapt efficiently versus those that may struggle. This will provide a powerful means to build and explain offering to clients, ranging from pure renewables to fast adapters. A solution such as this provides a way to accelerate an organisation in terms of expertise and capability to be competitive in an evolving marketplace.

## Future and Development Plans

In choosing a supplier of solutions one must look at the strength of their capability in proving genuine innovation in this space, do they have commitment to research and innovation, do they


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have the experience and knowledge quantitative skills to address the challenges of climate risks. Do they have the knowledge of the financial sector regulation and processes to address the complexity of implementation in your organisation?

At Quant Foundry we have a commitment to building cutting edge solutions built upon leading research. This is blended with years of experience in implementing solutions in banks and other financial institutions.

## About Quant Foundry and its Commitment to Building a Best In Class Climate Solution

Quant Foundry is a start-up company that provides quantitative modelling solutions and consulting services and has won awards for its innovative AI solutions to help mitigate climate impacts in agriculture.

Quant Foundry is committed to delivering and building a best in class climate solutions, led by its founder Chris Cormack(*) we are actively involved in research with a number of Universities around the world looking into new methods of addressing the risks of climate change and we have a commitment to publishing this research to allow people to gain an insight into the challenges of modelling these risks so that ideas can develop.

We have a team of quantitative modellers, analysts and consultants that can provide advice, implementation and customisation for your climate and other risk needs.

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** Dr Chris Cormack, co-founder of QF is a fellow of Imperial College's Centre for Climate Finance and Investment in the Business School. He is involved as part of work with the NGFS to build and design scenarios for central banks around the world. Quant Foundry is also a founder partner in CERAF the UK's new centre for climate risk modelling.*

**Authors**

**Dr Chris Cormack** is Co-Founder and Managing Director of Quant Foundry Ltd (and owner of the Quant Foundry Climate Model)


E: enquiries+climate@quantfoundry.com