Autorité
des marchés
financiers

Draft methodology for the 2024 Standardized Climate Scenario Exercise

Standardized Climate Scenario Exercise – draft for consultation

Date: April 11, 2024

1. Introduction

The Autorité des marchés financiers (the "AMF") is the body mandated by the Government of Québec to regulate Québec's financial markets and assist financial consumers. The AMF is unique in that it oversees, in an integrated manner, the areas of insurance, securities, derivatives, deposit institutions—other than banks—and the distribution of financial products and services, including mortgage brokerage and the activities of credit assessment agents. The AMF's mandate includes ensuring that financial institutions ("FIs") comply with Québec's legal, normative and regulatory requirements and that they carry out integrated risk management that is supported by strategies, policies and procedures that enable them to identify, assess, quantify, control, mitigate and carefully monitor material risks. It fulfills its mandate by focusing on the safety and soundness of FIs.

Climate-related risks, including physical and transition risks, could have significant impacts on the safety and soundness of FIs, and the broader Québec financial system. Building financial resilience against intensifying climate-related risks requires institutions to address their vulnerabilities in their business model, their overall operations, and ultimately on their balance sheet.

In November 2023, the AMF published the draft Climate Risk Management Guideline (CRMG) for consultation. The CRMG, which will come into effect in 2024, sets out the AMF's expectations for the management of climate-related risks. Section 3 describes the AMF's expectations with respect to climate scenario analysis.

This draft document describes the methodology for a Standardized Climate Scenario Exercise (SCSE). This exercise will enable the AMF to assess and compare the aggregate exposures of FIs to physical and transition risks. The SCSE is an analysis tool that is intended to supplement, but not substitute for, the analytical work that FIs will be required to conduct individually using their own methodology.

The AMF worked jointly with the Office of the Superintendent of Financial Institutions (OSFI) to develop the SCSE methodology. In the remainder of this document, the methodology described should be understood to be identical to the one published on the OSFI website, unless otherwise indicated.

This draft document describing the SCSE methodology reflects the feedback received by OSFI during the first part of its SCSE consultation. In addition to the SCSE methodology, the second part of the consultation includes a set of instructions and a workbook. The final version of these documents and a questionnaire will be published in the second half of 2024.

Comments regarding this SCSE consultation are welcome. Please note, however, that no major changes will be made to the following aspects of the SCSE methodology:

1. Industry sectoral and regional mapping (section 3.3.)
2. The expectations for geocoding and the geographical scope of physical risk exposure assessments (sections 5.4 and 5.5, respectively).

Participating FIs that wish to start working now toward their SCSE submission may begin mapping their exposures using the industry sectoral and regional classification for transition risks and geocoding and the geographical scope of physical risk exposure assessments.

The AMF has requested the participation in this first SCSE exercise of Québec-chartered FIs that have a significant impact on the Québec financial system ("Participating FIs"). It expects each of these institutions to submit a completed workbook and questionnaire.

The AMF wishes to thank its OSFI colleagues for the opportunity to work with them on this very important initiative and for generously sharing their expertise in assessing climate risks and their impacts on the Canadian financial system.

2. SCSE overview

Scenario analysis is a tool that can be used to measure the financial outcomes given different possible future states. Climate scenarios often refer to future states that reflect different possible climate policies and their associated physical impacts. Climate scenario analysis is often based on a set of forward-looking climate scenarios. However, the intent of these scenarios is not to predict the future. Climate scenario analysis exercises are intended to enable a better understanding of how different climate scenarios could impact financial market participants, including participating FIs, and the financial system.

The approach to developing the SCSE recognizes that climate scenario analysis is in its nascency. The SCSE is not associated with changing climate policies, nor is it intended to "size the risks" i.e., trying to arrive at a definitive, absolute quantitative impact of climate change or predict the future. Risk sizing is a complex and difficult undertaking given the uncertainty associated with climate scenario analysis. The underlying modelling that links climate risks to financial risks is relatively untested, and the second order impacts of climate change are highly complex. Therefore, instead of sizing the risks, the SCSE will focus on risk discrimination and exposure assessments. While absolute risks can be hard to measure, we believe that risk discrimination, i.e., identifying relative areas of higher risk, between counterparties, industries, and even FIs is achievable, even utilizing relatively less sophisticated approaches and modeling methodologies.

The SCSE aims to measure climate risks that are arguably not reflected using traditional risk quantification techniques, e.g., models that use historical experience to measure risks. The SCSE will consider characteristics associated with individual exposures that are not typically used in risk quantification today but may provide strong risk discrimination under future climate scenarios. The SCSE will not consider broad impacts of macroeconomic stresses since FIs' stress testing and capital requirements already consider the impact of a stressed macroeconomic environment.

2.1. Objectives

Three key objectives have been identified for the SCSE.

1. Raising awareness and encouraging a strategic orientation with FIs to better understand the potential exposures to climate change.

Climate risk quantification is a fast-developing field that is still in relatively early stages. Financial institutions and regulators in many jurisdictions are trying to better understand their exposure to climate risks through climate scenario analysis. The SCSE is designed as a starting point aiming to increase regulators' and FIs' understanding of the risks.

2. Encouraging the building of FIs' capacity to assess the impact of climate related catastrophic events and policies and to conduct climate scenario analysis exercises.

The exercise is designed to encourage participating FIs to design and develop the foundational infrastructures necessary to identify and quantify climate risk in their financial exposures in their future climate risk assessment exercises.

The SCSE will require FIs to identify in-scope exposures and map them to climate relevant sectors using NAICS codes and/or latitude-longitude coordinates (i.e., geocoding), according to the nature of the exposure. Furthermore, FIs with real estate exposures will be expected to identify additional relevant information related to climate risks, such as building energy and heating sources.

3. Establishing a standardized quantitative assessment of climate related risks, both transitional and physical in nature.

The motivation to issue a **standardized** climate scenario exercise comes from the lessons learned from the 2021 Bank of Canada/OSFI Pilot Project "Using Scenario Analysis to Assess Climate Transition Risk". A key finding from the exercise was that climate risk assessments from the participating financial institutions varied greatly, despite the guidance that was provided. This made it challenging to compare the results between FIs.

A comprehensive sizing of climate risks is not an objective of the SCSE.

The SCSE is a foundational step; it is the first climate scenario analysis issued to FIs by their regulator and its results will be used to define future exercises. It is limited in scope across several dimensions, recognizing that climate scenario analysis will continue to evolve over many years. For example, the transition risk modules estimate climate risks at the industry sector level, ignoring the underlying distributions of climate risks for exposures within the same sector. The SCSE primarily considers direct impacts of climate risks, while indirect impacts, such as business interruptions, may pose even larger risks to FIs' exposures. These limitations constrain the SCSE, such that sizing the risks from the results would likely be an underestimation.

2.2. Overview of exercise

2.2.1 Operational approach

Different components of climate scenario analysis could be classified as "Top-down" or "Bottom-up", depending on their design and implementation. Top-down scenario analysis is generally performed by a public authority using its own climate scenario analysis framework and the scenario narratives are translated into projections for high-level risk drivers. Bottom-up scenario analysis is generally performed by a financial institution using their own internal risk assessments to determine the impact of scenario narratives.

The SCSE will be implemented using a hybrid approach, as described in Figure 1.

Figure 1: Operational approach

Top-down	Bottom-up
The regulator will define and develop the 2024 SCSE Methodology, scenarios, adjustment parameters, and calculations.	FIs will identify exposures, classify them into relevant sectoral and geographical segments, and perform calculations.

1. The regulator develops the SCSE Methodology
2. The regulator prescribes scenarios, risk parameters, formulas, etc. to FIs
3. FIs assess impacts to their exposures using prescribed information from the regulator.

2.2.2 Scope of the SCSE

The SCSE includes four separate modules and a questionnaire. The modules are generally independent of each other and the SCSE does not consider how risks measured in each module may overlap or correlate. For example, the SCSE does not consider how physical risks may be impacted by different climate transition scenarios.

Figure 2: SCSE modules

SCSE modules

Scope	Climate Risk	Exposures	Financial Risk
Impact of Climate Transition on Credit Risks for Commercial Exposures	Transition Risk	Commercial (Global)	Credit Risk
Impact of Climate Transition on Market Risk for Commercial Exposures	Transition Risk	Commercial (Global)	Market Risk
Climate Transition Real Estate Exposure Assessments	Transition Risk	Real Estate-related (Canadian)	Exposure Assessment
Physical Risk Exposure Assessments	Physical Risks	Real Estate-related (Canadian)	Exposure Assessment

2.3 Reporting SCSE results

The regulators plan to finalize the SCSE Methodology, SCSE Workbook, associated SCSE Instructions, supporting data, and questionnaire later in 2024, taking into consideration the feedback received from parts I and II of the consultation on the SCSE.

All participating FIs will be required to complete the SCSE Workbook and questionnaire according to the associated instructions and using the supporting data. We will encourage FIs to complete an additional copy of the SCSE Workbook, or a subset of it, using their own approaches, models, and data, if they believe the SCSE does not adequately capture their specific climate risks.

2.3.1 Scope of consolidation

The SCSE shall be completed on a consolidated basis, up to the financial sector level, i.e., deposit taking institutions, life insurance companies, P&C insurance companies.

2.3.2 Contact Information

FIs will be provided with or granted access to several datasets in order to complete the SCSE. To enable this, FIs are asked to complete the Identification worksheet from the SCSE Workbook and submit it as a standalone document to ScenarioClimatique@lautorite.qc.ca by **May 3, 2024**. We will either provide datasets to FIs using submitted email addresses or provide details where FIs can acquire datasets directly.

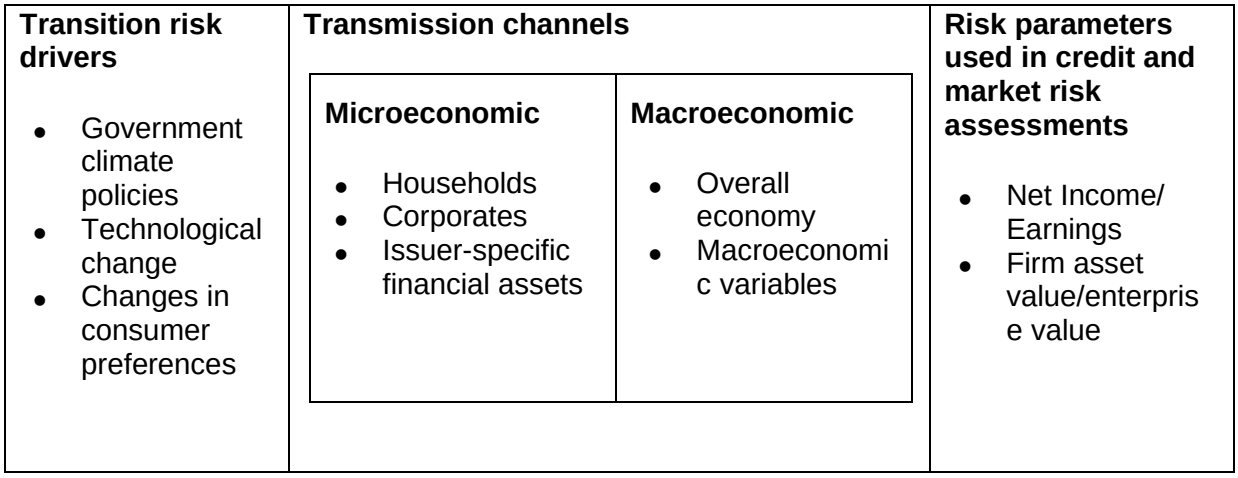
3. Climate transition risk for commercial exposures

Climate transition scenarios may translate into financial losses for FIs through multiple transmission channels. Economic transmission channels explain how the underlying climate risk drivers may transform climate transition uncertainty into tangible risk parameters priceable by financial markets. The underlying risk drivers and risk parameters establish the link between how the transition climate scenarios translate into financial losses by negatively impacting the value of and/or likelihoods of default of investments and assets held by the FIs. Climate transition risk drivers stem from at least three different sources:

1. Policy changes to adapt the economy to a low-carbon setup (e.g., stringent carbon-pricing policies to limit emissions, stricter energy efficiency standards);
2. Technological changes (e.g., the introduction of more competitive low-carbon technologies);
3. Changes in consumer preferences (e.g., environmentally concerned consumers tilting their decisions towards sustainable products).

Each of these sources could impact the underlying risk parameters that typically drive credit and market risk assessments. Transition risk affects corporate, firm-specific financial assets, and the overall economy through its impact on macroeconomic parameters such as GDP, interest rates, and inflation. Figure 3 presents an illustration of transition risk channels.

Figure 3: Transition risk transmission channels



There are two modules related to transition risk for commercial exposures in the SCSE: one covering credit risk, and one covering market risk. Sections 3.1, 3.2, and 3.3 of the SCSE Methodology apply to both modules, Section 3.4 applies to credit risk, and Section 3.5 applies to market risk.

Both modules related to transition risk for commercial exposures build upon the Bank of Canada/OSFI 2021 Pilot Project and will be generally consistent with its approaches and methodologies.

3.1 Balance sheet assumptions

Climate scenario analysis requires FIs to project future balance sheets. These projections can be described as “dynamic” or “static”. The SCSE will use a static balance sheet approach for the transition risk modules of the SCSE. Specifically:

1. Balance sheets at 5-year intervals from 2030 – 2050 will be assumed to be identical to balance sheets as of Q4 2023.
2. For each 5-year interval, FIs will perform forward-looking calculations that assume the balance sheet runs-off.

The SCSE Instructions include illustrative examples of how credit risk factors are applied using a Q4 2023 static balance sheet and forward-looking calculations for the credit risk module. The SCSE Instructions also include illustrative examples of how market risk shocks are applied using a static balance sheet assumption for the market risk module.

Q4 2023 has been selected as the snapshot for this module, and the SCSE generally, given that it is the first year-end that some FIs will report under IFRS 9.

Assuming balance sheets are static is a limitation of the SCSE. Real balance sheets are dynamic and reflect FIs evolving views of risks. However, dynamic balance sheets introduce significant complexity that does not align with the foundational nature of the SCSE.

3.2 Transition scenarios

Scenario analysis typically begins with identifying a set of hypothetical future scenario narratives and a set of macroeconomic and financial variable projections that capture the quantitative impact of these scenarios. The broad scenario narratives and assumptions for the two transition risk modules are discussed in the following section.

3.2.1 Selected scenarios and narratives

The transition risk modules will consider three different scenario narratives, each of which captures different degrees of transition risks.

1. **Below 2℃ immediate** - an immediate policy action toward limiting average global warming to below 2℃ by 2100.
2. **Below 2℃ delayed** - a delayed policy action toward limiting average global warming to below 2℃ by 2100.
3. **Net-zero 2050 (1.5℃)** - a more ambitious immediate policy action scenario to limit average global warming to 1.5℃ by 2100 that includes current net-zero commitments by some countries.

The three scenario narratives will be benchmarked against a baseline scenario which is defined in Sections 3.4 and 3.5 for credit and market risk respectively.

Both the **Below 2℃ immediate** and **Net-zero 2050** scenarios assume that climate policies are introduced early and gradually become more stringent. For the **Net-zero 2050** scenario, global warming is limited to 1.5℃ through stringent climate policies and technological innovation, with net-zero carbon emissions reached in around 2050. The smooth and gradual nature of the transitions in these two scenarios ensures that the costs resulting from the energy transition are minimized.

The **Below 2℃ delayed** scenario considers the greater transition risk associated with delays in policy action. The key underlying assumption is that no new climate policies are introduced until 2030, and strong policy actions are then needed to limit warming to below 2℃ by 2100 and to compensate for lost time which leads to higher transition risks.

In addition to transition risks, the three transition scenarios may also reflect different degrees of physical risks. Acting early, which is reflected in the two immediate policy action scenarios, may help mitigate future increases in physical risks compared to delayed policy action. However, the risk factors that will be prescribed for credit and market risk will only consider the impact of transition risk and abstract from any physical risk impacts.

The **Below 2℃ immediate**, **Below 2℃ delayed** and **Net-zero 2050** scenarios will be benchmarked against a baseline scenario. To develop the risk factors, the regulator benchmarked these scenarios against a current policy scenario, which is the baseline scenario consistent with global climate policies currently in place. The SCSE will not require FIs to work directly with climate scenarios; instead, FIs will apply the prescribed risk factors to their own baseline assessments. More details are provided in Section 3.4 and Section 3.5.

3.2.2 Scenario data sources

The three transition scenario narratives vary in terms of policy ambition and climate target and therefore the values differ for a range of metrics such as carbon price and GDP. These values will also vary for different implementations of these scenario narratives. Given the uncertainty associated with climate scenario analysis, the SCSE transition risk factors are developed using two implementations of these scenario narratives. Both implementations of the scenario narratives provide a 30-year scenario time horizon, and therefore the transition risk modules of the SCSE will also consider a 30-year time horizon.

1. We have used scenario data developed by the Network for the Greening of the Financial System (NGFS), the international standard setter for climate scenario data, specifically NGFS Phase III scenarios.
2. We have also used scenario data developed by the Bank of Canada (BoC), and customized to the Canadian economy. This data is similar to the climate transition scenario data made available as part of the reporting of the 2021 climate scenario analysis pilot, but with updated values.

These datasets contain different levels of information, but neither include the level of information to be provided to FIs, i.e., financial risk factors.

Figure 4: Data sources

Level of information included in different scenario data sources

Data sources	NGFS scenarios	Bank of Canada scenarios	SCSE
Climate scenario data, e.g., carbon prices	included	included	included
Sectoral impacts, e.g., net incomes	not included	included	included

Level of information included in different scenario data sources

Data sources	NGFS scenarios	Bank of Canada scenarios	SCSE
Financial risk impacts, e.g., sectoral credit risk adjustments, sectoral changes in credit spreads, etc.	not included	not included	included

Both modules related to transition risk for commercial exposures build upon the Bank of Canada/OSFI 2021 Pilot Project and will be generally consistent with its approaches and methodologies.

There are other differences between the two sources of scenario data:

Modeling techniques and macroeconomic models

- The Bank of Canada scenario data use a suite of models – an Emissions Policy Prediction and Analysis model from the Massachusetts Institute of Technology (MIT-EPPA) and two macroeconomic general equilibrium models that produce realistic macroeconomic outputs considering the possible transition risks.
- The NGFS scenarios also use a suite of models approach, but with a different set of models, specifically, three integrated assessment models (IAM); GCAM (Global Change Analysis Model), REMIND (Regional Model of Investments and Development), and MESSAGE (Model for Energy Supply Strategy Alternatives and their General Environmental Impact). These IAMs produce transition pathways and are used in combination with NiGEM (National Institute Global Econometric Model), a macroeconomic model that generates macro-financial variables corresponding to each IAM. We considered all three IAMs and their NiGEM outputs and concluded GCAM was the most appropriate for capturing Canada's macroeconomic environment as a unique geography within North America. However, GCAM is a partial equilibrium model which may under-estimate macroeconomic impacts of the transition, possibly materially. This limitation may be mitigated by the complementary use of the Bank of Canada scenario data.

Sectoral granularity

- The Bank of Canada climate transition scenario data is segmented into ten climate relevant sectors. However, the impacts of the climate transition may vary within a given sector, e.g., air transportation may be impacted differently than rail transportation. The latter limitation may be mitigated by the complementary use of the NGFS scenario data.
- The NGFS – GCAM IAM offers flexibility in defining sectors and we have developed a classification methodology for the SCSE which is discussed in the following section.

To develop the macro-financial risk factors for the three transition scenarios, we will leverage BoC scenarios and data from Moody's Analytics which is based on the NGFS-GCAM sectoral transition pathways. This will address model uncertainty to some degree while also allowing us to draw robust insights across different models. FIs will use the resulting risk factors which will be prescribed for the three transition scenarios referenced in Section 3.2.1.

3.3 Industry sector and regional sector classification

Industry sector classification is a critical aspect the SCSE used to measure impacts of climate transition scenarios on financial risks. While a counterparty-level analysis may yield more accurate results, a sectoral approach avoids data challenges associated with the lack of reliable Greenhouse gas (GHG) emission data by using industry classification as a proxy to assess the impact of different climate scenarios. A sectoral approach also allows the SCSE to consider transition risks for counterparties that may not be high GHG emitters themselves, for example, GHG emissions produced up and down the value chain of a company, known as scope 3 emissions, could be considered using a sectoral approach.

3.3.1 Industry sectors

For the transition risk modules, we identified 25 industry sectors for which financial risk factors/formulas will be provided. The financial risk factors and formulas are discussed in the credit and market risk modules.

Electricity Production • Electricity Production from Renewable Sources and Nuclear • Electricity Support and Distribution • Fossil Fuel Electricity Production • Hydro Electricity Production	**Energy Intensive Industries** • Manufacturing • Mining • Paper and Pulp • Water, Sewage System, and Waste Management	**Fossil Fuels** • Coal Industry and Support • Fossil Fuel Refinery • Natural Gas Industry and Support • Oil Extraction • Oil Extraction Support • Sand Oil Extraction and Support
Transportation • Air Transportation • Rail Transportation • Other Transportation	**Agriculture and Forestry** • Crop Production and Support • Livestock Production and Support • Forestry and Support	**Other Sectors** • Finance and Insurance • Food and Beverage Industry and Support • Real Estate • Service Sectors • Other Industries

3.3.2 Industry sectoral mapping

A comprehensive mapping of the North American Industry Classification System (NAICS) 2022 Version 1.0 codes (for both Canadian and US systems) into industry sectors is included in the SCSE Instructions. FIs will identify and classify in-scope exposures of the credit and market risk modules into industry sectors (see Sections 3.4 and 3.5).

We encourage FIs to use the NAICS to SCSE industry sector mapping. However, FIs that map exposures using other industry sector systems will be permitted to create their own mapping to SCSE industry sectors provided that this mapping is sufficiently granular to capture the SCSE industry sectors. FIs who choose this approach will be expected to include their mapping with their SCSE submission.

We will not provide prescriptive implementation instructions on how FIs will map individual counterparties to NAICS codes. FIs are expected to establish a common set of principles and rules to assign NAICS codes consistently for all counterparties, including counterparties that are active in multiple industry sectors. These assignments should be consistent, replicable and FIs should be able to explain and justify the principles and judgements of their designed mapping methodology.

3.3.3 Regional mapping

We have included a regional classification in the SCSE Instructions. FIs will be expected to identify and classify in-scope exposures of the credit and market risk modules into these regions. This mapping is designed to capture the applicable narrative of transition scenarios for each region.

We will not provide prescriptive implementation instructions on how FIs will map individual counterparties to these regions. FIs are expected to establish a common set of principles and rules to assign regional affiliation for all counterparties, including counterparties that are active in multiple regions. These assignments should be consistent, replicable, and FIs should be able to explain and justify the principles and judgements of their designed mapping methodology.

In the absence of detailed data, FIs could rely on proxy data (such as the location of a counterparty's headquarters). FIs will be expected to explain the use of any such proxies.

The regional sectors are:

- Canada
- United States
- South America, Central America, and the Caribbean
- Advanced European economies
- Rest of Europe
- Advanced Asian and Oceanic Economies
- Rest of Asian and Oceanic Economies
- Middle East
- Africa

For this classification, we benefited from the classification of economies published by IMF. The mapping was also extended to the complete list of countries and territories using ISO 3166 country codes which is included in the SCSE Instructions.

3.4 Credit risk

Credit losses associated with exposures such as commercial loans and corporate bonds could be significantly higher under certain climate transition scenarios. Climate policies in different jurisdictions may lead to revaluations of assets, increased production costs, and liquidity stresses. These impacts may lead to increased Probability of Defaults (PD) and Loss Given Default (LGD) for some participants in the economy, which could negatively affect FIs' exposures through increased expected credit losses.

In the credit risk module, the regulator aims to measure the impact of different climate scenarios through their implications for the Expected Credit Loss (ECL) of the participants of the exercise. Conventionally, ECL is modelled through assessing PD, LGD, as well as Exposure at Default (EAD). Baseline and climate adjusted ECL calculations will leverage the International Financial Report Standard (IFRS) 9 ECL accounting framework. Climate adjusted ECLs will be estimated by adjusting PD and LGD components based on different climate scenarios. This methodology is described in further detail in the rest of this section.

3.4.1 Scope and classification of exposures

Exposures are in scope for the credit risk module if they satisfy the following three conditions:

1) the exposure is a corporate bond, preferred share, or corporate and commercial lending exposure that falls under the scope of IFRS 9 expected credit loss accounting standard;
2) the exposure is not part of the trading book or measured at fair value through profit or loss (FVTPL);
3) the value of the exposure, as of Q4 2023, exceeds an absolute threshold of CAD $1.5 million.

The credit risk module results will be aggregated by asset classes in the SCSE Workbook. The credit risk adjustments defined in this section of the methodology do not vary by asset class, however, they do vary by industry sector, regional sector, and credit quality bucket (defined in Section 3.4.3) and are also aggregated by these dimensions.

Figure 5: Asset classes for credit risk

SCSE Asset Class	Deposit Taking Institutions (DTIs)	Insurers
Corporate bonds	Public and private corporate bonds that are part of the banking book	Corporate bonds that are accounted as Fair Value through Other Comprehensive Income (FVOCI) and Amortized Cost
Preferred shares	Preferred shares that are part of the banking book and fall under IFRS 9 ECL	Preferred shares that are accounted as Fair Value through Other Comprehensive Income and Amortized Cost
Corporate and commercial lending exposures	Corporate and commercial lending exposures that are part of the banking book, such as loans and lease receivables,	Corporate and commercial lending exposures such as non-residential mortgage loans that are accounted as Fair Value through Other Comprehensive Income and Amortized cost

3.4.2 Baseline ECL

The baseline ECL ($baseECL$) for a given exposure is its lifetime ECL, calculated using a set of forward-looking macroeconomic scenarios as per IFRS 9. The baseline ECL is not calculated using a single FI-specific baseline scenario. The baseline ECL for each exposure is calculated based on the following formula:

$$baselineECL = \sum_{k=1}^{m} w_k \sum_{i=1}^{n} PD_i^k \times LGD_i^k \times EAD_i^k \times \frac{1}{(1+r)^i}$$

where for each ECL scenario k:

- w_k is the weight of the ECL scenario k
- PD_i^k, LGD_i^k, and EAD_i^k are the respective PD, LGD and EAD of the exposure for year i
- r is the discount rate
- m is the number of underlying ECL scenarios
- n is the remaining maturity of the exposure[1] in years.

Lifetime ECLs are to be calculated for all exposures that are in scope, i.e., the SCSE ignores the 'staging' mechanism in IFRS 9 ECL calculations.

ECL formulas are presented on an annualized basis for simplicity.

3.4.3 Credit quality buckets

The 'credit quality bucket' for a given exposure is determined based on its 'credit quality PD' (PD_{CQ}). Credit quality PD represents the weighted average of all the annualized projected baseline PDs for the underlying exposure at year 2024 for all the ECL macroeconomic scenarios, given by the following formula:

$$PD_{CQ} = \sum_{k=1}^{m} w_k \, PD_{i=1}^k$$

where for each ECL scenario k:

- w_k is the weight of the ECL scenario k
- $PD_{i=1}^k$ is the initial PD of the exposure for year $i = 1$.
- m is the number of underlying ECL scenarios.

The credit quality bucket given an exposure's PD_{CQ} is determined as shown in the following table.

[1] As mentioned above, the labeling "baseline" in front of PD and LGD is compared to climate adjusted PD and LGD and is not related to the ECL baseline scenarios used by FIs in calculating their scenario weighted IFRS 9 ECL estimations.

Figure 6: Credit Quality Buckets

SCSE Credit Quality Bucket	Credit Quality PD (PD_{CQ}) Range
1	$0.00\% \leq PD_{CQ} < 0.07\%$
2	$0.07\% \leq PD_{CQ} < 0.25\%$
3	$0.25\% \leq PD_{CQ} < 1.00\%$
4	$1.00\% \leq PD_{CQ} < 7.00\%$
5	$7.00\% \leq PD_{CQ} < 20.00\%$
6	$20.00\% \leq PD_{CQ} < 100.00\%$

The credit quality bucket calculation is included in the illustrative example in the SCSE Instructions. As mentioned above, the purpose of the credit quality classification is solely to define appropriate climate PD adjustments for different initial PD values and is not a measurement of creditworthiness of underlying assets.

3.4.4 Climate adjusted ECL

The climate adjusted ECL ($climateECL$) is calculated the same way as the baseline ECL, but with PDs and LGDs replaced by climate adjusted PDs and climate adjusted LGDs.

The formula for the climate adjusted ECL for snapshot T is as follows:

$$climateECL_T = \sum_{k=1}^{m} w_k \sum_{i=1}^{n} climatePD_{T,i}^{k} \times climateLGD_{T,i}^{k} \times EAD_i^k \times \frac{1}{(1+r)^i}$$

Where $climatePD_{T,i}^{k}$ and $climateLGD_{T,i}^{k}$ are the respective climate adjusted PD and LGD estimates for the combination of years T, i for the ECL scenario k. These adjustments are further discussed in the subsequent sections. The EAD parameter is agnostic to climate scenarios. The SCSE Instructions contain an example showing forward-looking ECL calculations at T for a hypothetical exposure.

The difference between climate adjusted ECL and baseline ECL, i.e.,

$$\Delta ECL_T := climateECL_T - baselineECL$$

can be interpreted as the impact of the underlying climate scenario measured through the change of the expected credit loss of the in-scope exposures at T within the horizon of the exercise.

Both climate adjusted and baseline ECL calculations are repeated at 5-year time steps throughout the scenario projection horizon, i.e., T is selected from 2030, 2035, … , 2050 for each of the climate scenarios discussed in Section 3.2.1.

Climate adjusted PD

We will prescribe climate PD add-ons ($climateAdd - on$) to calculate climate transition adjusted PDs. For each scenario narrative and year, PD add-ons will vary across the following exposure characteristics:

- regional sector
- industry sector
- credit quality bucket

For each exposure and to calculate the climate adjusted ECL at time T, climate adjusted PDs are calculated using the following formula:

$$climatePD_{T,i}^{k} = \frac{1}{1 + \exp\left(-(logit\left(PD_{i}^{k}\right) + climateAdd - on_{T,i})\right)}$$

Where:

- PD_i^k denotes the FIs' internally estimated PD for the underlying exposure year i and the ECL scenario k
- $climateAdd - on_{T,i}$ is the climate PD add-on prescribed for the underlying exposure, based on the characteristics of the exposure, for the combination of years T, i and for a given climate scenario
- $logit(t) = \ln\left(\frac{t}{1-t}\right)$

We will provide climate PD add-ons on an annual basis. FIs that calculate ECLs using monthly or quarterly time steps can assume that a climate PD add-on for a given year is constant for the entire year.

Climate PD Add-ons under the three transition scenarios **Below 2℃ immediate**, **Below 2℃ delayed,** and **Net-zero 2050** will be prescribed (see Section 3.2.1 for further description of the scenarios). If an asset's forwarded lifetime extends beyond the interval of provided climate PD add-ons, the climate PD add-on for the last available year can be applied for the remaining lifetime of the asset.

Climate adjusted LGD

Similarly to the Bank of Canada/OSFI Pilot Project, climate adjusted LGD ($climateLGD$) is calculated using the Frye-Jacobs relationship[2] which provides a single-parameter, generic relationship between PD and LGD. Climate adjusted LGDs are calculated using the following formula:

[2] For a description of the methodology, see J. Frye and M. Jacobs, "Credit Loss and Systemic LGD," Journal of Credit Risk 8, no. 1 (Spring 2012): 109–140.

$$climateLGD_{T,i}^{k} = \frac{\phi\left[\phi^{-1}\left(climatePD_{T,i}^{k}\right) - \phi^{-1}\left(PD_{i}^{k}\right) + \phi^{-1}\left(PD_{i}^{k} \times LGD_{i}^{k}\right)\right]}{climatePD_{T,i}^{k}}$$

Where ϕ represents the cumulative distribution function of the standard normal distribution, and ϕ^{-1} represents the inverse of the same function. We assume the climate adjusted expected PD and LGD ($climatePD$ and $climateLGD$) obey a comonotonic Vasicek Distribution with no correlation between distinct exposures.

3.5 Market risk

Climate transition risk could significantly impact the value of financial assets such as stocks and bonds. As countries implement climate policies to reduce their overall emissions, the resulting transition risk drivers such as changes in policy, technology, and adjustments in general consumption patterns are expected to impact asset market valuations. Investors in financial markets could demand higher risk premiums for investing in assets of firms that are particularly vulnerable to economic consequences of transition risk, such as the emission intensive firms.

While markets might already be pricing in climate-transition risks, for example, by demanding higher credit spreads on bonds issued by firms that have high carbon footprints and might face potential regulatory costs, there is not enough empirical evidence to confirm that climate risk is being adequately priced in. It is currently unclear if, how, and to what extent markets account for climate risks when determining the market value of a financial asset[3]. Furthermore, the unprecedented elevation of climate risk and the opacity of climate-vulnerable exposures make asset mispricing and downside risks of asset price shocks particularly relevant. This warrants further investigation and assessment of market risks for FIs.

The market risk modules, therefore, aim to assess the impact of different transition scenarios on FIs' market risks by evaluating the changes in the market value of assets in the three transition scenarios. Changes will be measured relative to a baseline scenario. The market risk modules use "current policies" as the baseline scenario, given that market valuations may already reflect the impact of climate transition policies that are currently in place. The NGFS defines current policies as a scenario where no new climate policies are implemented and the market risk factors that will be prescribed by the regulator will only consider the transition risk impacts and abstract from any direct impacts of physical risk.

The market risk modules will only focus on equity risk and interest rate risk (for interest rate sensitive assets in scope). The modules do not explore other types of market risks such as foreign exchange risk, changes in the market value of properties, right-of-use assets, equipment, etc. Thus, for any assets that are denominated in a foreign currency, the impact of fluctuations in exchange rates is not in scope.

3.5.1 Scope of exposures

Only FIs with more than $25 billion in total assets as of Q4 2023 are required to complete market risk modules. We encourage FIs that have significant exposures in scope for these modules to complete them even if their total assets are less than the above-indicated threshold.

[3] See Bank for International Settlements, "Climate-related risk drivers and their transmission channels," April 2021.

The two broad asset classes that are in scope for the market risk modules are equities and corporate bonds. Only assets that are part of a FI's trading book or accounted as fair value through profit and loss (FVTPL) are in scope for the market risk modules.

In addition to equity and corporate bond assets, exposures to equities and corporate bonds in pooled funds are also in scope for both DTIs and insurers:

- Any equities and corporate bonds in pooled funds such as mutual funds, exchange-traded funds, etc.
- For life insurers, any to equities and corporate bonds under segregated fund assets and index-linked products are in scope. Life insurers are only required to assess the impact on the market value of the underlying assets, not the segregated fund liabilities.

Underlying exposures of equities and corporate bonds in a pooled fund are determined based on the percentage allocation of the underlying exposures in the pooled fund. The risk factors prescribed by the regulator can be applied to the underlying exposure amounts given their industry sector and region. Any investments in the fund that correspond to any assets other than equities and corporate bonds are out of scope.

The following assets are not in scope for both DTIs and insurers:

- Equities and corporate bonds that are part of a DTI's banking book or accounted as fair value through other comprehensive income or at amortized cost
- Any sovereign, non-sovereign government, quasi-government, or supranational bonds
- Any equity or bond allocations to pension plan assets
- Securitized assets such as covered bonds and asset backed securities
- Any asset that falls under the alternative asset class such as private equity, hedge funds, infrastructure, commodities, directly held real estate
- Liabilities are not in scope - the impact of interest rate changes on liabilities will not be assessed
- Fair value hedges in trading book and Fair value hedges that are used to hedge any in-scope FVTPL assets can be included as an optional analysis.

FIs may provide the regulator an additional completed SCSE workbook that incorporates fair value hedges.

The two market risk modules are described in Sections 3.5.2 and 3.5.3.

3.5.2 Market risk for common shares

The methodology described in this section applies to publicly listed common shares in the trading book or accounted as FVTPL as well as underlying publicly listed common shares in pooled assets such as mutual funds or segregated fund assets.

The regulator will prescribe paths for equity prices for a baseline scenario ($baselineEquityIndex$) and instantaneous percentage equity shocks for the three transition scenarios ($EquityShock$) to be applied to equity holdings.

Equity paths in the baseline scenario and equity shocks in the three transition scenarios will be prescribed for each reporting snapshot T ($T = 2030, 2035, \ldots, 2050$). Within each year, baseline equity paths and equity shocks for three transition scenarios will vary across the following exposure characteristics:

- regional sector
- industry sector

For each region, baseline equity paths will be prescribed as an index with 2023 as the base year and instantaneous equity shocks will be prescribed for the region as a whole and for different industry sectors within the region.

For each equity exposure, given the region and industry sector, and for each reporting snapshot of time T in the scenario horizon FIs will estimate the projected baseline market value ($baselineMarketValue$) of the equity exposure as follows:

$$baselineMarketValue_T = EquityExposure_{Q42023} \times baselineEquityIndex_T$$

Where:

- $EquityExposure_{Q42023}$ is the market value of the equity exposure as of Q4 2023
- $baselineEquityIndex_T$ is the baseline equity index value at time T

For each transition scenario, FIs will then assess the changes in market value ($\Delta MarketValue$) using the equity shocks prescribed by the regulator, based on the following formula:

$$\Delta MarketValue_T = baselineMarketValue_T \text{ x } EquityShock_T$$

Where:

- $baselineMarketValue_T$ is the baseline market value of the exposure at time T
- $EquityShock_T$ is the regulator-prescribed instantaneous percentage equity shock at time T for the underlying exposure in a given transition scenario, relative to the baseline scenario, based on the characteristics of the exposure

3.5.3 Market risk for corporate bonds and preferred shares

The methodology described in this section applies to public and private corporate bonds and preferred shares that are part of the trading book or accounted as FVTPL as well as underlying corporate bonds and preferred shares in pooled assets such as mutual funds or segregated fund assets.

The impact on corporate bond and preferred share exposures will be assessed through two key parameters; corporate credit spread shocks, and changes in 10-year government bond yields as the "risk-free" rate. Projected changes in 10-year government bond yields will be used as a proxy for the change in risk-free rates at all maturities. FIs will estimate the change in market values under the three transition scenarios (relative to the baseline scenario i.e., current policies), based on these two parameters.

The regulator will prescribe the annual shocks to 10-year risk-free rates. The shocks will vary by climate scenario narrative and year. For each transition scenario narrative and year, shocks will be prescribed relative to the baseline and will vary across different regions.

For corporate credit spreads, the regulator will provide guidance to FIs on how to derive the credit spread shocks based on financial market traded credit spreads and changes in PD in Section 3.4.4

The rest of this section describes the process for FIs to derive instantaneous shocks to corporate credit spreads.

Deriving baseline and climate PD ratings

For each in-scope exposure, FIs will determine a baseline PD as of Q4 2023, e.g., by mapping to a PD using the rating of the exposure. Subsequently, following the methodology described in Section 3.4.4, for each year i, the baseline PD will be adjusted to generate the climate adjusted PD ($climatePD_i$) using the climate PD adjustment prescribed in Section 3.4.4, based on the following formula:

$$climatePD_t = \frac{1}{1 + exp\ (-(logit(PD)\ +\ climateAdd - on_{t,0}))}, \quad t = 2030, 2035, \dots, 2050$$

$$climatePD_i = climatePD_t \qquad for \qquad t \le i < t + 5$$

The climate adjusted PDs will vary by climate scenario narrative and year. For each scenario narrative and year, climate adjusted PDs will be calculated relative to the baseline PD and will vary across the following exposure characteristics:

- regional sector
- industry sector
- credit quality bucket

If a reporting snapshot T extends beyond the interval of provided climate PD add-ons, the climate PD add-on for the last available year can be applied for the remaining years.

For each year i, FIs will then assign a climate PD rating to the exposure based on the climate adjusted PDs, using their internal risk rating grade.

Deriving climate credit spreads

Step 1: For each exposure given its region, sector and maturity, FIs will determine the credit spreads for the baseline ($baselineCS$) and transition scenarios ($climateCS$), for each year i in the horizon of the exercise, based on the baseline and climate PD ratings for each year i discussed in the previous step by using their internal mapping of financial market traded credit spreads.

$$baseline\ PD\ rating\ \rightarrow\ baselineCS$$

$$climate\ PD\ rating\ for\ year\ i\ \rightarrow\ climateCS_i$$

Step 2: Subsequently for each year i, the annual credit spread shock (ΔCS) will be calculated as the difference between the credit spread in the transition and the baseline scenarios:

$$\Delta CS_i = climateCS_i - baselineCS$$

Step 3: For each snapshot T (T = 2030, 2035, …., 2050) assuming n years until maturity of the exposure, FIs will estimate the maximum ($\Delta CS_{max,(T,T+n)}$) and minimum $(\Delta CS_{min,(T,T+n)})$ credit spread shocks starting at time T until the maturity of the bond (year $T+n$) as follows:

$$\Delta CS_{max,(T,T+n)} = \max_{T \le i < T+n} \{\Delta CS_i, 0\}$$

$$\Delta CS_{min,(T,T+n)} = \min_{T \le i < T+n} \{\Delta CS_i, 0\}$$

Step 4: Subsequently for each snapshot T, the instantaneous shock to credit spreads $(CSshock)$ will be calculated as follows:

$$CSshock_T = \begin{cases} \Delta CS_{max,(T,T+n)}, & if \quad |\Delta CS_{max,(T,T+n)}| > |\Delta CS_{min,(T,T+n)}| \\ \Delta CS_{min,(T,T+n)}, & if \quad |\Delta CS_{max,(T,T+n)}| < |\Delta CS_{min,(T,T+n)}| \end{cases}$$

Step 5: Similarly for each snapshot T, FIs will also estimate the instantaneous shocks to the risk-free rates ($RFshock$) based on steps 3 and 4 as described above by replacing the annual credit spread shocks (ΔCS) with the annual shocks to 10-year risk-free rates prescribed by the regulator.

For each exposure, climate scenario, and snapshot T, FIs will use the corresponding instantaneous shocks for credit spreads ($CSshock$) and risk-free rate ($RFshock$) derived above to estimate the instantaneous change in market value (ΔMarket $Value$) of the bond (relative to the baseline) as follows:

$$\Delta Market\ Value_T = CS01 \times CSshock_T + PV01 \times RFshock_T$$

Where:

- $CS01$ is the absolute change in bond valuation when the underlying bond issue's credit spread widens/narrows by one basis point, more commonly referred to as the modified duration of a bond
- $PV01$ is the absolute change in valuation when the risk-free rate increases/decreases by one basis point, more commonly referred to as the effective duration of a bond

As explained above, the shocks to credit spreads and risk-free rates in each transition scenario will be derived relative to the baseline scenario. FIs will use their internal estimates of bond sensitivity parameters for each exposure i.e., $CS01$ and $PV01$ and apply them to credit spread and risk-free rate shocks to estimate the change in market values.

The resulting change in market valuation will not be precise since this is an approximation based on first order sensitivities i.e., duration. Duration alone overestimates a decline in bond prices when credit spreads widen and underestimates an increase in bond prices when credit spreads narrow. The accuracy of the market value change estimation can be improved by including second order impacts, i.e., convexity adjustment. FIs can include second order impacts of convexity as an optional analysis. However, FIs that choose to do so must report the first order impacts and the combined impacts (first and second order) separately.

FIs can estimate the combined first and second order impacts as follows:

$$\Delta\text{Market Value}_{instant,T} = \left[CS01 \times CSshock_T + \frac{1}{2} C \times (CSshock_T)^2\right] + \left[PV01 \times RFshock_T + \frac{1}{2} C_{eff} \times (RFshock_T)^2\right]$$

Where:

- C is the convexity adjustment for the bond due to a one basis point change the underlying bond issue's credit spread
- C_{eff} is the effective convexity of the bond i.e., convexity adjustment due to a one basis point change in the risk-free rate

An illustrative example showing how to derive and apply instantaneous credit spread and risk-free shocks is provided in the SCSE Instructions.

4. Real estate transition risk exposure assessment

Climate transition risks may translate into financial losses for FIs' real estate secured lending and investment portfolios. The transition risks and their associated economic transmission channels are different than the transition risks associated with corporate and commercial exposures.

The following possible transmission channels have been identified related to the transition away from a carbon-intensive economy that may impact the risks associated with real estate lending and investments:

1. Exposures to properties that are powered or heated by carbon-intensive sources such as fossil fuels or natural gas may be impacted by the transition to net-zero.
    a. Property values may decrease relative to properties that use renewable power or electric heating sources as real estate buyer preferences change with the transition and due to the costs required to upgrade such buildings to an efficient heating source. These relative decreases in value may impact borrower PDs and LGDs given the risk discrimination associated with loan-to-value ratios (LTV) for real estate exposures.
    b. As carbon tax policies lead to an increase in energy prices, borrowers may be under higher levels of stress due to the higher costs of maintaining and operating these properties. This additional stress may impact borrower PDs.
2. Borrowers employed in industries exposed to higher transition risks may face additional financial hardship given shifts in the labour market. These shifts may impact borrower PDs.

In this module, we are aiming to better understand the extent to which climate transition risk may impact real estate exposures. The module focuses on the possible transmission channels related to properties' heating and energy sources as described in 1a. and 1b. above.

Recognizing that some FIs may have data gaps that prevent them from assessing real estate transition risks at an exposure level, this module does not attempt to measure financial impacts, e.g., credit risks. Instead, the module is a foundational exercise that may be used to inform future climate scenario analyses.

We also considered how the transition away from a carbon-intensive economy may cause higher inflation, which may impact interest rates and put additional stress on mortgage borrowers. However, unlike the possible impacts listed above, interest rates would impact all borrowers, and the risks associated with rising interest rates are already reflected in regulatory policy such as the borrower stress test in Residential Hypothecary Lending Guideline, and capital regimes.

4.1 Balance sheet assumptions

The real estate transition exposure assessment will be based on FIs' balance sheets as of Q4 2023. There is no temporal nature to this aspect of the SCSE; it is a snapshot of exposures at a point-in-time.

4.2 Transition scenarios

The real estate transition exposure assessment assumes that there will be a transition away from a carbon-intensive economy but does not attempt to specify the timing of the transition. The scenario narratives discussed in Section 3.2.1 are not applicable to this module.

4.3 Scope and classification of exposures

4.3.1 Exposures for DTIs

There are nine exposure classes for DTIs that are in scope for the real estate transition risk exposure assessment. Exposure classes are defined by the lending product, collateral/physical asset type, and the presence of mortgage default insurance status where applicable.

Figure 7: Exposures for real estate transition risk for DTIs

<table>
<tr><th>Exposure ID</th><th>Lending Product</th><th>Physical Asset</th><th>Mortgage insurance</th></tr>
<tr><td>1</td><td rowspan="3">Mortgages</td><td rowspan="6">Secured by residential property</td><td>CMHC insured</td></tr>
<tr><td>2</td><td>Other insured</td></tr>
<tr><td>3</td><td>Uninsured</td></tr>
<tr><td>4</td><td>HELOCs</td><td rowspan="6">Not applicable</td></tr>
<tr><td>5</td><td>Non-mortgage loans excluding HELOCs</td></tr>
<tr><td>6</td><td>Reverse mortgages</td></tr>
<tr><td>7</td><td>Mortgages</td><td rowspan="2">Secured by non-residential property</td></tr>
<tr><td>8</td><td>Non-mortgage loans</td></tr>
<tr><td>9</td><td>Not applicable</td><td>Buildings</td></tr>
</table>

Note that for Exposure IDs 1-8, the Physical Asset column describes the collateral type for a loan. However, for Exposure ID 9 the Physical Asset represents buildings owned by the FI.

All securitized mortgages (i.e., securitized through the National Housing Act MBS program) are not in scope for the real estate transition risk module. These mortgages are insured by either CMHC or other mortgage insurers, and so losses due to transition risk as described in the earlier part of this section are likely to fall on the insurer.

Investments in mortgage-backed securities (MBS) are also not in scope for the real estate transition risk module, i.e., DTIs are not expected to obtain or proxy property-level information for underlying mortgages for MBS investments.

Non-securitized mortgages that are insured are in scope for this module.

4.3.2 Exposure classes for Insurers

There are three exposure classes that are in scope for the real estate transition risk exposure assessment for insurers.

The following two asset exposure classes are in scope for insurers:

- Investments - Mortgage Loans
- Investment Properties and Own use Property

The only insurance exposures that are in scope for insurers are mortgage insurance exposures. All other insurance exposures are out of scope.

4.4 Dimensions and aggregated amounts

For this module, FIs will create two province level summaries capturing exposures' primary heating source and primary energy (electricity) source into fuel-based and non-fuel based sources.

The SCSE Instructions provide further information of the classification of the heating and energy sources into fuel and non-fuel based sources.

Understanding that there could be data gaps in heating and energy sources for FIs' real estate exposures, the use of data proxies will be permitted for this module if collecting this information represents a significant burden on the FI. For example, if a FI does not know the heating source of the properties associated with their real estate lending or investment portfolios, they may refer to the Statistics Canada Table: 38-10-0286-01 Primary heating systems and type of energy. This table provides percentages of heating source type at the provincial level and for 35 Census Metropolitan Areas (CMAs). Any use of data proxies should be rationalized and documented. Please see the SCSE Instructions for an example of how proxy data can be used for this module.

FIs are invited to consider collecting the requisite information for future climate risk assessments.

The exposure assessment will also include a summary segmented by the following dimensions:

1. Province
2. Exposure class (as listed in Section 4.3)
3. Loan-to-value buckets for lending exposures, see the Instructions for specific buckets
4. Physical asset type, see the Instructions for specific physical assets

All summaries will include the following aggregated amounts

- Balances outstanding
- Authorized amounts (if applicable)
- IFRS 9 ECL (if applicable)

5. Physical risk exposure assessments

Physical climate scenarios may translate into financial losses for FIs through multiple transmission channels. Chronic and acute physical hazards have the potential to cause significant damages to physical assets held by FIs, impacting their values and/or likelihoods of default. Indirect impacts of physical hazards may impact financial risks as well; chronic hazards may impact asset values even if damages are repaired, large acute hazards may lead to business disruptions, etc.

In this module, we are aiming to better understand the extent to which FIs are exposed to certain physical hazards. Like the transition risk real estate exposure assessment, this module does not attempt to measure financial impacts, e.g., credit risks. Instead, the module is a foundational exercise that may be used to inform future climate scenario analyses.

5.1 Balance sheet assumptions

The physical risk exposure assessments will be based on FIs' balance sheets as of Q4 2023. Unlike transition risk, where financial risks can be measured at different points in time, physical climate scenarios are often summarized into singular statistical values such as averages or return period values, e.g., 1:100-year hazards. The physical risk module includes average estimates that reflect historical data and return period/percentile values that reflect possible future climate scenarios for acute physical risks.

5.2 Physical climate scenarios

Climate scenarios that focus on physical risks are often defined using Representative Concentration Pathways (RCP). RCPs describe future patterns, in the context of future greenhouse gas emissions.

Three specific RCP scenarios are often considered in physical climate risk scenario analysis. Each scenario makes a different assumption about global average temperatures.

- **RCP 2.6:** average rise in temperatures of 0.9 to 2.3℃ by 2100, which would require the most action to reduce GHG emissions.
- **RCP 4.5:** average rise in temperatures of 1.7 to 3.2℃ by 2100, which would require significant action to reduce GHG emissions.
- **RCP 8.5:** average rise in temperatures of 3.2 to 5.4℃ by 2100.

In 2021, there was an introduction of Shared Socioeconomic Pathways (SSP), which consider the societal and economic factors that drive emissions and other climate-relevant activities. These include population growth, economic development, technological change, and governance structures. SSPs are designed to be considered in conjunction with RCPs.

Three SSP scenarios are often considered.

- **SSP-1:** The world undergoes a gradual shift towards sustainability and inclusive development, respecting environmental limits. Improved global commons management, increased investments in education and health, and a shift from economic growth to human well-being and reduce inequality, emphasizing sustainable consumption.
- **SSP-2:** The world follows a path where social, economic, and technological trends stay close to historical patterns. Development is uneven, with slow progress in sustainable goals, moderate population growth, persistent income inequality, and environmental degradation.
- **SSP-5:** The world emphasizes competitive markets, innovation, and participatory societies for rapid technological progress and sustainable development. Despite global economic growth, challenges arise from fossil fuel use, but local environmental issues are successfully addressed, and faith in effective social and ecological management persists.

The physical risk exposure assessments will focus on one future scenario for each hazard and compare this against historical average annual values.

5.3 Scope and classification of exposures

The physical risk exposure assessments include exposures related to immobile assets, such as residential properties, non-residential properties, land, and other immobile assets.

5.3.1 Exposures for DTIs

There are nine exposure classes for DTIs that are in scope for the physical risk module. Exposure classes are defined by the lending product, collateral/physical asset type, and the presence of mortgage default insurance where applicable.

Figure 8: Exposures for physical risks for DTIs

<table>
<tr><th>Exposure ID</th><th>Lending Product</th><th>Immobile Physical Asset</th><th>Mortgage insurance</th></tr>
<tr><td>1</td><td rowspan="3">Mortgages</td><td rowspan="5">Secured by residential property</td><td>CMHC insured</td></tr>
<tr><td>2</td><td>Other insured</td></tr>
<tr><td>3</td><td>Uninsured</td></tr>
<tr><td>4</td><td>HELOCs</td><td rowspan="5">Not applicable</td></tr>
<tr><td>5</td><td>Non-mortgage loans excluding HELOCs</td></tr>
<tr><td>6</td><td>Reverse mortgages</td></tr>
<tr><td>7</td><td>Mortgages</td><td rowspan="2">Secured by other than residential property</td></tr>
<tr><td>8</td><td>Non-mortgage loans</td></tr>
<tr><td>9</td><td>Not applicable</td><td>Land, buildings, and immobile equipment</td></tr>
</table>

Note that for Exposure IDs 1-8, the Physical Asset column describes the collateral type for a loan. However, for Exposure ID 9 the Physical Asset represents Land, buildings, and immobile equipment owned by the FI.

Mortgages insured by the Canada Housing and Mortgage Corporation (CMHC) or other mortgage insurers are in scope whether or not they have been securitized through the National Housing Act MBS program, i.e., regardless of whether or not they are on the balance sheet. These mortgages are in scope because in the case of mortgage default, the FI that forecloses on the underlying property is exposed to its associated physical risks since mortgage insurance policies do not provide coverage for force majeure events.

Investments in mortgage-backed securities (MBS) are not in scope for the physical risk module and DTIs are not expected to geocode underlying mortgages for MBS investments.

Non-mortgage loans secured by other than residential property are only in scope if the underlying collateral is itself an immobile physical asset. Unsecured non-mortgage loans and non-mortgage loans secured by mobile or non-physical assets are not in scope.

5.3.2 Exposure classes for Insurers

The following two asset classes are in scope for insurers:

- Investments - Mortgage Loans
- Investment Properties and Own use Property and Equipment

The following insurance exposures are in scope for insurers:

- For the flood hazard, residential and commercial property insurance exposures that cover damages from riverine or coastal flooding
- For the wildfire hazard, residential and commercial property insurance exposures that cover damages from wildfires
- Mortgage insurance exposures

All other insurance exposures are out of scope.

5.4 Location and geospatial data

The physical hazard maps used in the SCSE include shapes that are defined using latitude and longitude coordinates (geolocations). Merging these maps to exposure datasets will generally require FIs to know geolocations of individual exposures to an appropriate level of precision. This information is obtained through geocoding (i.e., taking text-based address information to determine geolocations), which may be required to complete the physical risk exposure assessment.

Geocoding multiple asset classes is an essential undertaking that will build capacity within FIs to conduct physical vulnerability assessments going forward. Physical hazard data is usually expressed using geolocations rather than postal locations. Geocoding will allow FIs to refine their physical climate risk assessments beyond this standardized exercise as more detailed and accurate hazard data becomes available.

FIs will provide the regulator with aggregated amounts and not any exposure level location data. Geocoded data will remain with FIs.

5.4.1 Single-point geocoding

Many exposures, e.g., residential real estate exposures will require FIs to determine single-point geolocations. i.e., one latitude and longitude pair.

5.4.2 Multi-point exposures

Some exposures, e.g., large land areas, pipelines, may require geocoding that is more complex than obtaining a single geolocation for a counterparty. This is because some in-scope collateral may have a large physical footprint that is not adequately captured by a single point. In these cases, geocoding a single point is not sufficient for this exercise. However, given the challenges that can be associated with multi-point geocoding, FIs may use approximations and simplifications in this exercise. In such cases, FIs would be expected to provide documented rationale on any approximations or simplifications along with their SCSE submission.

5.5 Hazards

The physical risk exposure assessments are limited to exposures in Canada and include two physical hazards:

- Riverine and coastal flooding
- Wildfire

5.5.1 Riverine and coastal flooding

For the riverine and coastal flooding hazard, we have worked with riskthinking.AI, who will provide FIs with flood depth data for selected in-scope geographies at no cost. We will provide FIs with a link to a riskthinking.AI portal as soon as it is available via the contact emails requested in Section 2.3.2. This portal will contain the flood depth data needed for the SCSE and documentation describing how flood depths estimates were determined by riskthinking.AI.

The riverine and coastal flooding maps will include two estimates of flood depths:

1. estimates that represent "normal" flooding, specifically, flood depths under recent historical climate conditions using an Annual Exceedance Probability[4] (AEP) of 50%, or a one in two-year return period
2. estimates that represent severe but plausible flood depths under possible future climate conditions, specifically, flood depths using an AEP of 1%, or a one in one-hundred-year return period and a stochastic approach to climate scenarios that captures a range of RCP and SSP scenarios as of 2050

The riverine and coastal flooding maps will include flood depths from eleven urban geographical regions. We have named these geographic areas based on the central city in the area, however, some regions include some surrounding areas. We have selected the regions for inclusion based on findings from the Bank of Canada/OSFI flood project to target areas where there are material exposures and material flood risk.

However, **these regions do not capture the entirety of flood risk in Canada and for certain FIs may not capture even the majority of their exposure to flood risks**.

The eleven regions are:

- Vancouver, British Columbia
- Calgary, Alberta
- Edmonton, Alberta
- Winnipeg, Manitoba
- Kitchener-Waterloo-Cambridge, Ontario
- Ottawa-Gatineau, Ontario/Québec
- Montréal, Québec
- Québec City, Québec
- Sherbrooke, Québec
- Saguenay, Québec
- Fredericton, New Brunswick

The specific Forward Sortation Areas[5] (FSAs) that define each region are listed in the SCSE Instructions. All exposures that are outside of these FSAs are out of scope for the flood risk exposure assessment.

The map that will be provided by riskthinking.AI to the exercise participants will include unique flood depths for given locations that are defined by hexagonal grid cells using the H3 indexing system[6]. For each asset in scope, FIs can obtain geolocations, i.e., latitude and longitude coordinates, and use them to identify each asset's associated H3 hexagon at resolution of 7.

[4] The Annual Exceedance Probability is the likelihood of a specified flood depth being exceeded in a given year.
[5] A forward sortation area is defined by the first three digits of a Canadian postal code.
[6] Information about the H3 information system can be found at Introduction | H3 (h3geo.org). A visualization tool for the H3 information system can be found at https://wolf-h3-viewer.glitch.me

Information about the approach used by riskthinking.AI to estimate flood depths will be provided by riskthinking.AI to the exercise participants along with the flood maps.

5.5.2 Wildfire

For the wildfire hazard, we are working with Environment and Climate Change Canada (ECCC), who plan to publish fire weather index projections on climatedata.ca in the summer of 2024. Fire weather refers to the often hot, dry and windy conditions conducive to wildfires. These upcoming projections use weather outputs from global climate models to estimate the extent to which the weather aspect of wildfire danger will be affected by changing climate conditions We will provide FIs with a link to the location of this data as soon as it is available via the contact emails requested in Section 2.3.2.

It should be noted that these fire weather index projections will provide information on only one factor (the weather component) that contributes to wildfire activity. Other factors include, but are not limited to, fuel availability and fire ignitions (human-caused or natural). This is identified as a limitation of this module.

The wildfire maps will include a variety of estimates. Similar to the flood exposure assessment, we will prescribe which of the two estimates to use:

1. averages of “historical” (recent past) wildfire weather
2. estimates of wildfire weather under possible future climate scenarios

The wildfire maps will cover all of Canada. However, similarly to the flood exposure assessment, the wildfire exposure assessment will focus on a relevant subset of Canada. We have selected eight rural geographical regions for inclusion based on the target areas where there are material exposures and material wildfire risk. The eight regions are:

- Northwest Territories
- Northern Alberta
- Northern Saskatchewan
- Northern Manitoba
- Northwest Ontario
- Northern Québec
- Eastern Labrador
- Northeast Newfoundland

The selection of these regions was informed in part by the "Community Wildfire Risk" map presented in the research paper Mapping wildfire hazard, vulnerability, and risk to Canadian communities. As in the case of flood risk, this list does not represent an exhaustive consideration of wildfire risk. The specific FSAs that are included in each region are listed in the SCSE Instructions. All exposures that are outside of these FSAs are out of scope for the wildfire risk exposure assessment.

The map that will be available on climatedata.ca will include wildfire weather risk metrics for all of Canada in the form of a 50x50 kilometer gridded dataset. The precise metrics will be finalized and communicated to participants via contact emails once available. This dataset will contain central latitude and longitude pairs for each rectangle, along with the wildfire weather metrics.

5.6 Reporting aggregated amounts

FIs will not be expected to include physical risk information at the address or geocoded location level as part of the SCSE. Instead, in-scope exposures will be aggregated into exposure classes and across other dimensions. The physical risk exposure assessment is segmented by the following dimensions:

- Regions, as described in Sections 5.5.1 and 5.5.2 respectively
- Exposure class (as listed in Section 5.4)
- Loan-to-value buckets for lending exposures
- Physical asset type
- Physical hazard buckets
  - For the flood exposure assessment, exposures will be bucketed by flood depths, as specified in the SCSE Instructions
  - For the wildfire exposure assessment, exposures will be bucketed by the Wildfire Hazard metric

The exposure assessment will include the following aggregated amounts:

- Balances outstanding
- Authorized amounts (if applicable)
- IFRS 9 ECL (if applicable)
- Insured amounts for insurance exposures

6. Appendices

6.1 Abbreviations

Abbreviation	Definition
AEP	Annual Exceedance Probability
BoC	Bank of Canada
CMA	Census Metropolitan Area
CMHC	Canada Mortgage and Housing Corporation
DTI	Deposit Taking Institution
EAD	Exposure at Default

Abbreviation	Definition
ECCC	Environment and Climate Change Canada
ECL	Expected Credit Losses
FBB	Foreign Bank Branch
FI	Participating Financial Institution
PP	Pension Plan
FVOCI	Fair Value through Other Comprehensive Income
FVTPL	Fair Value through Profit and Loss
FSA	Forward Sortation Area
GCAM	Global Change Analysis Model
GHG	Greenhouse gas
GICS	Global Industry Classification Standard
IAM	Integrated Assessment Model
IFRS	International Financial Reporting Standard
LGD	Loss Given Default
LTV	Loan-to-value ratio

Abbreviation	Definition
MBS	Mortgage-backed securities
MESSAGE	Model for Energy Supply Strategy Alternatives and their General Environmental Impact
MIT-EPPA	Massachusetts Institute of Technology Emissions Policy Prediction and Analysis
NAICS	North American Industry Classification System
NGFS	Network for Greening of the Financial System
NiGEM	National Institute Global Econometric Model
OSFI	Office of the Superintendent of Financial Institutions
PD	Probability of Default
RCP	Representative Concentration Pathways
REMIND	Regional Model of Investments and Development
SCSE	Standardized Climate Scenario Exercise
SSP	Shared Socioeconomic Pathway

6.2 Assumptions and limitations

In this section, a list of major assumptions and limitations related to the design and execution of the SCSE is presented. The following list is not exhaustive; a more comprehensive list will be presented within future documentation of the exercise.

SCSE – all modules

a. **Climate scenarios are not predictions:** The intent of the SCSE is to enable a better understanding of how different climate scenarios could impact FIs and the financial system, not to predict the future.

b. **Limitations of NGFS scenarios:** NGFS scenarios have several limitations that could underestimate the true impact of climate change, possibly significantly. For example, they do not account for climate tipping points and the wider societal impacts of climate change such as migration etc. We encourage FIs to explore alternative scenarios and models through their internal climate scenario analysis exercises.

c. **Not using the latest scenarios:** We will use inputs from NGFS Phase III and BoC scenarios to develop the risk factors for this exercise. This is an extensive process and hence we may not be able to incorporate the latest updates into the scenarios such as those related to GDP, population and most recent country level commitments.

d. **Sizing the risk:** The SCSE does not aim to execute a comprehensive sizing of climate risks, as discussed in Section 2.1. In particular, as a foundational exercise the SCSE does not comprehensively explore indirect or second order impacts, such as business interruptions, that may pose even larger risks to FIs' exposures.

e. **Standardization:** There is a trade-off between standardization of a scenario analysis, and a comprehensive measurement of each individual FIs' risks. The standardization of scenario selection, execution, methodology, and reported results yields more comparable results while a more comprehensive exercise may yield more accurate results for certain FIs.

Transition risk

a. **Static Balance sheet:** Even though real balance sheets are dynamic and reflect FIs' evolving views of risks, a static balance sheet approach is appropriate for an initial and/or standardized assessment of the vulnerability of financial institutions to climate risk, such as the SCSE.

b. **Use of Industry Sectors:** To measure the impact of transition climate scenarios, the SCSE relies on industry sector and regional classification based on an assumption of homogeneity within each sector/regional group. Given the lack of readily available direct and indirect GHG emission data, this assumption is common.

c. **Exchange Rate impacts:** The SCSE does not account for the impact of exchange rate movements on foreign currency investments and exposures for both credit and market risk modules. A comprehensive inclusion of climate related exchange rate movements would require portfolio specific modeling to ensure all aspects of the implied exchange rate fluctuations are thoroughly captured and assessed.

Credit risk module

a. **Out of Scope Asset Types:** As described in Section 3.4.1, the scope of the credit risk module is a subset of the IFRS 9 ECL scope, however, climate transition may also impact assets outside the scope of the credit risk module.

b. **Second Round Impacts:** While the exercise attempts to capture some second-round impacts through the exposure classified as "Finance and Insurance" (see Section 3.4.1), this assessment is not comprehensive.

c. **Agnostic EAD:** As discussed in Section 3.4, the impact of climate scenarios on credit risk estimates is captured by adjusting PD and LGD. The EAD parameter is assumed agnostic to climate scenarios.

d. **Frye-Jacobs LGD:** Using Frye-Jacob formula for the LGD, we assumed the climate adjusted LGD is a function of climate adjusted PD, baseline PD, and baseline LGD. Doing so we accept all the assumptions which are applicable to this relation, including the assumption of Vasicek Distribution for climate PD and LGDs. To simplify the formula, we further assumed the correlation factors in all the underlying Vasicek Distributions is zero.

Market risk module

a. **Systemic risks not included:** The market risk module only accounts for changes in asset valuations driven by shocks to the fundamental value factors such as firm level net income or free cash flows. It does not account for the systemic risk channels. However, financial sector interlinkages and common exposures may lead to a financial market contagion, flight to safety may result in fire sales and other disorderly market adjustments.

Real estate exposure assessment

a. **Financial impacts not included:** The Real Estate Exposure Assessment does not consider the potential financial impacts of the climate transition on real estate exposures.

b. **Borrower risk:** Possible impacts of climate transition scenarios on a borrower's ability to maintain their financial obligations are not considered in this exposure assessment.

c. **Data gaps:** Understanding that there could be data gaps in heating and energy sources for FIs' real estate exposures, the use of data proxies will be permitted for this module if collecting this information represents a significant burden on the FI. These proxies may lead the exposure assessment to be somewhat inaccurate.

Physical risk exposure assessments

a. **Financial impacts not included:** The Physical Risk Exposure Assessment does not consider the potential financial impacts of the climate transition.

b. **Direct damages for collateralized assets only:** The physical risk exposure assessment only considers direct damages on collateralized assets caused by acute physical hazards, while indirect impacts, such as business interruptions, may pose even larger risks to FIs exposures.

c. **Physical hazards in scope:** The Physical Risk Exposure Assessment will include a limited number of physical hazards and will not consider their possible interactions. The compounding impacts of multiple physical hazards occurring over a short period may be substantial.

6.3 Industry Classification

In this section, we provide more information regarding the rationale and the methodology of the industry classification.

While this section discusses the development of the NAICS mapping for this exercise, it does not discuss the use of the mapping by the participants. As mentioned in Section 3.3.2, implementation instructions on how FIs will map individual counterparties to NAICS codes are expected to be established by FIs through a common set of principles and rules which will be consistently applied for all the applicable exposures. In particular, these rules and principles shall address challenges associated with mapping complex counterparties involved in multiple industry sectors.

These assignments shall be consistent, replicable, and FIs shall be able to explain and justify the principles and judgements of their designed mapping methodology.

Use of NAICS:

We chose to map industry sectors using NAICS because:

1. Other classification systems, such as the Global Industry Classification Standard (GICS), do not necessarily enable the SCSE objectives, mostly due to their lack of granularity, especially in the key transition sensitive sectors (e.g., no separation of oil from gas in GICS).
2. Statistics Canada and United States Census Bureau maintain NAICS codes and update them frequently to ensure they retain their relevance and suitability. The codes are freely available to the public along with detailed descriptions and technical information which facilitates their use.
3. While US and Canadian NAICS codes are updated by the respective national agencies, the codes are coordinated and standardized across both systems. The standardization of NAICS codes has enabled us to develop the SCSE industry mapping which functions within both Canadian and US systems and therefore is accessible to participants if they have used either of these two systems.

Methodology:

The NAICS codes were distributed among 25 transition-sensitive sectors. The assignment of NAICS codes to different sectors is based on subject matter expert inputs, literature review, the description of the codes, and qualitative analysis. The SCSE Methodology implicitly assumes that exposures classified under one sector are subject to the same type and level of climate risk.

The sectoral classification has been built upon the BoC/OSFI pilot project classification. We have reviewed each of the pilot's sectors and their assigned codes and have further modified/refined the classification based on the following considerations.

- **Scope 1 Emissions:** Account for direct greenhouse gas emissions of the sector. On this ground, for example, we have divided electricity production into *Fossil Fuel Electricity Production, Hydro Electricity Production,* and other *Renewable Sources*.
- **Scope 2 Emissions:** Account for the greenhouse gas emissions of the sector from the use of electricity, heat, steam, or cooling. As a result, industries with intensive energy consumption have been divided into *Energy Intensive – Mining*, *Energy Intensive – Manufacturing, Energy Intensive – Water and Sewage, and Energy Intensive – Paper and pulp* which besides high scope 1 emissions, consume significant amount of energy produced by the energy sector.
- **Scope 3 Emissions:** Account for other indirect greenhouse emissions of the industries. For example, *Timber tract operations (NAICS 1131)* and *Forest nurseries and gathering of forest products (NAICS 1132)* have been grouped with *Support activities for forestry (NAICS 1153)* which indirectly inherits the greenhouse emissions of the forestry sector.

- **Stranded Assets:** Account for the assets stranded because of transition. These are the assets that are exposed to premature write-downs, devaluations, or conversions to liabilities as a result of energy transition. For example, based on this definition, in this exercise, *wood product manufacturing (NAICS 321)* and *Timber tract operations (NAICS 1131)* have been grouped together, as they would be impacted a transition that gives rise to stranded assets in the lumber sector.

Note that in many cases, several similar arguments have contributed to the resulting classification. For example, we have split Oil Production into Sand Oil and Other Oil Extractive Codes, as Canadian sand oil is considered to be one of the most carbon intensive forms of oil production from the extraction stage (stage 1 and 2 emission) to refinery (stage 3 and stranded asset).

This methodology has been inspired by and is aligned with the mapping proposed in The NACE - CPRS - IAM mapping: A tool to support climate risk analysis of financial portfolio using NGFS scenarios. We have also benefited from reviewing the work conducted on NACE mapping of different sectors in Climate Policy Relevant Sectors.

How to Use the Mapping Tool:

The SCSE Instructions include a mapping tab which provides the mapping from NAICS codes (in both US and Canadian systems) to SCSE industry sectors in the draft.

Note that the only reason a code is not assigned is that it includes multiple sectors which are deemed heterogenous under climate scenarios. For example, NAICS code 11 (Agriculture, forestry, fishing, and hunting) includes codes 111 (Crop Production), 112 (Animal Production and aquaculture), 113 (Forestry and logging), 114 (Fishing, hunting and trapping), 1151 (support activities for crop production), 1152 (support activities for animal production), and 1153 (support activities for forestry), which are all leading NAICS codes in this exercise, that is all the NAICS codes that start with the same digits also belong to the same sector.