Carbon Risk Real Estate Monitor

CRREM Risk Assessment Reference Guide

Carbon Risk Assessment Tool for the
European Commercial Real Estate Industry

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 785058.

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About CRREM

The *Carbon Risk Real Estate Monitor (CRREM)* is a European Horizon 2020 research and innovation project. The objective of *CRREM* is to accelerate the decarbonisation and climate change resilience of the EU real estate sector by providing appropriate science-based carbon reduction pathways at property, portfolio and company level. *CRREM* aims to integrate carbon efficiency and retrofit requirements into investment decisions by evaluating and clearly communicating the downside financial risks associated with a low energy performance and quantifying the financial implications of stricter regulatory environment regarding carbon intensity on the building stock.

Carbon Risk Assessment Tool for Commercial Real Estate

The *CRREM Risk Assessment Tool* for stranded assets is designed for asset owners and investors to understand the carbon risks inherent in their portfolio.

The *CRREM* tool attributes portfolio level carbon risk by breaking down the global GHG emissions budget that is consistent with the Paris Climate Agreement towards individual countries, the commercial real estate sector, property types and individual assets. The *CRREM* tool offers the possibility to evaluate the progress of a portfolio's carbon reduction performance against reduction targets in line with the Paris Agreement (i.e., limiting global warming to 2°C / 1.5°C). The *CRREM* tool helps to identify which properties will be at risk of stranding due to the expected increase in stringent building codes, regulation, and carbon prices. It also enables an analysis of the effects of refurbishing single properties on the total carbon performance of a company, including by assessing emissions related to embodied carbon.

Pre-release version of the Reference Guide

This pre-release version of the *CRREM Reference Guide* is primarily released for discussion purposes and will be updated in the coming months. The final (1.0) version of the *CRREM Risk Assessment Tool* is expected to be released on January 31, 2020. Until the release of the final *CRREM* tool, the project consortium appreciates industry feedback on both the tool and this guide (info@crrem.eu).

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Research Consortium

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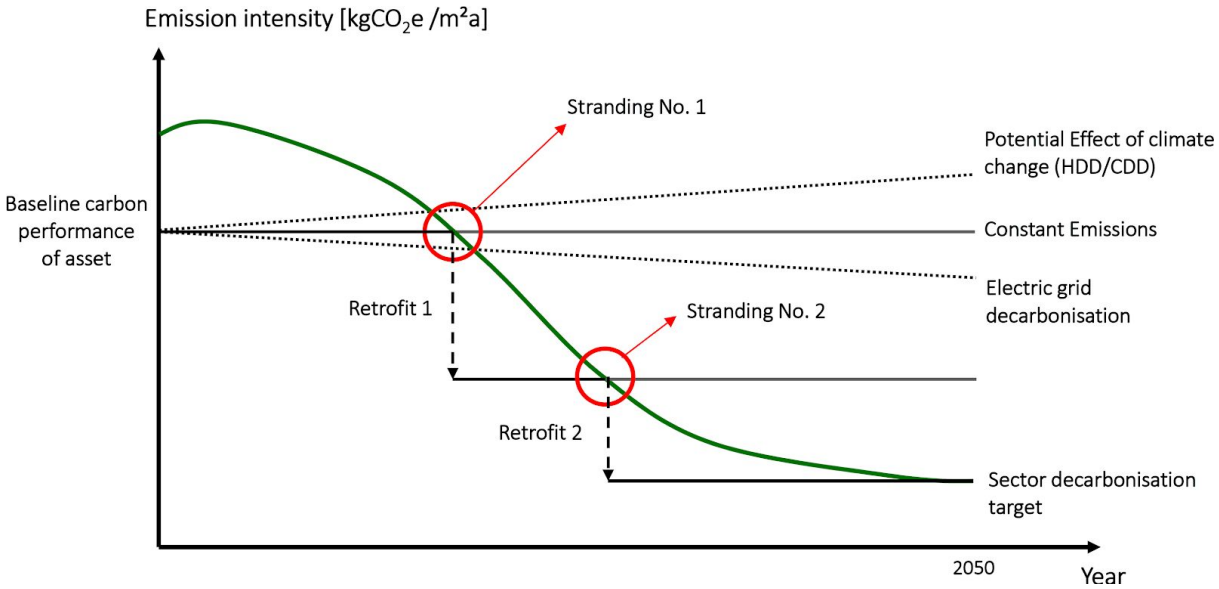
Introduction

This Pre-release Reference Guide accompanies the *CRREM Carbon Risk Assessment Tool* for the European Commercial Real Estate Industry. The guide provides overall instruction on how the *CRREM* tool should be applied, as well as in-depth guidance into the user input variables for the tool, user adjustable variables, default data underlying the tool and resulting output figures on property and portfolio level.

CRREM defines decarbonisation targets and pathways in line with the EU commitment to limit global warming to well below 2°C or even 1.5 °C for individual EU countries and property types. These pathways and targets provide investors in European Commercial Real Estate with a roadmap for individual properties and portfolios on how to reduce carbon footprints over the next decades.



The figure ("Stranding diagram") above provides a summary of the fundamental principle of *CRREM's* stranding risk analysis approach for single properties:

- **Black line:** The black line represents a building's baseline and future carbon performance in terms of the so-called greenhouse gas (GHG) intensity, which is calculated as the amount of annual greenhouse gas emissions per building floor area. Emission figures include those directly generated by the on-site combustion of fossil fuels for heating and indirect emissions (caused by the use of district heating and/or electricity consumption).
- **Green curve:** The green curve represents the target decarbonisation pathway of a specific building that aligns with a certain climate target (1.5°C/2°C) and must not be exceeded. If the emission intensity is above the target value, "stranding" occurs.

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In the illustration above, the exemplary building fulfils the requirements only at the very beginning and faces stranding far before the end of the observation period (2050). Only appropriate retrofit measures reducing the GHG emissions can ensure that the building will meet the future emission ceilings.

CRREM also considers the influence of two additional effects on the GHG performance of a property, which are per se independent of any retrofit measures:

- **Potential effects of climate change:** A certain building's future carbon performance will be affected by the impact of climate change on the heating and cooling demand. While global warming is expected to reduce the demand for heating across Europe, the energy required for air conditioning systems are increasing correspondingly. *CRREM* uses scientific modellings of the future development of so-called heating and cooling degree days (HDD/CDD) to consider this effect.
- **Electricity grid decarbonisation:** The second effect that *CRREM* takes into account when determining the future stranding risk of a property, is the influence of the electricity grid decarbonisation on the indirect emissions of a property. The increasing share of electricity that is generated from renewable sources implies that the average amount of GHG emitted per consumed kWh (also called GHG intensity of power generation or emission factor) will continue to decrease.

Scope of the CRREM Risk Assessment Tool

The scope of the *CRREM* tool and research project is to assess the carbon risks associated with operational assets and retrofit actions on European commercial real estate properties, At this stage, the project does not cover residential properties, or countries outside of the EU.

Input variables for the tool are largely based upon existing frameworks, such as the EPRA sBPRs, GRESB, GRI and the GHG Protocol Corporate Standard. The output variables produced by the *CRREM* tool are intended to assist with reporting in accordance with the Task Force on Climate-related Financial Disclosure (TCFD) recommendations.

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Structure of the Carbon Risk Assessment tool

The v1.0 pre-release version of the CRREM Risk Assessment Tool consists of the following tabs:

Instructions
Contains introductory step-by-step instructions on how the *CRREM* Risk Assessment Tool should be used.
Data dictionary
Explanation of the variables and graphs included in the *CRREM* Risk Assessment Tool.
Decarbonisation target tool
This sheet provides the possibility to identify decarbonisation pathways without entering data for individual buildings. Pathways depend on selected country, building type and global warming target (1.5°C/2°C) and are presented in the form of a line chart and tabulated data.
Asset data input
Primary sheet where the user inputs the building data. Covers the following categories: • **Reporting characteristics:** Covers basic information on the reported data, such as asset name and the period for which data is reported. • **Building characteristics:** Covers basic building characteristics such as asset location, property type, and primary areas. • **Energy consumption data:** Covers the main input field which enables users to enter energy consumption data, in turn used for calculating carbon emissions. • **Refrigerant losses:** Covers additional input field for calculating fugitive emissions using refrigerant losses. • **Renewable energy:** Covers on-site and off-site renewable energy. • **Building-use:** Covers additional building-use characteristics that will enable the normalisation of consumption values.
GHG Emissions data
Sheet where the user can both report upon GHG emissions data and see GHG emission data calculated and estimated by the *CRREM Risk Assessment Model*. Covers the following sections: • **Offsets and net zero commitment:** Enables users to report upon offsets purchased and allows users to report on whether they have made any net zero carbon commitments. • **CRREM calculated emissions:** Displays the emissions the CRREM Tool calculated based on the Asset Data Input Sheet. Also, includes information estimations used to cover data gaps. • **Self-reported emissions:** Enables users to report upon self-reported emissions, including market-based scope 2 emissions.

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Default asset data
Sheet specifically for advanced users that want to overwrite default data points. Enables tailoring of the risk assessment to user-specific scenarios. Covers the following categories: • **Normalisation:** Enables the user to adjust *CRREM* defined normalisation factors. • **Energy prices:** Covers default energy prices that can be overwritten by the user. • **Carbon prices:** Covers default carbon prices that can be overwritten by the user. • **Energy transition pathway:** Enables users to provide specific renewable energy scenarios affecting GHG emissions per unit of consumed electrical energy. • **Abatement model:** Covers a set of assumptions on the *CRREM Retrofit Model*.
Unit conversion tool
This sheet allows users to convert different units of energy consumption and area, enabling the calculation of required values directly within the *CRREM* tool.
Results: Asset Level
The asset level results will show actionable insights for users on what specific carbon risks an asset faces.
Results: Portfolio Level
The portfolio level results will include specific graphs and metrics useful for reporting between Limited Partners and their fiduciaries in accordance with the Task Force on Climate-related Financial Disclosures (TCFD) recommendations.
Retrofit tool
This tab will include the to be developed retrofit planning tool, enabling users to assess the retrofits costs necessary to comply with decarbonisation targets. The tool offers an analysis of potential economic and ecological costs and benefits of retrofits and will include analysis options for the embodied carbon of retrofits.
Statistical Model
In this sheet *CRREM* conceals its statistical model coping with data gaps and other sources of uncertainty.

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Overarching recommendations

Organisational boundaries

Participating real estate portfolios are expected to be standing commercial real estate investment portfolios. The tool does not cover new construction projects or residential holdings.

The current version of the tool covers the following property types: *Retail High Street, Retail Shopping Center, Retail Warehouse, Office, Hotel, Healthcare, Mixed use, Other*.

The *CRREM* tool is specifically intended for assessing risk of equity portfolios, and facilitates structured communication on climate change transition risks between real estate equity investors and their fiduciaries. As such, it is not intended to assess the risk associated with assets that are not owned by the portfolio (but might be occupied or operated by the manager), or fixed income holdings.

Data quality and assurance

It is important to ensure that the data inputted into the *CRREM* tool is of significant quality and that a company is aware of certain data gaps. This is especially relevant, as underreporting of, for instance, energy consumption data, can lead to an underassessment of a portfolio's carbon risk. To avoid underreporting risks, *CRREM* encourages users to conduct rigorous data quality checks and conduct third-party verification on energy and carbon data inputted into the tool.

Data availability and gaps

The *CRREM* tool has been specifically designed to enable risk assessment calculations with limited information. For example, if a company is unable to collect the energy consumption data from a single tenant, the user report upon this data gap arrears a "*maximum potential coverage area*" that covers all tenant areas, and a "*data coverage area*" for areas he has collected data for. Based on building-type-specific typical default values, the *CRREM* tool estimates missing data and provides the user with information on the resulting degree of uncertainty: The higher the data coverage, the lower the uncertainty and risk.

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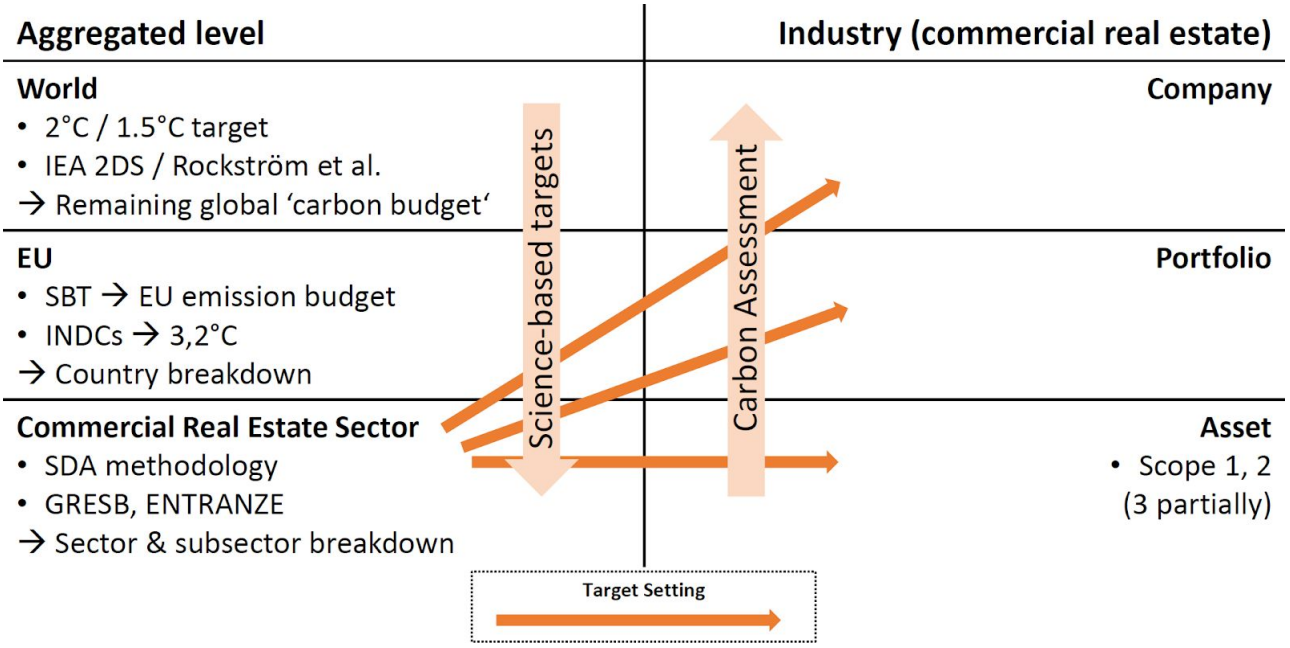
Background: Carbon Risk in Real Estate

Top-down approach for downscaling global carbon budgets and bottom-up approach from asset to commercial real estate sector carbon counting



Source: CRREM

CRREM Decarbonisation Model

CRREM has completed the decarbonisation model to calculate the pathways and carbon reduction targets required for the EU commercial real estate sector to comply with the Paris Conference (COP21) climate targets of limiting global warming to 1.5°C or 2°C. This model constitutes the core of the decarbonisation target tool. The following paragraphs briefly describe the main steps to develop the required pathways and targets. The full description and references for this process can be found in Section C of the document 'Stranding Risk & Carbon', available on the CRREM website.

Step 1. **Global carbon budgets and pathways.** The model adopts two warming scenarios to comply with COP21: 2°C and 1.5°C maximum warming by 2100, as well as the associated carbon budgets and emission pathways, calculated by the IEA amongst others. Budgets define the amount of carbon that can be emitted before 2050 not to exceed these warming limits.

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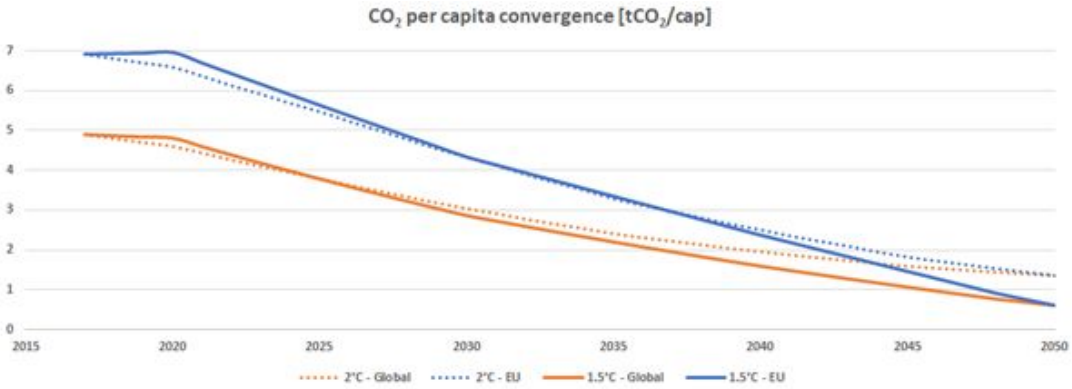
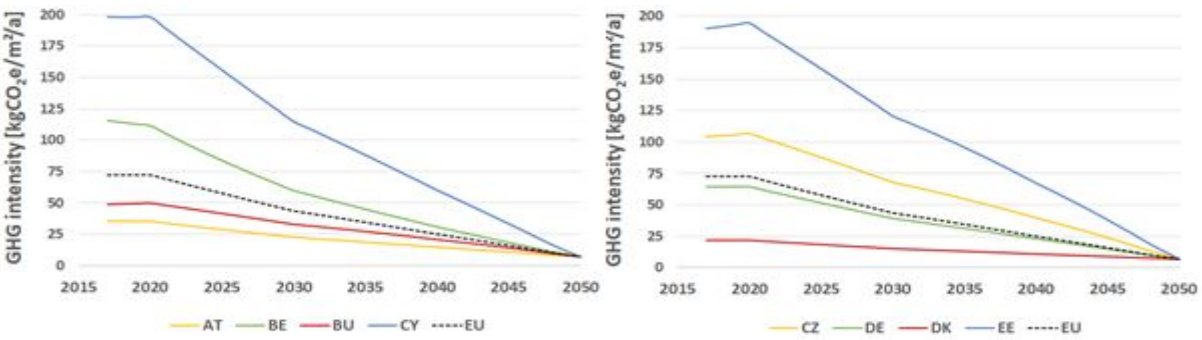
Step 2. **EU carbon budget and pathways.** From this global emission pathway, the model extracts the share of carbon that the EU could emit before 2050, establishing annual reduction targets of **CO_2 emissions per capita**. Global and EU pathways converge in the target year 2050.



Step 3. **EU commercial real estate.** Using data from the EU Reference Scenario 2016, the EU carbon budgets and pathways are further broken down into economic sectors, with focus on commercial real estate. This process takes into account the expected growth of the sector. The resulting converging pathways and annual targets are defined in **CO_2 emissions per square meter**.

Step 4. **Budget and pathways per country.** The next step is to allocate the responsibilities and efforts required from the real estate sector in each EU Member State. Two sets of expected decarbonisation pathways according to both warming scenarios are defined. All pathways start at the current emission intensity of each country's building stock and converge on the same decarbonisation target, common for the whole EU. The following graphs illustrate the pathways calculated for 8 of the 28 member states, although the pathways are calculated for all 28 countries.



Step 5. **Downscaling to building types.** The final step collects data from different EU sources to calculate the decarbonisation pathways and targets for different non-domestic building types, including Office, Retail High Street, Retail Shopping Centre, Retail Warehouse, Hotel, Healthcare, Mixed use and Other. The carbon emission rate and the saving capacity of each building type is intrinsically different due to the energy profiles of the activities that these buildings host. Therefore,

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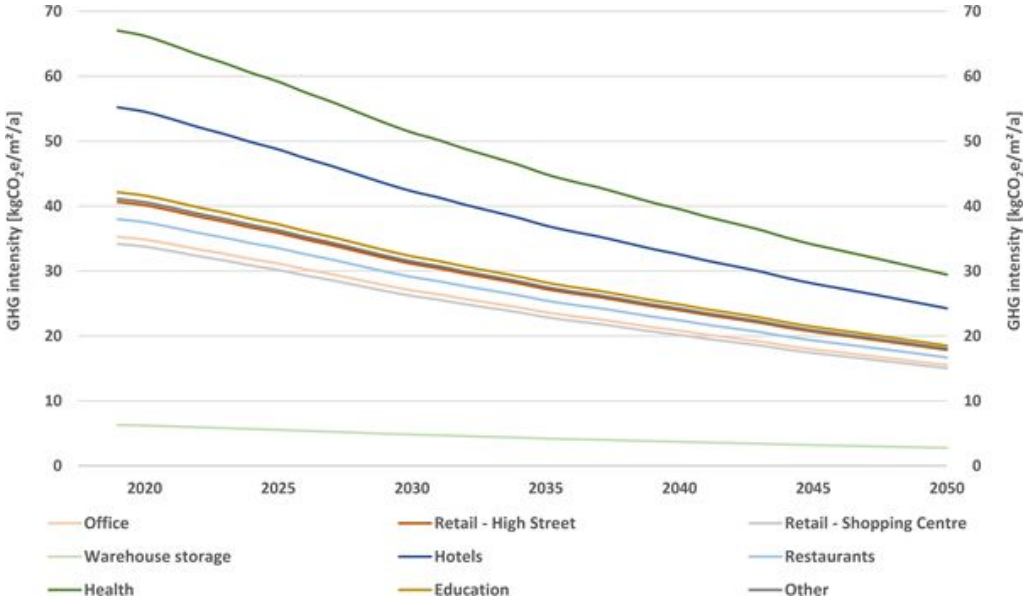
these pathways do not converge on the same target. The calculation takes into consideration the size, expected growth and current emission rate of each subsector per country and assumes constant relative differences between each subsector:



Decarbonisation target tool

This sheet of the *CRREM* tool provides the possibility to directly assess decarbonisation pathways (in terms of GHG intensity) without entering data for individual buildings. After selecting country, building type and global warming target (1.5°C/2°C) the *CRREM* decarbonisation target tool presents GHG intensity targets on an annual basis in the form of a line chart and tabulated data.

Asset data input

In the asset data input sheet users enter information on individual assets that is necessary to assess stranding risks within the *CRREM* tool. Not all fields are mandatory and used for risk calculation but will be included in the final reporting summary for each asset.

Reporting characteristics

The reporting characteristics provide information on the asset, such as the name, period for which data is reported, along with information on ownership. The entered information is mainly used for reporting purposes within the *CRREM* tool:

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REX_AT.ID	**Asset ID**	*Text*

Description: Unique Asset ID that enables data consistency checks and enables the user to match Asset level information with Data Management Systems (DMS) or GRESB using the GRESB Asset ID.

Requirements: None.

Rationale: Facilitates easy transfer of relevant variables across data platforms such as GRESB.

REX_NAME.	**Asset Name**	*Text*

Description: Name of the asset. This can also be the address of the asset.

Requirements: Mandatory. Provide the name of the asset, so that it can be identified in different tabs of the *CRREM* Risk Assessment Tool.

Rationale: Enables asset identification by the user.

RET_AS.YR	**Reporting year**	*Year*

Description: The year on which the user wants to report data for an asset.

Requirements: Mandatory. The *CRREM* Risk Assessment tool is intended to only allow users to report data from 2014 onward.

Rationale: The CRREM Risk Assessment tool enables users to report on multiple years as to track year-over-year progress and identify outliers.

REX_CURR.	**Currency**	*Drop-down*

Description: State the currency that is used to report data in the *CRREM* Risk Assessment Tool. *CRREM* intends to allow reporting using the following currencies:

- Danish Krone (DKK)
- Euro (EUR)
- Pound Sterling (GBP)
- Swedish Krona (SEK)
- United States Dollar (USD)
- Other

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Requirements: If the user selects other, the exchange rate at the end of the reporting period needs to be provided in the default data field. By default, the CRREM tool assumes values are reported in EUR.

Rationale: The *CRREM* Tool uses EUR as a basis for carbon price calculations. Currency conversion enables aggregation of risk information across regionally diversified portfolios.

BSV_AT.GV	**Gross Asset Value (GAV)**	*[€/$]*

Description: The total value of the asset at the end of the reporting year. GAV includes both debt and equity value.

Requirements: Mandatory. Report the figure at the end of the reporting period. Ensure the figure is in line with the currency reported in CUR.

Rationale: GAV is a key part for estimating the portfolio value at risk of becoming stranded due to future policy regulation.

BSR_OW.PP	**Percentage of ownership**	*[%]*

Description: The percentage of equity invested in the asset.

Requirements: Only to be filled in for Joint Ventures (JVs). *CRREM* assumes percentages are provided using a 0% to 100% scale. If left blank, the tool assumes 100% ownership of the asset.

Rationale: Enables the Risk Assessment Tool to correctly aggregate stranding risk in terms of value to a portfolio level.

RET_AS.SM	**Reporting period: Starting month**	*Drop-down*

Description: The first month for which data is reported in the *CRREM* Risk Assessment Tool. Dropdown consists of the months in the year.

Requirements: If left blank, *CRREM* will assumes this is January (e.g., aligned with the calendar year).

Rationale: Understanding the time period of the data is intended to be used for weather normalisation.

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RET_AS.MO	**Reporting period: Months of data**	*Drop-down*

Description: The number of months for which data is reported in the tool during the reporting year. Drop-down consists of 1 to 12 integer.

Requirements: If left blank, *CRREM* will assumes there was data for a full 12 months during the reporting year.

Rationale: *CRREM* aspires to normalise for missing months, but strongly encourages users to provide as much data as possible.

REX_AS.EN	**Entity**	*Text*

Description: This field can be used to categorise the analysis of assets amongst property managers, funds, separate accounts, or other entities.

Requirements: Ensure that the entity name is used consistently and mirrored across assets or reporting years.

Rationale: Provides advanced analytics for users that want to understand how a sub-part of their portfolio is performing.

Building characteristics

Building characteristics provide basic information associated with the asset such as asset location, property type, as well as primary areas. Generally, building characteristics remain the same over time and can thus be copied over across assessment years.

BSX_COUN.	**Location: Country**	*Drop-down*

Description: The country in which the asset is located.

Requirements: Mandatory. Dropdown of all EU countries including the United Kingdom.

Rationale: Understanding the country the asset is located in enables the tool to link the asset to the relevant Sectoral Decarbonisation Pathway, as well as convert energy consumption values to relevant electricity grid intensity metrics.

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BSX_CITY.	**Location: City**	*Text*

Description: The city in which the asset is located.

Requirements: None. Free text entry.

Rationale: Identification of the asset.

BSX_ZIPC.	**Location: Zip Code**	*Text*

Description: The Zip Code of the asset.

Requirements: Report using Zip Code. The *CRREM* automatically detects whether an entered Zip Code is valid for the selected country and, if not, provides the user with guidance regarding the correct format.

Rationale: Geo-location of asset (used to determine the local effects of climate change on future heating and cooling demand and local weather normalisation)..

BSX_ADDR.	**Location: Address**	*Text*

Description: The street address of the asset.

Requirements: None.

Rationale: Identification of the asset.

BSX_AS.TY	**Property type**	*Drop-down*

Description: The property type that the asset falls under.

Requirements: Mandatory. *CRREM* covers the following property types, which were originally adapted from the 2019 GRESB Real Estate Assessment:

- **Health Care:** Buildings used for the purpose of primary health care. Examples may include, but are not limited to: hospitals, clinics, physical therapy centers and mental health centers.
- **Hotel:** Includes hotels, motels, youth hostels, lodging, and resorts.
- **Mixed-use:** Assets that lack data availability by individual property type components but encompass several of the other property types in this list.

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- **Office:** Includes free-standing offices, office terraces, unattributed office buildings and office parks.
- **Other:** Any other property type that does not have similar energy use or data collection ability characteristics, as the other property listed in this list. Examples include, but are not limited to: kindergarten, community halls. This option should only be used if the investment does not fit into any of the options given.
- **Retail – High Street:** Retail buildings located on the high street in a particular area, usually terraced buildings located in the city centre or other high-traffic pedestrian zones.
- **Retail – Shopping Centre:** Enclosed centers for retail purposes. Examples may include, but are not limited to: regional malls and shopping malls.
- **Retail - Warehouse:** Refers to buildings in an unenclosed retail space, otherwise known as a strip center or strip mall, whereby buildings are usually stand-alone and situated side-by-side with their entrance facing a main street or carpark.

Rationale: *CRREM* has calculated decarbonisation pathways for individual property types. Entering this information enables *CRREM* to link the asset to a relevant decarbonisation target.

BST_CN.YR	**Construction year**	*Year*

Description: The year in which the asset was constructed.

Requirements: None.

Rationale: Construction year can be an important indicator for carbon risk, as building codes to promote energy efficiency have generally become more stringent over time.

BST_RT.YR	**Year of last retrofit**	*Year*

Description: The year in which the asset underwent its last capital intensive retrofit.

Requirements: Only report major retrofits that either significantly covered an assets floor area or tenants.

Rationale: Year of last retrofit is an important indicator for *CRREM* to understand the effectiveness of retrofits as well as energy efficiency opportunities.

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BSF_TO.FL	**Asset size: Total floor area**	*Area [m²/ft²]*

Description: The total floor area of the asset.

Requirements: Mandatory. *CRREM* recommends users to report Total Floor Area over Net Lettable Floor Area, and specifically floor area aligned with the International Property Measurement Standards (IPMS). Total floor area should not include indoor parking spaces.

Rationale: Floor area is the key denominator to calculate carbon and energy intensity metrics in real estate, which is an important determinant for assessing carbon risk in the Sectoral Decarbonisation Model.

BSF_UN.FL	**Asset size: Type [m²/ft²]**	*Drop-down*

Description: Select the type of metric in which floor area is reported.

Requirements: Data needs to be reported upon in either square meters or square feet. By default this is set to square meters.

Rationale: This is a key determinant to understand the value provided in TO.FL.

BSF_ME.FL	**Asset size: Measurement standard**	*Drop-down*

Description: The measurement standard used for the reported floor area.

Requirements: *CRREM* encourages portfolios to make use of the International Property Measurement Standards (IPMS), and tries to normalise for this standard if another measurement standard is used. *CRREM* uses IPMS as the default standard if no other standard is provided.

- **IPMS:** International Property Measurement Standards: this is the standard that CRREM uses by default and which other standards are normalised to.
- **Other:** If an asset is measured using a property measurement standard that is not listed above, the user is suggested to provide information on how the standard relates to IPMS in the default data tab.

Rationale: *CRREM* needs comparable floor area data to compare intensities which in turn are used to assess carbon risks.

References: RICS - International Property Measurement Standards [online]

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BSF_CC.FL	**Asset floor area: Common areas**	*Area [m²/ft²]*

Description: The total floor area of the common areas. A common area can be defined as "areas shared with other building occupants, including, but not limited to: entrance areas, corridors, lifts, staircases, waste storage stores, communal kitchen and breakout facilities".

Requirements: Leave blank if common areas are unknown or if user reports using lettable floor area.

Rationale: Key indicator for attributing energy consumption and data consistency checks.

BSF_SS.FL	**Asset floor area: Shared services/central plant**	*Area [m²/ft²]*

Description: Shared Services/Central Plant is a central source providing energy for the whole building, including common areas and shared services for tenants.

Requirements: If shared services area is unknown, you can use the asset's total floor area.

Rationale: Key indicator for attributing energy consumption and data consistency checks.

BSF_IP.FL	**Asset floor area: Indoor parking**	*Area [m²/ft²]*

Description: Indoor parking areas that are associated with the asset.

Requirements: Indoor parking should not be included in total floor area.

Rationale: Key indicator for attributing energy consumption. Used for data consistency checks.

BSF_TE.FL	**Asset floor area: Tenant areas**	*Area [m²/ft²]*

Description: Lettable floor area (both vacant and let/leased areas) that is or can be occupied by tenants.

Requirements: Key indicator for attributing energy consumption and data consistency checks.

Rationale: Key indicator for attributing energy consumption. Used for data consistency checks.

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Energy consumption data

This section covers the main input fields which enables users to enter energy consumption data. The *CRREM* tool in turn converts energy consumption data into GHG Emissions. If no data coverage is available for certain areas, *CRREM* intends to develop an estimation model that would still provide insights into potential carbon risks.

Energy consumption data can be entered for the following areas:

- **Whole building:** Energy used by tenants and base building services to lettable/leasable and common spaces. This should include all energy supplied to the building for the operation of the building and the tenant space. Use this section to report consumption data in the case that no separate data for Common Areas and Tenant Space is available.
    - **Purchased by [Tenant / Landlord]**: Indicate here whether the consumption type was purchased by the tenant or landlord. If electricity is purchased by the landlord, but submetered to the tenant (and the tenant pays for this), see whether you can report upon this through a combination of Base Building + Tenant Space. If not, report the data as Purchased by Tenant.
- **Base building:** Energy consumed in supplying central building services to lettable/leasable areas and common areas.
    - **Common Areas:** Areas shared with other building occupants, including, but not limited to: entrance areas, corridors, lifts, staircases, waste storage stores, communal kitchen and breakout facilities.
    - **Shared Services / Central Plant:** Shared Services/Central Plant is a central source providing energy for the whole building, including common areas and shared services for tenants.
    - **Outdoor/Exterior Areas / Parking:** Areas outside the building that are not considered as part of the lettable/leasable area, but which are within the site boundaries. Only complete these fields in case separate consumption data for outdoor, exterior and/or parking is available. Otherwise, include this in shared services.
- **Tenant Spaces, Purchased by Landlord:** Lettable floor area that is or can be occupied by tenants, and for which energy consumption is purchased by the landlord.
- **Tenant Spaces, Purchased by Tenant:** Lettable floor area that is or can be occupied by tenants, and for which energy consumption is purchased by the tenant.

An important distinction is made between data coverage and maximum potential coverage:

- **Data Coverage (m2/sq.ft):** The part of the asset or portfolio for which data is available, per space and fuel type. The floor area reported in these fields should reflect the floor area of the asset/portfolio for which energy consumption data is collected and reported upon.
- **Maximum Coverage (m2/sq.ft.):** The floor area reported in these fields should reflect the total floor area of the asset/portfolio of the area for which there is energy supply in the building.

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ENK_EL.EN	**Electricity**	*Consumption [kWh]*
ENW_EL.EN		*Capacity (peak demand) [kW]*

Description: The annual electricity consumption [kWh] and contracted capacity or peak demand [kW] of a building area. Electricity consumption can be either purchased by the tenant or landlord.

Requirements: *CRREM* aspires to both assess electricity demand and consumption:

- **Electricity Consumption (kWh):** Report upon the electricity consumption of the building area in kilowatt hour (kWh) for the duration of the reporting period.
- **Electricity Peak Demand (kW):** Report upon the (annual) peak electricity demand of the building area in kilowatts (kW).

Rationale:

- Electricity consumption is a key indicator for building efficiency, covering both appliances and increasingly building heating. The *CRREM Risk Assessment* links electricity to country grid carbon intensity factors, to assess a building's current and future carbon risk profile.
- Electricity demand is in many areas a key indicator for utility prices.

ENK_GA.EN	**Natural Gas**	*Consumption [kWh/m³]*

Description: Natural gas consumption of a building area. Natural gas can either purchased by the tenant or landlord, and is typically consumed for building heating.

Requirements: Report upon the natural gas consumption of the building area in kilowatt hour (kWh) or cubic meter (*m³)* for the duration of the reporting period.

Rationale: Natural gas is a key energy consumption type for building heating. The *CRREM Risk Assessment* converts natural gas consumption to carbon emissions using emission factors provided by the UK Government / BEIS 2018 Standard Set.

References: [Gov.uk - Government emission conversion factors for greenhouse gas company reporting [online]]

ENK_OI.EN	**Fuel oil**	*Consumption [kWh/litre]*

Description: Fuel oil consumption of a building area used for furnaces or boilers in buildings. Also known as heating oil. Fuel oil can either purchased by the tenant or landlord,

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 785058.

and is typically used in remote premises without a natural gas connection for residential home heating.

Requirements: Report upon the fuel oil consumption of the building area in kilowatt hour (kWh) or cubic meter (*m³)* for the duration of the reporting period.

Rationale: The *CRREM Risk Assessment* converts fuel oil consumption to carbon emissions using emission factors provided by the UK Government / BEIS 2018 Standard Set.

References: Gov.uk: Government emission conversion factors for greenhouse gas company reporting [online]

ENK_DH.EN	**District heating [steam]**	*Consumption [kWh]*

Description: System for distributing hot steam generated in a centralised location for residential and commercial heating requirements such as space and water heating.

Requirements: Report upon the steam consumption in kilowatt hour (kWh) for the duration of the reporting period. If the district heating consists of hot water instead of steam, you can report upon this in the “Other” energy consumption category.

Rationale: District heating [steam] is commonly regarded as an efficient heating source. CRREM aspires to convert district heating into emissions using localised emission factors.

ENK_DC.EN	**District cooling [chilled water]**	*Consumption [kWh]*

Description: System for distributing chilled water generated in a centralised location for residential and commercial cooling requirements.

Requirements: Report upon the chilled water consumption in kilowatt hour (kWh) for the duration of the reporting period.

Rationale: District cooling [chilled water] is commonly regarded as an efficient cooling source. *CRREM* aspires to convert district cooling into emissions using localised emission factors.

ENK_OO.--	**Other energy consumption type**	*Consumption [kWh]*

Description: Enables users to report upon other energy consumption types.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement no. 785058.

Requirements: Select the other energy consumption type from the drop-down, and report upon the other consumption type in kilowatt hour (kWh).

Rationale: Buildings can consume a wide range of energy sources in the form of fuels, gasses and solids, each corresponding to different carbon intensity values. *CRREM* aspires to measure a building's carbon performance as completely as possible, hence this other option is included for flexible reporting purposes. The following fuels and gases have been predefined:

- **Biogas (ENK_BG.EN):** Biogas consumption of a building area. Biogas can either purchased by the tenant or landlord, and it typically consumed for building heating. Some infrastructures produce it on site from anaerobic digestion of waste.
- **Biomass (ENK_BM.EN):** Biomass consumption of a building area. Biomass can either purchased by the tenant or landlord, and it typically consumed for building heating.
- **Coal (ENK_CL.EN):** Coal consumption of a building area. Coal can either purchased by the tenant or landlord, and it typically consumed for building heating.
- **Landfill gas (ENK_LF.EN):** Landfill gas consumption of a building area. Landfill gas can either purchased by the tenant or landlord, and it typically consumed for building heating.
- **LPGs (ENK_LP.EN):** Liquified Petroleum Gases (LPGs) consumption of a building area. LPGs can either be purchased by the tenant or landlord, and are typically consumed for cooking or building heating, normally in remote areas.
- **Other (ENK_OO.EN):** Energy consumption of a building area from other fuels, either purchased by the tenant or landlord.

The *CRREM Risk Assessment* converts fuel oil consumption to carbon emissions using emission factors provided by the UK Government / BEIS 2018 Standard Set.

References: Gov.uk - Government emission conversion factors for greenhouse gas company reporting [online]

Refrigerant losses

This section of the *CRREM Risk Assessment Tool* covers additional input fields for energy related Scope 1 and 2 GHG emissions including calculating Scope 1 GHG emissions associated with regriferent losses or fugitive emissions. Refrigerant losses can be an important emission factor related to cooling. This section allows users to provide self-calculated GHG emissions, as an alternative to the *CRREM* GHG conversion system based on entering data.

CBO_RF.FG	**Refrigerant losses**	*[kg]*

Description: Report upon refrigerant losses associated with fugitive emissions due to air conditioning, refrigeration or industrial processes. Fugitive emissions contribute to both climate change and local air pollution

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 785058.

Requirements: Report upon the type of gas as well as the leakage in kilograms (kg). Users have the option to report upon two types of refrigerant gases per asset. The *CRREM Risk Assessment* converts refrigerant losses to carbon emissions using official emission factors.

Rationale: Fugitive emissions can be an important source of Scope 1 emissions especially for retail assets or assets with (older) air conditioning systems.

References: Gov.uk - Government emission conversion factors for greenhouse gas company reporting [online]

Renewable energy generation

This section of the *CRREM Risk Assessment Tool* covers renewable energy generated and purchased by the portfolio. The use of renewable energy reduces negative environmental impacts associated with fossil fuel use.

The *CRREM Risk Assessment Tool* has a designated field to report upon Solar PV:

- **Solar PV:** Energy generated from solar heat and/or radiant light. Photovoltaic systems generate electrical power from sunlight by using solar cells or semiconductors. Solar water heating systems capture the heat from sunlight using solar thermal collectors to produce hot water.

Additionally, users can report upon an “other” renewable energy type, if these can be reported upon using kWh. Participants have the option to report upon one of the following renewable energy options:

- **Geothermal energy:** Energy from heat generated by the earth’s matter (e.g. ground pump heating systems). This includes geothermal storage.
- **Hydro energy:** Energy generated by the gravitational force of falling or flowing water.
- **Wind energy:** Energy generated by using wind turbines.

Biofuels, which can also be considered renewables, need to be reported upon in the “other energy consumption type field”.

ENK_RW.L1	***Generated and consumed on-site by landlord***	*[kWh]*

Description: Report upon the renewable energy that was generated on-site, as well as consumed on-site, by the landlord.

Requirements: Report upon the renewable energy in terms of kilowatt hour (kWh). Users have the option to report upon two types of renewables, of which one is Solar PV.

Rationale: Renewable energy generated and consumed on-site makes electricity costs less dependent upon energy price fluctuations.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement no. 785058.

ENK_RW.L2	***Generated on-site and exported by landlord***	*[kWh]*

Description: Report upon the renewable energy that was generated on-site but exported by the landlord.

Requirements: Report upon the renewable energy in terms of kilowatt hour (kWh). Users have the option to report upon two types of renewables, of which one is Solar PV.

Rationale: Renewable energy generated on-site and exported can serve as a hedge against energy price fluctuations.

ENK_RW.T1	***Generated on-site by third party or tenant***	*[kWh]*

Description: Report upon renewable energy that was generated on-site by a third party or the tenant. Many landlord's lease out their rooftops to specialised Solar PV providers.

Requirements: Report upon the renewable energy in terms of kilowatt hour (kWh). Users have the option to report upon two types of renewables, of which one is Solar PV.

Rationale: Renewable energy generated on-site by a third-party increases the sustainability profile of an asset.

ENK_RW.L3	***Generated off-site and purchased by landlord***	*[kWh] / Drop-down*

Description: Report upon renewable energy that was generated off-site and purchased by the landlord.

Requirements: Report upon the renewable energy in terms of kilowatt hour (kWh). Users have the option to report upon two types of renewables, of which one is Solar PV.

- **Type of contract:** Select the type of contract that was used for purchasing renewable energy, as well as the contract's duration.
    - **Power Purchase Agreement (PPA) <x years>:** a contract that defines commercial terms between two parties, one which generates electricity and one which is looking to purchase electricity (the landlord). Also select the duration of the agreement.
    - **Renewable Energy Certificates (RECs)**: Tradable, non-tangible energy commodities that represent proof that renewable energy was generated.

Rationale: Renewable energy generated off-site and purchased by the landlord reduces a portfolio's carbon emissions. Off-site renewable energy contracts with a longer duration lock in an asset's energy price.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 785058.

ENK_RW.T3	***Generated off-site and purchased by tenant***	*[kWh]*

Description: Report upon renewable energy that was generated off-site and purchased by the tenant.

Requirements: Report upon the renewable energy in terms of kilowatt hour (kWh). Users have the option to report upon two types of renewables, of which one is Solar PV.

Rationale: Renewable energy generated off-site and purchased by the tenant reduces a portfolio's (Scope 3) GHG Emissions.

Building-use

This section of the *CRREM Risk Assessment Tool* covers building-use information. Tenant use is an important factor determining a portfolio's carbon profile. Some building use cases however, are inherently energy intensive, but not necessarily inefficient. The C*RREM Risk Assessment Tool* aspires to normalise for these cases using regression models and includes several data fields that will be used for this:

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BSR_VC.AN	***Average annual vacancy rate***	*[%]*

Description: The average rate of vacancy per annum of the asset.

Requirements: Report upon the vacancy rate during the reporting year. If part of the building was vacant for only a part of the year, include this in your calculation. *CRREM* assumes percentages are provided using a 0% to 100% scale. If left blank, the tool assumes no vacancy during the reporting period.

Rationale: Vacant assets generally consume significantly less energy compared to non-vacant assets. Assuming decreasing vacancy rates over time, energy consumption and GHG emissions will increase.

BSX_OP.IY	***Operational use intensity***	*Dropdown / metric*

Description: Provide an intensity factor that indicates how intensive the asset is used by the tenant.

Requirements: Select the operational use intensity type from the drop-down list and provide the intensity metric. *CRREM* aspires to normalise for the following intensity metrics:

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- **Number of workers per floor area:** Measures average office space per floor area.
- **Number of hotel rooms:** Space use in hotels.
- **Number of visitors:** Operational intensity retail assets and hotels.

[More Operational Use Intensity metrics to be added]

Rationale: More intensively used assets generally consume more energy, even though more intensive use of space is likely to reduce overall carbon emissions from a macro perspective.

BSX_REST.	***Restaurant or cafeteria in asset***	*[True/False]*

Description: Indicate whether there is a restaurant or cafeteria present in the asset.

Requirements: Simply select True/False. If left blank, the *CRREM* Tool assumes there is no cafetaria present in the asset.

Rationale: Restaurants or cafetaria spaces generally consume more energy than other spaces.

BSX_TE.TY	***Tenancy characteristics***	*Dropdown / [m²/ft²]*

Description: Provide the primary characteristics of the tenants included in the asset.

Requirements: Select a tenant type from the dropdown list and provide an indication of this tenant's floor area.

- **Retail - Cinema**
- **Retail - Supermarket:** Supermarket or other type of convenient store.
- **Retail - Restaurant:** A regular type of restaurant.
- **Retail - Restaurant (high consumption):** Restaurant with a high energy consumption profile (e.g., wok restaurant, hot pot, korean bbq).
- **Retail - Retail Shop:** A general retail store.
- **Retail - Electronics:** A retail store selling electronic appliances.
- **Retail - Other:** Any other type of retail store.

[More tenancy types to be added]

Rationale: The type of tenant can strongly impact the energy consumption of the asset. The *CRREM Risk Assessment Tool* aspires to normalise for this.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 785058.

GHG Emissions data

Offsets and net zero commitment

This section enables users to report upon any GHG offsets that were purchased to offset their carbon emissions. One reason why portfolios offset carbon is to commit to being or becoming a net zero carbon real estate portfolio. Committing to becoming a net zero portfolio changes a portfolios carbon risk characteristics.

CBB_OF.PU	**GHG Offsets purchased**	*[kgCO2e]*

Description: Greenhouse gas offsets (Carbon offsets) can be purchased to compensate for the GHG emissions of the portfolio.

Requirements: Report upon the purchased GHG offsets in terms of kgCO2e.

Rationale: With current technologies, GHG Offsets are an important element of making a real estate portfolio carbon neutral. Having a policy to completely offset emissions improves the internal cost-benefit analysis of implementing energy efficiency investments.

PRB_OF.OT	**GHG Offsets costs**	*[€/kgCO2e]*

Description: The costs associated with the carbon offsets purchased.

Requirements: Report upon the purchased GHG offsets in terms of kgCO2e.

Rationale: With current technologies, GHG Offsets are an important element of making a real estate portfolio carbon neutral. Having a policy to completely offset emissions improves the internal cost-benefit analysis of implementing energy efficiency investments.

RET_NZ.YT	**Net zero carbon commitment**	*year*

Description: Report whether the organisation has made any commitments to be net zero carbon.

Requirements: Provide the year during which the organisation became net zero, or the point at which when the organisation will become net zero. If left blank, *CRREM* assumes the organisation has not made any net zero carbon commitment.

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Rationale: A net zero carbon commitment changes an organisation's carbon risk profile, as GHG emissions will need to be offset, and future offset costs can be modelled using different climate change scenarios.

CRREM Calculated GHG Emissions

This section covers the portfolio's carbon emissions as calculated from the Asset Input Data sheet. The *CRREM* tool converts energy consumption data into GHG Emissions. If no data coverage is available for certain areas, *CRREM* uses and estimation model that still provides insights into potential carbon emissions.

Carbon data is available for the same areas that were explained in the Energy Consumption paragraph:

- **Whole building:** Carbon emissions used by tenants and base building services to lettable/leasable and common spaces.
- **Base building:** GHG emissions related to central building services to lettable/leasable areas and common areas.
    - **Common Areas:** Areas shared with other building occupants, including, but not limited to: entrance areas, corridors, lifts, staircases, waste storage stores, communal kitchen and breakout facilities.
    - **Shared Services / Central Plant:** Shared Services/Central Plant is a central source providing energy for the whole building, including common areas and shared services for tenants.
    - **Outdoor/Exterior Areas / Parking:** Areas outside the building that are not considered as part of the lettable/leasable area, but which are within the site boundaries. Only complete these fields in case separate consumption data for outdoor, exterior and/or parking is available. Otherwise, include this in shared services.
- **Tenant Spaces:** Lettable floor area that is or can be occupied by tenants.

Greenhouse emissions can generally be split up in the following three categories, in accordance with the Greenhouse Gas Protocol Corporate Standard:

- **Scope 1:** GHG emissions from greenhouse gas sources (greenhouse gas source physical unit or process that releases a GHG into the atmosphere) owned or controlled by the organisation.
- **Scope 2:** Energy-related indirect greenhouse gas emission. GHG emissions from the generation of imported electricity, heat or steam consumed by the organisation.
- **Scope 3:** Other indirect greenhouse gas emissions. GHG emissions, other than purchased energy-related GHG emissions, which is a consequence of an organisation's activities, but arises from greenhouse gas sources that are owned or controlled by other organisations.

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CBB_FG.CB	**Fugitive emissions**	*[kgCO2e]*

Description: Fugitive emissions in terms of kilograme CO2 equivalents. Fugitive emissions that result from the release of HFC or other GHG gasses during the use of refrigeration, air conditioning, or industrial processes. Fugitive emissions are generally considered to be Scope 1 emissions.

Rationale: Fugitive emissions contribute to both climate change and local air pollution

References: Derived from Refrigerant losses (CBO_RF.FG).

CBB_RE.CB	**Reported GHG Emissions**	*[kgCO2e]*

Description: Reported emissions in terms of kilograme CO2 equivalents, along with the data coverage as a percentage, without accounting for data gaps.

- **kgCO2e:** Emissions are calculated through a combination of national grid emission factors and the BEIS 2018 Standard Set.
- **Data coverage:** Data coverage is calculated separately for each area, by summing up all data coverage areas from energy consumption in the Asset Data Input sheet and dividing that by all maximum coverage areas that can relate to that.

Rationale: A building's carbon emissions already provide an early indication of carbon risk. This data field is used for estimating complete carbon emissions per asset and subsequently normalising these.

References: Derived from energy consumption fields in Asset Data Input sheet in combination with BEIS 2018 Standard Set and national electricity grid intensity factors.

CBB_ES.CB	**Estimated Emissions**	*[kgCO2e]*

Description: The asset's emissions in terms of kilograme CO2 equivalents, along with a confidence interval data point.

- **kgCO2e:** Emissions are calculated through a combination self-reported energy data and the CRREM estimation model.
- **Confidence interval:** A to be developed confidence interval, indicating in what range the asset's carbon emissions are estimated to be.

Rationale: A building's estimated emissions can provide a better indication of carbon risk if there are significant data gaps.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 785058.

References: Derived from energy consumption fields in Asset Data Input sheet in combination with BEIS 2018 Standard Set, national electricity grid intensity factors, and the 2018 GRESB Asset Database.

Self-reported GHG Emissions

CBX_S2.ME	**Scope 2 Methodology**	*Drop-down*

Description: Provide what scope 2 calculation methodology was used. Scope 2 GHG emissions can either be calculated using the market-based approach or location-based method.

- **Market-based method:** A method to quantify Scope 2 GHG emissions based on emissions by the generators from which the reporter contractually purchases electricity. The market-based method reflects the GHG emissions associated with the choices a consumer makes regarding its electricity supplier or product (or the lack of choice).
- **Location-based method:** A method used to quantify Scope 2 GHG emissions based on average emissions intensity of grids on which the energy consumption occurs (using grid-average emission factor data). Emission factors are often defined using geographic locations. These can be based on local, subnational, or national boundaries.

Requirements: Use the dropdown to select the appropriate method. Report the GHG emissions in the subsequent fields.

- **Market-based method:** Report upon the GHG emissions as provided by the energy provider.
- **Location-based method:** *CRREM* automatically calculates GHG emissions using the location-based method using national grid intensity factors. As such, users are suggested to only report upon location-based GHG emissions if they believe their calculations are more accurate than the *CRREM* calculations. There can be several reasons for this:
    a. The user's own DMS calculates location based GHG emissions at time intervals shorter than a year (implying the use of sub-annual or even real time emission factors).
    b. The user's own DMS uses emission factors that are geographically more granular than those used by *CRREM* (e.g., at a sub-national or regional level).

Rationale: Market-based emission factors depend on the individual energy procurement. User must either enter their specific market-based emission factor to enable the *CRREM* tool to automatically calculate Scope 2 emissions from entered energy consumption data, or directly enter Scope 2 emissions data if known.

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CBB_S2.CB	**Whole building - Energy related Scope 2 GHG emissions**	*[kgCO2e]*

Description: Scope 2 GHG emissions related to the whole building.

Requirements: Use either the location or market based method as designated in SC2.MET**.** When using these fields, *CRREM* assumes that the user provides all Scope 2 GHG emissions associated with the building and that no Scope 2 GHG data is missing. If data is missing from, for example, tenant areas, ensure to use an appropriate estimation methodology for this.

Rationale: Allows users to report upon market-based Scope 2 GHG emissions and self-calculation location bases emissions.

CBB_S2.CC ***CBB_S2.SS*** ***CBB_S2.IP*** ***CBB_S2.OA***	**Base building - Energy related Scope 2 GHG emissions**	*[kgCO2e]*

Description: Scope 2 GHG emissions related to energy consumed by central building services to lettable/leasable areas and common areas.

- **Common Areas:** Areas shared with other building occupants, including, but not limited to: entrance areas, corridors, lifts, staircases, waste storage stores, communal kitchen and breakout facilities.
- **Shared Services / Central Plant:** Shared Services/Central Plant is a central source providing energy for the whole building, including common areas and shared services for tenants.
- **Outdoor/Exterior Areas / Parking:** Areas outside the building that are not considered as part of the lettable/leasable area, but which are within the site boundaries. Only complete these fields in case separate consumption data for outdoor, exterior and/or parking is available. Otherwise, include this in shared services.

Requirements: Use either the location or market based method as designated in CBN_S2.ME**.** When using theses fields, *CRREM* assumes that the users provide all GHG emissions associated with the base building and that no Scope 2 GHG data is missing. If data is missing from, for example, tenant areas, ensure to use an appropriate estimation methodology for this.

Rationale: Allows users to report upon market-based Scope 2 GHG emissions and self-calculation location bases emissions.

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CBB_S2.TE	**Tenant Spaces - Energy related Scope 2 GHG emissions**	*[kgCO2e]*

Description: Scope 2 GHG emissions related to tenant spaces.

- **From energy purchased by landlord:** Scope 2 GHG Emissions resulting from energy consumption that was purchased by the landlord.
- **From energy purchased by tenant:** Scope 2 GHG Emissions resulting from energy consumption that was purchased by the tenant.

Requirements: Use either the location or market based method as designated in SC2.MET**.** When using theses fields, *CRREM* assumes that the users provides all Scope 2 GHG emissions associated with the tenant spaces and that no Scope 2 GHG data is missing. If data is missing from, for example, tenant areas, ensure to use an appropriate estimation methodology for this.

Rationale: Allows users to report upon market-based Scope 2 GHG emissions and self-calculation location bases emissions.

Default asset data

This sheet is specific for advanced users and allows them to overwrite default data points to tailor the *CRREM Risk Assessment Tool* to portfolio-specific scenarios. *CRREM* assumes default scenarios that impact energy and carbon emissions normalisation, energy prices, climate transition pathway, and retrofit and abatement costs.

Normalisation

This section contains several options allowing users to change asset-level settings to normalise for occupancy, weather, operating hours and holidays.

REX_NO.OC	***Normalise consumption data to 100% occupancy rate***	*[TRUE/FALSE]*

Description: Enables the user to specify whether to normalise for 100% occupancy.

Requirements: Select TRUE or FALSE. By default this is set to TRUE.

Rationale: Vacancy can be an important factor impacting the carbon emissions of an asset.

References: Normalisation is based upon “average annual vacancy rate” (BSR_VC.AN) reported in the asset input sheet.

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REX_CU.DD	***Normalise current heating & cooling degree days***	*[TRUE/FALSE]*

Description: Enables the user to normalise the reporting year for heating & cooling degree days

Requirements: Select TRUE or FALSE. By default this is set to TRUE.

Rationale: Climatic differences can impact an asset's energy consumption through heating or cooling requirements.

References: Normalisation is based upon a climatic model derived from the European Environmental Agency.

REX_FU.DD	***Normalise future heating & cooling degree days***	*[TRUE/FALSE]*

Description: Enables the user to normalise the projected future heating and cooling degree days impact on energy consumption and carbon emissions.

Requirements: Select TRUE or FALSE. By default this is set to TRUE.

Rationale: Climatic differences can impact an asset's energy consumption through heating or cooling requirements.

References: Normalisation is based upon a climatic model derived from Spinoni et al. (2018).

BST_OH.WK	***Weekly operating hours***	*[Hours/week]*

Description: The number of hours that the asset is open to the public or that the majority of the workforce is present.

Requirements: Either report upon the number of hours per week that the asset is open to the public (if the asset it open to customers), or that the majority of the workforce is present.

Rationale: Operation hours are an important determinant of energy use. Low weekly operating hours can result in low energy consumption even if the intrinsic energy efficiency of an asset is poor.

References: EPA ENERGY STAR - How do I determine Weekly Operating Hours? [online]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 785058.

BST_HO.AN	***Holidays***	*[Days/year]*

Description: The number of holidays that affected the assets opening hours.

Requirements: The number of days during the year.

Rationale: During holidays assets can be closed to the public impacting energy use.

Emission factors

CBK_EC.EN	***GHG emission factor for electricity consumption***	*[kgCO2/kWh]*

Description: Alternative emission factor for electricity consumption. This can either be market or location based.

Requirements: Provide the alternative electricity grid carbon intensity factors.

Rationale: Buildings can have unique electricity grid intensity factors.

CBK_DH.EN	***GHG emission factor for district heat consumption***	*[kgCO2/kWh]*

Description: Alternative emission factor for district heating.

Requirements: Provide the alternative district heating intensity factors.

Rationale: The carbon intensity of district heating system can differ strongly across regions.

Energy prices

Enables users to overwrite asset-level energy price assumptions. Larger portfolios generally have more market power to set prices, and could thus face lower energy prices. Elements to be covered:

- Price per kWh gas consumption [€/$]
- Annual price increase per kWh gas consumption [%]
- Initial price per kWh oil consumption [€/$]
- Annual price increase per kWh oil consumption [%]
- Initial price per kWh district heating/cooling consumption [€/$]
- Annual price increase per kWh district heating/cooling consumption [%]
- Initial price per kWh electricity consumption [€/$]
- Annual price increase per kWh electricity consumption [%]
- Initial price per kWh renewable consumption [€/$]
- Annual price increase per kWh renewable consumption [%]

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Carbon prices

Enables users to overwrite asset-level carbon price assumptions. Elements to be covered:

- Consideration of a (fictional) carbon price [TRUE/FALSE]
- Default or own assumptions on carbon pricing
- Method for defining own carbon price development
- Year for beginning of carbon pricing
- Carbon price in initial year [€/tCO2]
- Target year for carbon price climax
- Climax carbon price in target year [€/tCO2]
- Year for beginning of carbon pricing
- Carbon price in initial year [€/tCO2]
- Type of growth path ('Linear' / 'Constant growth factor')
- Annual increase of carbon price [€/tCO2/a]
- Annual growth of carbon price [%]

Energy transition pathway

Enables users to provide specific renewable energy scenarios for the country or region the asset is located in.

- Renewable energy share of electricity consumption for 2020 in specific country/region
- Renewable energy share of electricity consumption for 2030 in specific country/region
- Renewable energy share of electricity consumption for 2040 in specific country/region
- Renewable energy renewable share of electricity consumption for 2050 in country/region

Retrofit model

Enables users to alter asset level retrofit assumptions and tailor the marginal abatement cost model. Enables adjusting the following elements:

- Discount rate for valuing future spendings and savings
- Property type and construction year specific abatement costs
- Choose default or own assumptions on abatement costs
- Choose abatement costs [€/(kWh/m²/a)]
- Annual reduction of costs for energetic refurbishments due to technological innovation ('Yes' / 'No')
- Factor for annual reduction of costs for energetic refurbishments due to technological innovation [%]

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Unit conversion tool

The *CRREM Unit conversion tool* is located in a separate sheet of the *CRREM* tool and allows users to convert different units of energy consumption and area, enabling the calculation of required values.

Energy consumption by burning natural gas can be entered either in kilowatt hour (kWh) or cubic meters (m³) directly in the Asset input data sheet I Regarding fuel oil, consumption data can be entered in kWh or litre. All other energy sources must be entered in kWh.

Floor area input data can be entered in square meter (m²) or square feet (ft²). Data on energy consumption or floor area based on other units must be converted into on of the supported units.

The *CRREM Unit conversion tool* enables users to do this conversion directly in the *CRREM* tool for a wide range of the most common units including the possibility to take account of common unit prefixes like *kilo* or *mega* (bold values can be directly entered in the tool):

Energy				
Kilowatt hour (kWh)	Kilojoule (kcal)	Kilocalories (kcal)	British thermal unit (btu)	Ton-hour

Square measures / Surface dimension				
Square metre (m²)	**Square foot (ft²)**	Square mile (sq mi)	Square yard (sq yd)	Acre (ac)

Cubic / volume measures						
Cubic metre (m³)	**Litre (l)**	Hectolitre (hl)	Cubic foot (cft)	Imperial gallon (Imp.gal)	Amercian gallon (US.liq.gall)	Amercian barrel (bbl)

Natural gas			
Kilowatt hour (kWh)	**Cubic metre (m³)**	Other energy units (see above)	Other cubic measures (see above)

Fuel oil			
Kilowatt hour (kWh)	**Litre (l)**	Other energy units (see above)	Other cubic measures (see above)

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Results: Asset level

This sheet contains all relevant analysis results on the individual asset level based on entered asset data input and the selected default or user-defined values and assumptions. The sheet is structured in two sections:

The upper part of the asset level results sheet shows a summary of the most important analysis results for a selected individual asset. After selecting an individual asset, the tool displays the stranding diagram with the decarbonisation target pathway based on the assets building type and location (country). The user can choose on which global warming target (1.5°C or 2°C) the decarbonisation pathway shall be based on or whether to apply user-defined target values. The diagram further contains the baseline and estimated future GHG intensity of the selected asset considering country-specific grid decarbonisation and location-specific (Zip code) effects of climate change (based on default or user-defines values). The diagram displays the potential year of stranding (red circle) when the asset's GHG intensity is higher than the decarbonisation target. Here are also two links to the specific rows of the selected asset in the asset data input sheet and the default data sheet enabling to do retrospective changes and assess the resulting effects.

Also in the upper part of the asset level results sheet, besides the stranding diagram, the tool provides a table with decarbonisation targets for the chosen asset on an annual basis (based on the selected global warming target) as well as further key analysis findings like

- estimated baseline annual energy costs,
- baseline whole building, base building and tenant space GHG emissions and intensity,
- cumulative emissions until 2050,
- the remaining emissions budget according to decarbonisation targets,
- Scope 1, 2 and 3 emissions,
- the cumulated amount of GHG emissions surpassing the decarbonisation target (these "excess emissions" can optionally be visualised on the stranding diagram) and
- the monetary costs of these emissions assuming a certain carbon price.

Below the graphical and tabulated results for individual selected assets, the tool contains a table of all entered assets, some key user input data (location, building type) and numerous derived data on stranding risk, energy consumption, GHG emissions and intensity, decarbonisation target and derived cost data (energy, carbon and retrofits) for each individual asset. The data is presented starting with the year of assessment until 2050 based on an annual basis, or in the form of cumulated figures where appropriate. Expand the respective columns by clicking the respective plus-symbol above the column captions. The tabulated part of the asset level results sheet provides direct links to adapt data input or default values for each asset.

The asset level results sheet further links to the to-be-developed retrofit planning tool, enabling users to assess the retrofits costs necessary to comply with decarbonisation

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targets. The tool offers an analysis of potential economic and ecological costs and benefits of retrofits and will include analysis options for the embodied carbon of retrofits.

Results: Portfolio level

This sheet provides specific graphs and metrics that can be used for structured carbon risk reporting between real estate investors and their fiduciaries. The insights in this tab will specifically be aligned with the Task Force on Climate-related Financial Disclosures (TCFD) recommendations as well as EPRA's Sustainability Best Practice Recommendations (SBPRs). All relevant asset level output figures can be aggregated for an entire entered portfolio or as belonging to specific funds, entities, building types or territorial units (countries or sub-national). The *CRREM* tool provides result figures for the selected type of aggregation comparable to those for individual assets applying weighted decarbonisation targets and pathways. It is also possible to compare individual assets and/or specified aggregations with each other and to assess the share of stranded assets for example within a specified fund or selected countries including the development over time of this share (based on the number of assets, GAV or floor area).

Statistical model

In this sheet *CRREM* conceals its statistical model coping with data gaps and other sources of uncertainty.

It is important to ensure that the data inputted into the *CRREM* tool is of significant quality and that a company is aware of certain data gaps. This is especially relevant, as underreporting of, for instance, energy consumption data, can lead to an underassessment of a portfolio's carbon risk. To avoid underreporting risks, *CRREM* encourages users to conduct rigorous data quality checks and conduct third-party verification on energy and carbon data inputted into the tool.

The *CRREM* tool has specifically been designed to enable risk assessment calculations with limited information. If a company is unable to collect, for example, the energy consumption data from a single tenant, the user can consider this in the further analysis process by providing information on specific data gaps. Based on building-type-specific typical default values, the *CRREM* tool estimates missing data and provides the user with information on the resulting degree of uncertainty: The higher the data coverage, the lower the uncertainty and risk.

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Additional Resources

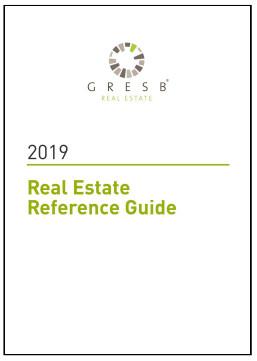
The development of the *CRREM* Tool has been underpinned by significant academic research. For this, *CRREM* has identified a wide range of academic articles and other resources, relevant for understanding carbon risk in real estate. A selection of these readings can be found on the *CRREM* website (available here).

CRREM specifically recommends real estate investment sustainability practitioners that use the Risk Assessment tool to have a comprehensive understanding of the following frameworks, as these have formed the basis in the development of the CRREM Risk Assessment tool, and represent overall industry best practices:

Stranding Risk & Carbon: Science-based decarbonising of the EU commercial real estate sector

This report forms the theoretical basis of the *CRREM Risk Assessment Tool*. In the report, *CRREM* explains how it defines science-based decarbonisation targets and pathways specifically for the commercial real estate industry. Additionally, the report covers corporate strategies for reducing carbon risk.

2019 GRESB Real Estate Assessment Reference Guide



The GRESB Real Estate Assessment is the global standard for ESG benchmarking and reporting for listed property companies, private property funds, developers and investors that invest directly in real estate. The Assessment evaluates performance against 7 Sustainability Aspects, including information on performance indicators, such as energy, GHG emissions, water and waste, or tenant and community engagement.

EPRA Sustainability Best Practices Recommendations Guidelines

The EPRA Sustainability Best Practices Recommendations (sBPR) consist of guidelines on how listed real estate companies and REITs should disclose their sustainability information. The guidelines have been developed by the EPRA Sustainability Reporting Committee in consultation with other EPRA members. These measures are largely based on the GRI Standards and Construction and Real Estate Sector Supplement Disclosure.

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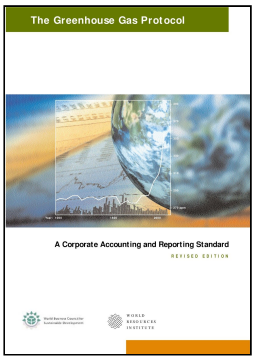
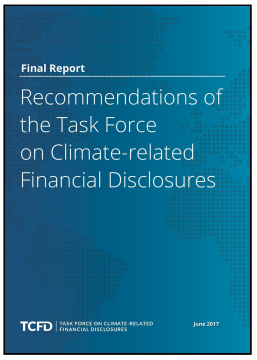
The GHG Protocol Corporate Accounting and Reporting Standard



The GHG Protocol Corporate Standard provides requirements and guidance for companies and preparing a corporate GHG emissions inventory. It is the most important global standard for corporate GHG accounting, and its principles form the basis of most other GHG reporting regimes.

Recommendations of the Task Force on Climate-related Financial Disclosures



The TCFD recommendations are designed to disclose forward looking information on the material financial impacts of climate-related risks and opportunities. This includes risks related to the global transition to a lower-carbon economy. The recommendations are expected to form a key part of corporate communications on climate-related risks.

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Appendix A: Acronyms and Abbreviations

CDD	Cooling Degree Day
DKK	Danish Krone
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CRE	Commercial Real Estate
CRREM	Carbon Risk Real Estate Monitor
DMS	Data Management System
EPC	Energy Performance Certificate
EPRA	European Public Real Estate Association
EU	European Union
EUR	Euro
ft^2	Square feet
GBP	Pound Sterling
GHG	Greenhouse gas
GRI	Global Reporting Initiative
GWP	Global Warming Potential
HDD	Heating Degree Day
HFC	Hydrofluorocarbons
HVAC	Heating, Ventilation and Air Conditioning
IEA	International Energy Agency
INDC	Intended Nationally Determined Contribution
INREV	European Investors in Non-Listed Real Estate
IPCC	Intergovernmental Panel on Climate Change
IPMS	International Property Measurement Standards
JV	Joint Venture
kWh	Kilowatt hour
m^2	Square metre
NUTS	Nomenclature of Territorial Units for Statistics
LP	Limited Partner (in private equity)
PV	Photovoltaics
PPA	Power Purchase Agreement
sBPR	Sustainability Best Practice Recommendations
SBT	Science Based Targets
SDA	Sectoral Decarbonisation Approach
SEK	Swedish Krona
USD	United States Dollar

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Appendix B: Frequently Asked Questions

Who should I use the CRREM Risk Assessment Tool?

The *CRREM Risk Assessment tool* helps asset owners and managers understand the long term transition risks of their real estate investment portfolios. Climate change might endanger the business case of real estate companies if no measures to transform the property stock under management are taken. Therefore, a stronger focus on climate change risk management is essential. A company strategy and risk management must ensure that individual efforts to mitigate CO2 within their portfolio must be sufficient to fulfill EU targets – otherwise the market participant might face a situation where properties do not meet future market expectations and therefore will be exposed to write-downs (we call this the risk of "Stranded assets"). The *CRREM Risk Assessment tool* help users to assess the carbon risks of commercial real estate equity investments based on property specific decarbonisation pathways ensuring that assets are aligned with the Paris climate targets.

Will the CRREM Risk Assessment Tool also cover non-EU countries or residential assets?

The current scope of the *CRREM* project only covers EU countries and commercial real estate properties. The Risk Assessment tool and methodological foundations might also be applicable for non-EU countries and residential properties.

How can I be involved in the development of the CRREM Risk Assessment tool?

Parties that are interested in providing feedback or pilot testing the *CRREM* tool can contact info@crrem.eu.

How is the CRREM Consortium funded?

The *CRREM* Project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 785058.

Is the CRREM Risk Assessment tool free?

The *CRREM Risk Assessment tool* can freely be used for non-commercial use and can be used in corporate reporting if correctly referenced. If you are interested in using the *CRREM Risk Assessment tool* for commercial purposes, please contact info@crrem.eu.

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