Carbon Risk Real Estate Monitor

CRREM Risk Assessment Reference Guide

- User manual for the CRREM Risk Assessment Tool V2

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Please note: Users will fill in the tool offline, therefore no private user data will be saved by the CRREM initiative.

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1 INTRODUCTION

ABOUT CRREM

The *Carbon Risk Real Estate Monitor (CRREM)* is the leading global initiative for establishing targets for operational ("in-use") carbon emissions for standing real estate investments consistent with the ambitions of the Paris agreement. *CRREM* publicly released decarbonization pathways that translate the ambitions of limiting global warming to 1.5°C and 2°C by the end of the century into regionally- and property-type-specific trajectories against which real estate assets and portfolios can benchmark themselves.

The pathways and other resources provided - like the *CRREM-Tool* - to assess asset benchmarking with relevant trajectories, help the market to identify and price risks related to in-use carbon emissions from buildings. *CRREM* is aligned with the leading international accounting and reporting frameworks, disclosure guidelines and recommendations published by initiatives working within the field of decarbonization and real estate. The initiative was initially an EU project and is now being funded by the Laudes Foundation as well as APG Asset Management, PGGM and Norges Bank Investment Management, and supported by major industry bodies such as SBTi, INREV, IIIGCC, NZAOA and many others.

The developed software (so called "CRREM-Tool" or Carbon Risk Assessment Tool) derives carbon emission intensities as well as energy consumption intensities and demonstrates the 1.5-degree-readiness of each analysed property. Besides isolating transition risks of individual properties, the tool also helps to identify and visualise strategies for improvement. Related to this document we advise interested parties to also refer to other documents provided by the CRREM initiative:

- CRREM Methodology & downscaling documentation: Online via https://www.crrem.eu/tool/
- Carbon accounting document: Online via https://carbonaccountingfinancials.com/en/standard
- CRREM definition of the term "stranding" and "stranding risk" often used in this document: Online via https://www.crrem.eu/tool/

CARBON RISK ASSESSMENT TOOL FOR "IN-USE" EMISSIONS

The *CRREM Risk Assessment Tool* to identify stranded assets is designed for asset owners and investors to understand the carbon risks – also referred to as transition risk - inherent in their real estate portfolio.

CRREM has derived decarbonisation pathways by breaking down the global anthropogenic GHG emissions budget that is consistent with the *Paris Climate Agreement* towards individual countries, the respective real estate sector in those countries, 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 (the developed "pathways") in line with the Paris Agreement (i.e., limiting global warming to 2°C / 1.5°C). The *CRREM* software is XLS based and helps to identify which properties will be at risk of stranding due to the expected increase in stringent building codes, other regulation, shifting demand and carbon prices. It also enables an analysis of the effects of refurbishing single properties on the total carbon performance of a portfolio or entire company, including by assessing emissions related to the embodied carbon of the energetic retrofit itself.

The *CRREM* tool and pathways were originally developed for commercial real estate in Europe only. Over time the scope and coverage evolved significantly: to date global pathways for residential and commercial real estate have been

developed covering 44 countries which translates to approx. 90% of the institutional property stock. In addition to national trajectories also sub-regional pathways have been released for some regions like Australia and the USA. The global and sub-regional pathways are available via: www.crrem.org and www.crrem.eu/tool. Separate *CRREM* tool versions for Europe, Asia-pacific and North America are available for download.

By applying the guide "How to use the tool for non-covered countries", users can enter any further country pathways or the pathways for residential assets that are not prefilled in one of the three regional versions. Please note that the CRREM initiative has been providing licence agreements to many commercial providers of transition/climate risk benchmarking organizations and IT-companies. Also via their offerings the CRREM pathways can now be excessed. A full list of licence partners can be found here: link.

Your feedback is welcome: Please do not hesitate to contact us if you have any questions or wish consultation regarding the *CRREM* tool. The CRREM team appreciates industry feedback from user application (info@crrem.eu).

INTRODUCTION TO THE FUNDAMENTAL RATIONALE

This Reference Guide accompanies the *CRREM Carbon Risk Assessment Tool* for the Global Commercial & Residential Real Estate Industry. The guide provides an 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.

These pathways and targets provide global investors in Real Estate with a regional-specific roadmap for individual properties and portfolios on how to reduce carbon footprints over the next decades until 2050. Pathways are twofold: user can focus on energy intensity and carbon intensity likewise.

Please note: In addition to the CO_2-intensity pathway, the *CRREM initiative* has also published country-and property-type specific pathways which account for the other GHGs (here: refrigerant losses related to the real estate sector). The add-on for the respective countries is displayed in terms of $KgCO_2$"e" per square meter in 2020 – 2050. F-Gases at a country level have furthermore been allocated to the commercial and residential sector and given an extra allowance if cooling equipment has been installed. It is of fundamental importance that this allowance is only granted as long as the use of F-Gases is also reported for the building. If this is not the case, only the CO_2 pathway must be applied. (For further information, please see our methodology document chapter 6 "INTEGRATION OF F-GASES & OTHER GHG'S IN THE BUILDING SECTOR").

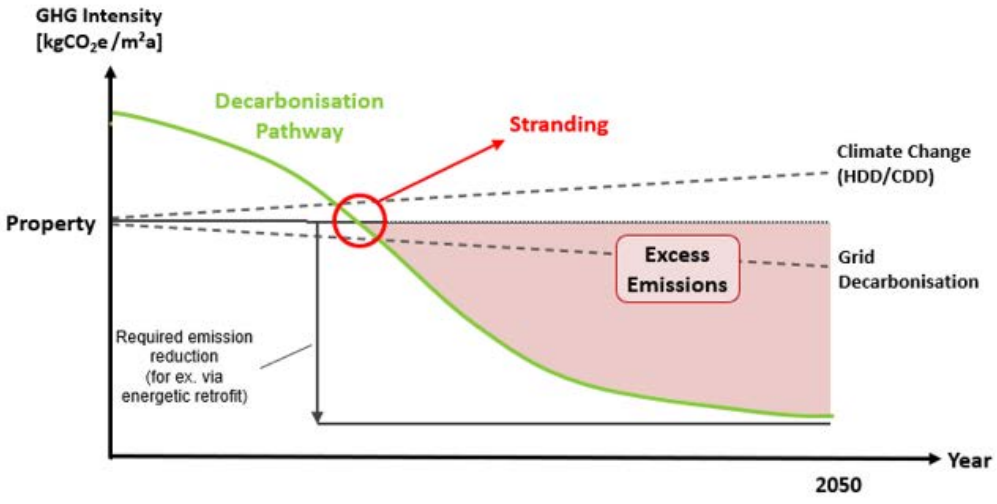


Figure 1: Stranding Diagram

'Stranding diagram': The figure 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 type in a specific country that aligns with a certain climate target (1.5°C/2°C) and must not be exceeded if a property intends to be "Paris-proof". If the emission intensity is above the target value, "stranding" occurs. In that case the asset would have a carbon-footprint that is above the fair-share derived by downscaling the carbon budget to property level.

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 (in 2050). Only appropriate retrofit measures reducing the GHG emissions can ensure that the building will meet the future emission ceilings. This might include changing the energy source (to renewables), decarbonization of the electricity grid and/or simply reducing consumption due to lower demand or due to higher insulation.

Climate Impact and Grid Decarbonisation: *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 (and energy consumption) 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, the energy required for air conditioning systems are increasing correspondingly. *CRREM* uses scientific modelling 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 or Emission Factor, EF) will continue to decrease over time.

SCOPE OF THE CRREM RISK ASSESSMENT TOOL

The scope of the *CRREM* tool is to assess the carbon risks associated with operational emissions from standing investments and retrofit actions on global commercial and residential real estate properties. *CRREM* published pathways for 44 countries, if the tool currently does not include a country your asset may be located in, users can manually enter further countries in the tool using the guide "How to use the tool for non-covered countries" (the guide and the full set of the global pathways are available on www.crrem.org).

Alignment with major initiatives

Data input for the tool was aligned with the *GRESB* asset level, further input variables for the software are also largely based upon existing frameworks, such as the *EPRA sBPRs, GRI* and the *GHG Protocol Corporate Standard – for further details also see the following report.* The output figures produced by the *CRREM* tool are also intended to assist with reporting in accordance with the *Task Force on Climate-related Financial Disclosure (TCFD) and other* frameworks.

Many further initiatives and companies have integrated the *CRREM* pathways, allowing users to benchmark for example in front-end ESG tool solutions (such as measurabl, MSCI, GRESB, etc.). The full list of *CRREM* partners is available via: www.crrem.eu/partners.

Sub Regional Pathways: Australia & USA

- USA: *CRREM* currently has sub-regional pathways for the 15 largest cities in the USA. These include New York, Los Angeles, Chicago, Houston, Phoenix, Philadelphia, San Antonio, San Diego, Dallas, San Jose, Austin, Jacksonville, Washington DC, San Francisco, and Boston.
- Australia: *CRREM* has developed sub-regional pathways for the different climate zones in Australia. These include Zone 1, 2, 3, 5, 6 and 7.[1]

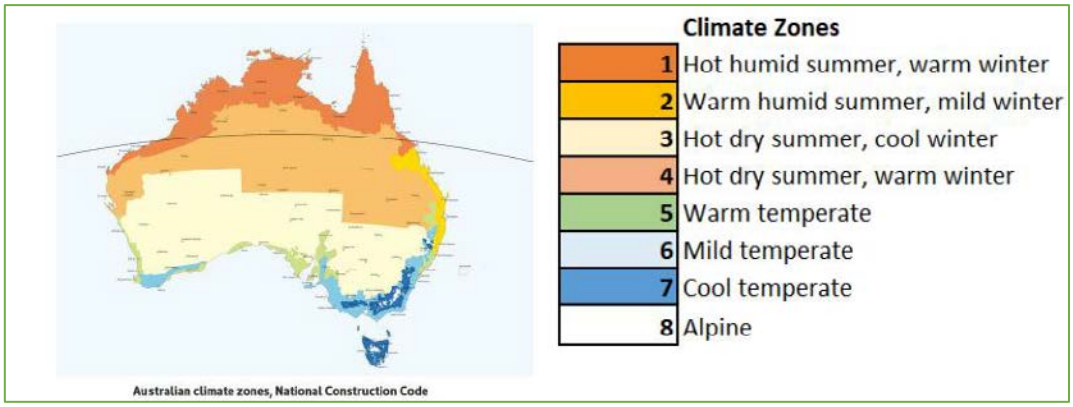


Figure 2: CRREM sub-regional pathways available for the climate zones in Australia

STRUCTURE OF THE CARBON RISK ASSESSMENT TOOL

The tool can be accessed via www.crrem.eu, the user has the option to download an empty version (for the region his property is located in) or a pre-filled version can be downloaded as an example. Once downloaded, the tool will open on the start/summary page and users have the option to navigate to different stages e.g. input sheet, asset-level or portfolio-level analysis. The tool consists of eight different pages, with the use of the starting/summary tab the user can easily access and enter the desired functionality.

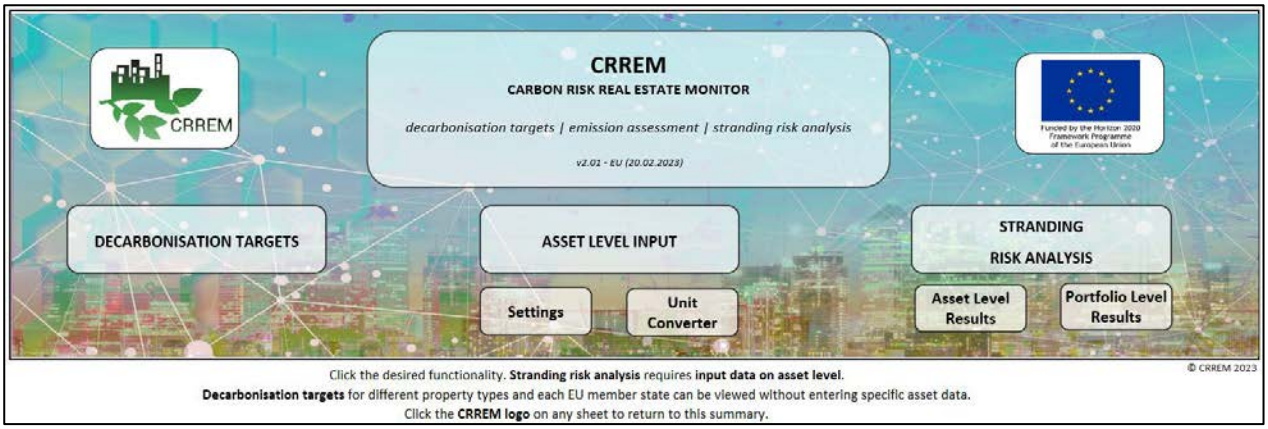


Figure 3: CRREM tool Summary/Preface Tab

[1] Please note: Whole building approach - In Australia many asset managers and investors are used to referring data and responsibility to the "base building" only (excluding tenant space). However, on a global level the industry and international standards are typically focusing on the "whole building" approach. All data if possible should therefore be entered using the "whole building" approach (or data coverage normalization will be applied).

The CRREM Risk Assessment Tool consists of the following tabs:

Summary/Preface
Enables user to enter desired functionality of the tool. By clicking on the *CRREM* logo on any sheet, the user is taken back to this summary. Short explanations of the variables and graphs are included in the *CRREM Risk Assessment Tool*. General introductory information and specific instructions on how the *CRREM Risk Assessment Tool* should be used is provided on each sheet. Further specific detail/instruction on data input is available and blended in as a comment on each cell when required.
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/GHGe/2°C/User-defined) and are presented in the form of a line chart and tabulated data. User can select country, asset type and global warming target by dropdown option. Data and graphs can in this way also be used for company target setting without using the tool itself. Users can use the tabs to directly access the different sections (e.g. data input, output, settings) of the tool or use the hyperlinks to navigate via the homepage.
Asset data input
Primary sheet where the user inputs the building data. This part covers the following categories: • **General information:** Covers basic information on the reported data, such as asset name, Gross Asset Value (GAV), reporting year, entity allocation and the period for which data is reported. • **Building characteristics:** Covers basic building characteristics such as asset location, size, property type, and primary floor areas, use of air conditioning and average annual vacant area. • **Total energy procurement:** Covers the main input field which enables users to enter whole building procured energy data, in turn used for calculating carbon emissions. • **Refrigerant losses:** Covers an additional input field for calculating fugitive emissions for the whole building using refrigerant losses. Type of gas and amount of leakage can be reported. • **Renewable energy:** Covers on-site and off-site generated renewable energy, with the differentiation of consumed on-site and export. • **Retrofit action:** Enables the user to enter one future retrofit scenario for each asset. Year of investment, value and embodied carbon related to retrofit can be entered. • **Building-use:** Covers additional building-use characteristics option of user defined settings that will enable to change the *CRREM* default assumptions for a specific asset. The individual input sections are separated by different colors (e.g. green for the general information, dark blue for the energy procurement, etc.). Please note: data in certain areas can only be filled if all other mandatory sections are completed (e.g. energy consumption data can only be supplied once the asset size has been defined). All fields mandatory are indicated and further descriptions/explanations for data input are supplied via comments. Individual assets can be chosen to be included or excluded (column D), this will enable the user to exclude certain assets in the evaluation. Please note: the properties entire “energy-consumption” therefore is made up of total energy procured and total produced and consumed on-site.

Results: Asset Level

This sheet shows the results of the *CRREM* stranding risk analysis for each property entered in the asset input sheet. The individual assets can be selected via the ID or can be viewed in a tabular format from row 35 onwards. The level of ambition (1.5°C) against which the individual asset is to be benchmarked can also be selected here. The upper part shows diagrams and specific risk analysis results for selected individual properties and global warming target.

This section covers the following analysis and diagrams per asset starting at the very left and extends to:

- **Stranding diagram:** Interactive diagram that enables users to view the point of stranding, performance and excess emissions against the selected decarbonisation target ("pathway"). The asset carbon intensity performance per year is analysed. Further the Carbon Value at Risk (CVaR) is also provided below the graph as figure.
- **Energy reduction pathway:** Shows the energy intensity per year of the individual asset against the country and property type-specific energy target. Year of exceedance is given. Please note: due to the updated methodology this graph now compares the properties total energy consumption against the energy pathway (in the first version the graph illustrated the NED (Net Energy Demand)instead)..
- **Excess emission:** Provides an overview of the excess emissions per floor area for the climate reduction targets as well as providing the user-defined targets if provided.
- **Costs of energy and carbon emissions:** Shows the annual energy costs distinguishing between the type of emission.
- **Total net energy per floor area:** Shows the produced energy as a percentage of consumed energy and the share of renewables on energy consumption.
- **Carbon costs of excess emissions:** Shows emissions above or below the decarbonisation target and the corresponding annual costs. Carbon Value at Risk is provided as a percentage for the given discount rate.
- **Costs of retrofitting to comply with decarbonisation pathway:** Provides costs of retrofitting per target (1.5°C/2°C) over the time horizon up to year 2040 for the individual retrofit scenarios entered in the input sheet.
- **Individual retrofit scenarios & payback:** Shows the energy intensity with retrofit measures and provides a payback diagram illustrating the break-even point.
- **Economic payback:** Shows the retrofit investment against the cumulated discounted energy savings from retrofit actions. Point of break-even is given at the applied discount rate.
- **Energy and carbon intensity with and without retrofit measures:** Shows individual retrofit scenarios including payback and stranding point after retrofit. This enables users to assess the retrofits costs necessary to comply with decarbonisation targets.

In the lower part of the sheet the information is presented in a tabular format as an overview on all assets entered.

Results: Portfolio Level

The portfolio level results include specific graphs and metrics useful for reporting between investors and their fiduciaries in accordance with the Task Force on Climate-related Financial Disclosures (TCFD) recommendations. Analysis can be conducted for the entire portfolio or filtered by country, property type and individual entities (e.g. funds) as defined in the Asset input sheet. Covers the following diagrams:

- **Evolution of stranding within the portfolio:** Display choice between relative share of stranded assets and absolute figures. A Filter can be applied to set a specific county, property type and fund. Results are displayed in the form of the Gross Asset Value (GAV), gross floor area or number of buildings against the selected climate target. Furthermore, the user can select scenarios of individual assets of the portfolio being sold and view its implications of stranding events over the course of time.
- **Stranding events:** Summary of stranding events over the course of time (in GAV and floor area).
- **Emissions of portfolio vs 1.5°C & GHGe scenario emissions:** Provides illustration of annual emissions with and without retrofit measures against the decarbonisation targets.
- GHG intensity of portfolio: Shows the CO_2 or GHGe intensity for the selected portfolio against the Paris targets.
- **Costs of excess emissions of portfolio:** Shows the annual costs of excess emissions for the two target scenarios. Further the CVaR is also provided as a percentage.
- **Evolution of stranding within the portfolio:** Share of stranded assets within the portfolio.

Default asset data (settings)

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.
- **Electricity emission factor:** Enables the user to apply user-defined electricity emission factors.
- **District heating and cooling emission factor:** Enables the user to apply user-defined EFs.
- **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.
- **Discount rate:** Enables user to set own discount rate for valuing future spending and savings.
- **User-defined decarbonisation pathways:** Enables the user to enter individual decarbonisation pathways for each asset.

Unit conversion tool

This sheet allows users to convert different units of energy consumption, weight/mass and volume, enabling the calculation of required values directly within the *CRREM* tool.

(Backend)

The *CRREM* tool is xls based and therefore very transparent regarding the applied calculation, (default) input data and sources used for both. Users who wish to look at more details might or view the formulas used can view the different sections in this tab. Users can also use the backend to view default asset data and average values used for specific countries. Default values include for example emission factors, energy prices and carbon prices (see Section 6 for a detailed list).

2 OVERARCHING RECOMMENDATIONS

ORGANISATIONAL BOUNDARIES & APPLICATION

Real estate portfolios applying the CRREM tool are expected to be standing commercial and/or residential real estate investment. The *CRREM* tool versions cover 44 countries and differentiate the following property types: *Retail High Street, Retail Shopping Center, Retail Warehouse, Office, Hotel, Healthcare, Mixed use, Industrial Distribution Warehouse, Industrial Distribution Warehouse Cooled, and Leisure & Recreation*.

CRREM uses a "Whole Building Approach", therefore all in-use-operational emissions are included (regardless if they are Scope 1, 2 or 3 for the lessor/investor). Emissions related to energy consumption and other GHG can be entered and benchmarked. Further, it is important to mention that both regulated and unregulated emissions are considered. The approach "polluter-pays principle" is taken, considering the entire carbon intensity of the asset for the assessment. The *CRREM* tool is specifically intended for assessing the transition risk of assets that are directly managed by the investor/owner or an asset-management-company. Likewise other financial institutions like banks can make use of the tool if they have all relevant data for the properties used as collateral for a loan available.

DATA QUALITY & 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.

Please note: the tool can also be used if data coverage is significantly below 100% since extrapolation functionalities can be applied.

EXTRAPOLATION & NORMALISATION

The tool extrapolates data for **"Reporting Period"**, **"Occupancy"** and **"Data coverage". Please note:** The extrapolation for months of reported data to 12 months **does not occur linear** due to the corresponding relevance in which months of the year cooling or heating is effectively carried out.

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. Should there be vacancy in the asset, the tool extrapolates the information and normalises to full occupancy (this can also be changed in the settings sheet). The portfolio-level and asset-level results enable data comparison against the set climate targets of 1.5°C, in addition the tool enables a comparison of the results against user-defined values.

Please note: The *CRREM* pathways refer to the **normal/ average operating hours** of the specific asset-class in a given country. Of course, users must ensure to normalize data (in regard to operating hours) in advance of the analysis to ensure a like-for-like comparison. E.g. operating hours for many offices are 8 hours. Therefore a 24/7 operating property should be normalized before entering data.

DATA AVAILABILITY & GAPS

The *CRREM* tool V2 enables users to enter reporting data for 2020, 2021 and 2022. Should mandatory information required not be reported/inputted, then the tool will not calculate and display output data for this specific asset. This asset will not be listed in the asset- and portfolio-level results. Please return to the input sheet and input further required data.

TOOL BENEFITS

- ✓ CRREM is intuitive and easy to use. The value of a global tool that captures a very wide range of geographies was noted.
- ✓ CRREM fills a void and is a significant advancement in transition risk analysis and what it can contribute to portfolio construction and management.
- ✓ Participating investors have already, and have interest in, using CRREM as a resource in asset acquisition.
- ✓ Having both energy and carbon intensity figures and targets is valuable.
- ✓ Country level carbon emission pathways aggregated in one place is helpful to highlight differences in carbon emissions from national grids. This can support invest decisions for on-site energy and help prioritise investments in jurisdictions with high grid carbon intensity, all other things equal and with limitations requiring a selection between options.
- ✓ The assumptions on capex spend to push out stranding date is valuable, though more certainty on the figures is needed in order to use this internally and externally.
- ✓ As there are a wide range of internal and external stakeholders that will be consumers of disclosed data and analyses, the wide range of CRREM outputs is very welcomed.
- ✓ Stranding risk was noted as a particularly useful output, and it was appreciated that it relies upon a limited set of objective measures and clear assumptions.
- ✓ Pre-populating the CRREM file with GRESB data was useful in speeding up the process (one reviewer did note difficulty in getting the data transferred across correctly, however).

3 CRREM DECARBONISATION PATHWAYS

CRREM has completed the decarbonisation model to calculate the pathways and carbon reduction targets required for the *global* commercial and residential real estate sector to comply with the Paris Conference (COP21) climate targets of limiting global warming to 1.5°C.

This model constitutes the core of the decarbonisation tool as the resulting decarbonization-pathways serve as a benchmark within the tool. The full description and references for this process can be found in the methodology document or in Section C of the document 'Stranding Risk & Carbon', available on the *CRREM* website.

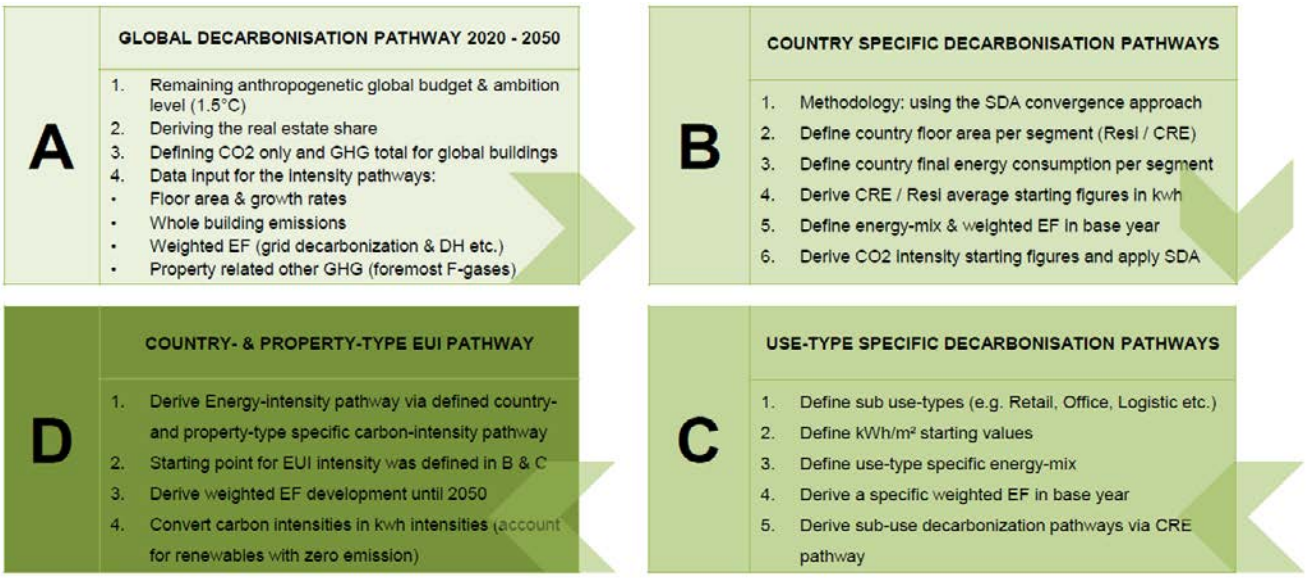


Figure 4: Required steps, CRREM 2023.

4 DECARBONISATION TARGET TOOL

This sheet of the *CRREM* tool provides the possibility to directly assess decarbonisation and energy reduction pathways (in terms of CO_2 or GHGe intensity) without entering data for individual buildings. After selecting country, building type and global warming target (1.5°C/1.5°C GHGe/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.

Please note: *CRREM* now uses emission factors excluding transmission & distribution losses. *CRREM* is using updated and current emission factors (for the baseline year 2020) for all countries. From 2021 to 2050 the grid decarbonisation is projected.

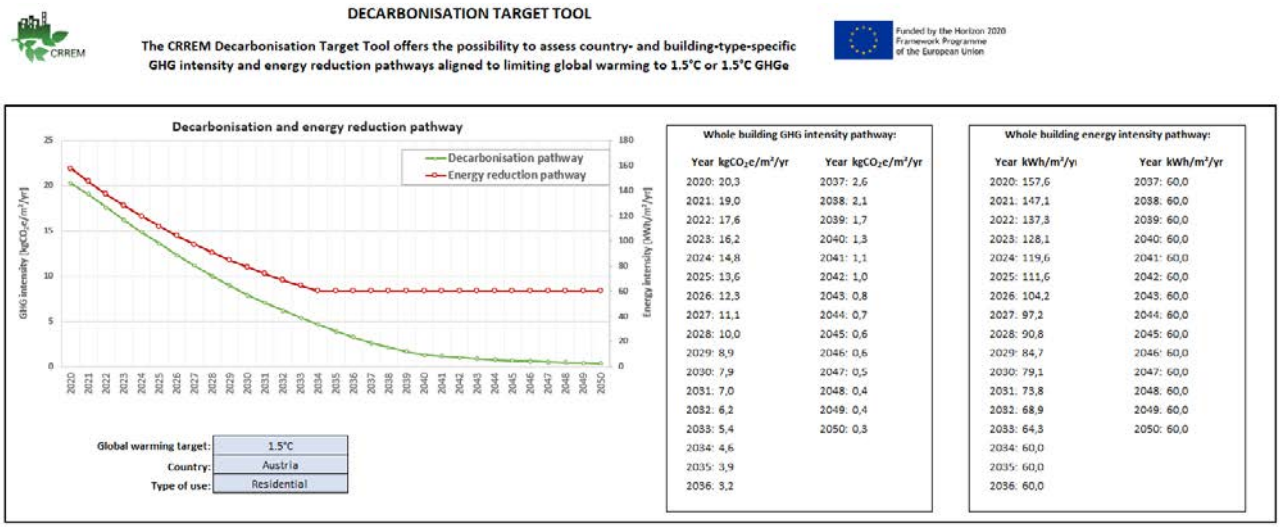


Figure 5: CRREM tool Decarbonisation Target Tab

CRREM has now changed the methodology from the energy pathways related to the NED (Net Energy Demand) to consumption-based pathways. ***C**RREM* has also implemented energy targets based on forecasts referring to the available renewable energy available by 2050 (aligned with IEA). A global breakdown takes into account the respective possibilities and limits of energy efficiency in the climate zones and allocates the budget based on bioclimatic zones and resulting HDD/CDD. The countries building stock is also considered, based on population projections in order to ensure that the available budget is not exceeded. HDD have a bigger impact than CDD on the overall kWh target for 2050. This is based on the energy use in 2050 projected for heating and cooling spaces. Space heating is projected to account for 17% of the overall energy use ('whole building approach') whereas space cooling just accounts for 11%.

Note: the target achievement is only reached if the EUI corresponds to the path value, AND the asset is operated exclusively from renewable energy sources that have an EF of zero.

5 ASSET DATA INPUT

In the asset data input sheet users enter information on individual assets; that information is necessary to assess the properties transition risks and most other output, like stranding-point etc. within the *CRREM* tool. The information entered in this sheet is mainly related to consumption data and property characteristics.

The tool calculates results displayed in other sheets based on certain default data (e.g. emissions factors for certain energy sources, country specific average energy prices etc.); if users have already made their own assumptions or have more specific information in contrast to the default figures, these user-defined values can be entered in the settings sheet.

Not all fields are mandatory and used for risk calculation but will still be included in the final reporting summary for each asset. The sheet is structured in the following six sub-sections:

GENERAL INFORMATION

This part of the asset input sheet is to provide data on the asset, such as the name, period for which data is reported, Gross Asset Value (GAV) and entity name for later aggregation:

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: Pre-filled unique asset identifier that enables the user to identify assets throughout the *CRREM* risk analysis on various tabs.

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

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.

AS.YR	**Reporting year**	Drop-down

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 2020 onwards.

Rationale: The *CRREM* Risk Assessment tool enables users to report on multiple years as to track year-over-year progress and identify outliers. Either business year 2020, 2021 or 2022 can be selected. In order to enable an automatic comparison of two assets over time, create a separate entry for both years and use the same *Asset Name (NAME).*

GAV	**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: Optional. Report the figure at the end of the last reporting period.

Rationale: GAV is a key part for estimating the portfolio value at risk of becoming stranded due to future policy regulation. The GAV is also required to calculate the carbon value at risk (CVaR).

AS.MON	**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: The covered time period of the data is used for normalising non-full-year to a full year period considering different heating and cooling requirements in the course of the year.

AS.LENG	**Reporting period: Months of data**	[1-12]

Description: The number of months for which data is reported in the tool during the reporting year. Values entered can range from 1 to 12.

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. The **extrapolation to 12 months does not occur linear** due to the corresponding relevance in which months of the year cooling or heating is effectively carried out.

ENT	**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 and enables further possibilities of aggregation.

GENERAL INFORMATION INPUT:

	General information							
Asset ID	Inclusion	Asset Name	Reporting year	Gross Asset Value (GAV)	Reporting period		Entity	General information
					Starting month	Months of data		
Pre-filled			Mandatory	Optional (required for calculating certain risk indicators)	Mandatory	Mandatory	Optional (for further possibilities of aggregation)	
	Dropdown	Text	Year	[€]	Drop-down	Number of Months	Text	
ID	*INC*	*NAME*	*AS.YR*	*GAV*	*AS.MON*	*AS.LENG*	*ENT*	
1	Exclude							

Figure 6: CRREM tool Input Tab, General information input

BUILDING CHARACTERISTICS

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

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

Description: The country in which the asset is located.

Requirements: Mandatory. Dropdown of countries included in the respective tool.

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.

CITY.	**Location: City**	*Text*

Description: The city in which the asset is located.

Requirements: Optional. Free text entry.

Rationale: Identification of the asset.

Please note: If the City input does not match the Country selected, this has no impact. The climate corrections are made according to the zip code according to the country selected. If this does not exist there, the country average is used. The entered place name is irrelevant.

ZIP	**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. Guidance regarding the correct format is available in an embedded comment in the tool.

Rationale: Geo-location of the asset (used to determine the local effects of climate change on future heating and cooling demand and local weather normalisation). If no or an invalid Zip Code is provided, the tool does the corresponding calculations on a country-level.

Address	**Location: Address**	*Text*

Description: The street address of the asset.

Requirements: Optional.

Rationale: Identification of the asset.

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 centres and mental health centres.
- **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.
- **Office:** Includes free-standing offices, office terraces, unattributed office buildings and office parks.
- **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 centres 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 centre or strip mall, whereby buildings are usually stand-alone and situated side-by-side with their entrance facing a main street or carpark.
- **Industrial** – **Distribution Warehouse Warm:** Refers to a building in an unenclosed space, usually these are stand-alone buildings situated by a car park or truck loading areas as they act as a shipping hub, receiving shipments and holding items until they are loaded onto trucks and distributed elsewhere. Often the warehouses are in the form of large halls and are located around the outskirts of cities.
- **Industrial** – **Distribution Warehouse Cooled:** Refers to a building in an unenclosed space, usually these are stand-alone buildings situated by a car park or truck loading areas as they act as a shipping hub. Operators of cold storage warehouses and refrigerated distribution centers require reliable temperature control to ensure

the quality and shelf life. These assets have a higher energy-intensity on average due to cooling large open spaces, cold rooms and low temperature-controlled environments.

- **Lodging, Leisure & Recreation**: Includes lodging, sports club houses, gyms, sports stadia, indoor sports arenas, halls, swimming pools, theatre and auditoria.

If **Mixed Use** is selected it is mandatory to state the floor area share of each building type, stated as a percentage. Given percentages must sum to one-hundred percent.

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

When applying the CRREM pathways, it is crucial to consider the significant heterogeneity among individual property types, especially those in the logistics, retail, or hospitality sectors. Special attention should be given to energy-intensive sub-property types that have already optimized their energy efficiency and incorporated the maximum on-site renewable capacity. Even in scenarios where deviations from the designated CRREM pathways may occur, these sub-property types could still be regarded as compliant with the 1.5-degree target. This acknowledgment holds weight, given that CRREM pathways encapsulate the average market intensity within each sector. For a more in-depth understanding of the CRREM methodology, additional information can be found in the CRREM methodology document. (Verlinkung: https://www.crrem.eu/wp-content/uploads/2023/05/CRREM-downscaling-documentation-and-assessment-methodology_Update-V2_V1.01-03.05.2023.pdf)

AC.YN	**Air conditioning**	Drop-down

Description: Selection of "yes" or "no" if air conditioning is used and available in the property.

Requirements: Optional.

Rationale: Air conditioning usage is an indicator for *CRREM* to understand the energy usage.

Please note: AC for the whole Building: if one has the AC for the whole building but does NOT know the energy procured directly by the tenant for other things, then user can enter the electricity (without air con) for common space (and have the data coverage without tenants' space). To account for the AC, he/she can use e.g., district cooling and insert the whole building data coverage and kWh and use the settings sheet the option for individual EF (in that case for electricity procured for AC or the location-based EF for electricity). So, all would be accounted for in the correct way.

TO.FL	**Asset size: Total gross internal area**	*Area [m²]*

Description: The total gross internal area of the asset, measured in IPMS 2.

Requirements: Mandatory. Users should report the gross internal area of the asset, aligned with the International Property Measurement Standards (IPMS 2).

Please note: Any outdoor/exterior areas as well as indoor parking (heated as well as non-heated) should be excluded.

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. The tool calculates with whole building energy consumptions, therefore requires whole building energy data (tenant space & common area energy use). All energy reported should be energy used for the operation, energy consumed as part of refurbishment measures should be included. If the user will input a user-defined pathway (e.g. for residential buildings), then the tenant space as well as common area energy consumption still applies.

Conversions: Conversions may be required if the national data collected is not automatically available in terms of GIA (Gross Internal Area) as per IPMS 2. This may be the case in the following countries:

- Switzerland: EBF (Energiebezugsfläche) has been converted to GIA using a factor of 0.9 (EBF /0,9 = GIA)
- Hong Kong: Residential Leasable Area has been converted to GIA using a factor of 1.15.

Source: Please also further information published by RICS.

BSR_OC.AN	**Asset size: Average annual vacant area**	Area [m²]

Description: The average annual vacant floor area in m².

Requirements: Mandatory. 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. If left blank, the tool assumes no vacancy during the reporting period.

Rationale: Vacant floor area is the key indicator to calculate carbon and energy intensity metrics in the property. 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. Should there be vacancy in the asset, the tool extrapolates the information and normalises to full occupancy (this can also be changed in the settings sheet).

BUILDING CHARACTERISTICS INPUT:

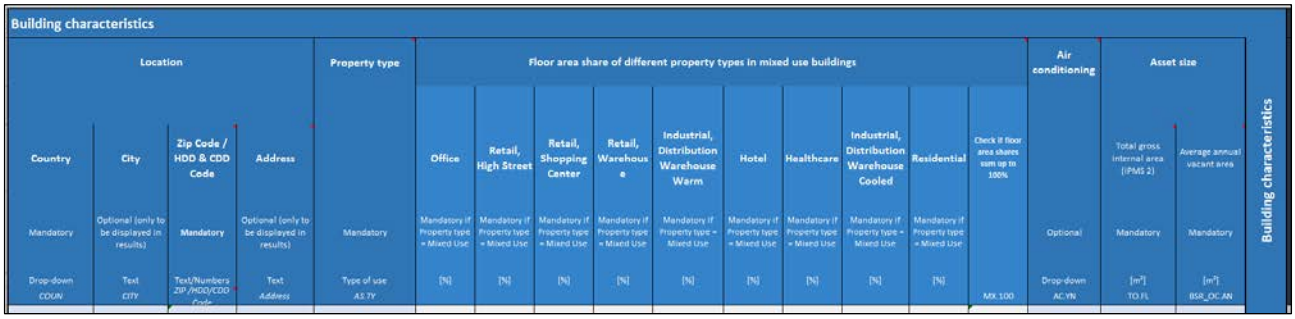


Figure 7: Tool Input Tab, Building characteristics input

(PROCURED) ENERGY CONSUMPTION DATA

This section covers the main input fields which enables users to enter the whole building procured energy consumption data. The *CRREM* tool in turn converts procured 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.

Whole building energy consumption is entered in this section (the combined energy consumptions of common areas and tenant space). This includes 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 except from energy consumed as part of refurbishment measures. Please note: the tool calculates with country specific emission factors. The default emission factors evolve dynamically over time, with the district heating emission factor being coupled to the development of the electricity emission factor of the selected country. User-defined emission factors and the development can be entered in the settings sheet.

Before energy consumption data entry, normalisation for the operating hours needs to be performed:

- **Operating hours:** The pathways refer to the normal/ average operating hours of the specific asset-class in the given country. Users should normalize data in advance of the analysis to ensure a like-for-like comparison.

Please note: Electrical Vehicle (EV) charging stations and the resulting electricity consumptions of those should be excluded. CRREM only considers energy associated with the building. Parking areas should also be excluded in line with the IPMS 2.

Tenant-type Data Normalization: Energy consumption data can further be normalized if the tenant type significantly differs from the average tenant for the respective property-type. Any normalization undertaken should be reported and stated transparently. Examples may include:

- 24/7 high efficiency operating call centre as a tenant in office space: Call centres may have longer operating hours on average as well as a higher density occupancy within the spaces compared to an average office tenant.
- Laboratory work in office building: Laboratories tend to have an above-average consumption compared to the typical office tenant. All energy directly associated to laboratory equipment may therefore be excluded.

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

- **Data Coverage (m^2):** 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 (m^2):** 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.

EL.GRID	**Grid Electricity**	*(Procured) Consumption [kWh]*
EL.DC/EL.MC		

Description: The annual procured electricity consumption [kWh] of a building area. Electricity consumption can be either purchased by the tenant or landlord.

Requirements (**Electricity Consumption (kWh)):** Report upon the procured electricity consumption of the building area in kilowatt hour (kWh) for the duration of the reporting period.

Rationale: Procured 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.

NG.CON	**Natural Gas**	*Consumption [kWh/m^3]*

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 (*m^3)* 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 2020 Standard Set.

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

OL.CON	Fuel oil	*Consumption [kWh/m³]*

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, 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 2020 Standard Set.

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

DH.CON	District heating [steam]	*Consumption [kWh/m³]*

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. For district heating and cooling The district heating EF is coupled to the electricity EF and develops analogously to the electricity EF. This method is used as the heat production/distribution is often dependent on electricity. For accuracy please use local heating EF from your power provider and insert to the respective part in the settings sheet.

DC.CON	District cooling [chilled water]	*Consumption [kWh/m³]*

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.

OT1.TY	Other (procured) energy consumption type	*Consumption [kWh/m³]*

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

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:** 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.
- **Wood chips:** Wood chips consumption of a building area. It is typically consumed for building heating.
- **Wood pellets:** Wood pellets consumption of a building area. It is typically consumed for building heating.
- **Coal:** Coal consumption of a building area. Coal can either purchased by the tenant or landlord, and it typically consumed for building heating.
- **Landfill gas:** 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:** 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.

The *CRREM Risk Assessment* converts fuel oil consumption to carbon emissions using emission factors provided by the UK Government / BEIS 2020 Standard Set.

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

ENERGY CONSUMPTION INPUT:

Total energy procurement

Whole building total energy procurement

Combined energy procurement of Common Areas + Tenant Space

Energy procured 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 except from energy procured as part of refurbishment measures.

Grid Electricity			Natural gas			Fuel oil			District heating [steam]				District cooling [chilled water]				Other energy consumption type 1				Other energy consumption type 2			
Usage	Data Coverage Mandatory if usage ≠ 0	Maximum Coverage Mandatory if usage ≠ 0	Usage	Data Coverage Mandatory if usage ≠ 0	Maximum Coverage Mandatory if usage ≠ 0	Usage	Data Coverage Mandatory if usage ≠ 0	Maximum Coverage Mandatory if usage ≠ 0	Usage	Set user-defined emission factor Hyperlink	Data Coverage Mandatory if usage ≠ 0	Maximum Coverage Mandatory if usage ≠ 0	Usage	Set user-defined emission factor Hyperlink	Data Coverage Mandatory if usage ≠ 0	Maximum Coverage Mandatory if usage ≠ 0	Type Mandatory if usage ≠ 0	Usage	Data Coverage Mandatory if usage ≠ 0	Maximum Coverage Mandatory if usage ≠ 0	Type Mandatory if usage ≠ 0	Usage	Data Coverage Mandatory if usage ≠ 0	Maximum Coverage Mandatory if usage ≠ 0
[kWh]	[m²]	[m²]	[kWh]	[m²]	[m²]	[kWh]	[m²]	[m²]	[kWh]	Hyperlink	[m²]	[m²]	[kWh]	Hyperlink	[m²]	[m²]	Drop-down	[kWh]	[m²]	[m²]	Drop-down	[kWh]	[m²]	[m²]
EL.GRID	EL.DC	EL.MC	NG.CON	NG.DC	NG.MC	OL.CON	OL.DC	OL.MC	DH.CON		DH.DC	DH.MC	DC.CON		DC.DC	DC.MC	OT1.TY	OT1.CON	OT1.DC	OT1.MC	OT2.TY	OT2.CON	OT2.DC	OT2.MC
1.000.000	10.000	10.000	500.000	10.000	10.000					Settings				Settings										

Figure 8: Tool Input Tab, Total energy procurement input

Waste & Water: Please note, that CRREM only considers operational emissions / operational carbon from energy use and other gases, energy used for waste & water treatment up- or downstream are not included in this analysis.

FUGITIVE EMISSIONS / REFRIGERANT LOSSES

This section of the *CRREM Risk Assessment Tool* covers additional input fields for refrigerant losses or fugitive emissions resulting within the whole building limits (so Scope 1 for the tenant and Scope 1 or Scope 3 for the lessor/investor). 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.

GHG.Leak1,Type	**Fugitive Emissions / Refrigerant losses**	*[kg]*
GHG.Leak1.Amount		

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. Amount of emissions

reported will apply to all years (from reporting year up until 2050). **Please note:** Refrigerant losses may not be recorded yearly, as the re-fill period may extend one year. In this case, the user needs to normalise the data to one (typical/representative) year. E.g. 12Kg of the respective liquid were refilled covering a period of together 3 years, this results in a yearly leakage/refill amount of 4 Kg.

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]

FUGITIVE EMISSIONS INPUT:

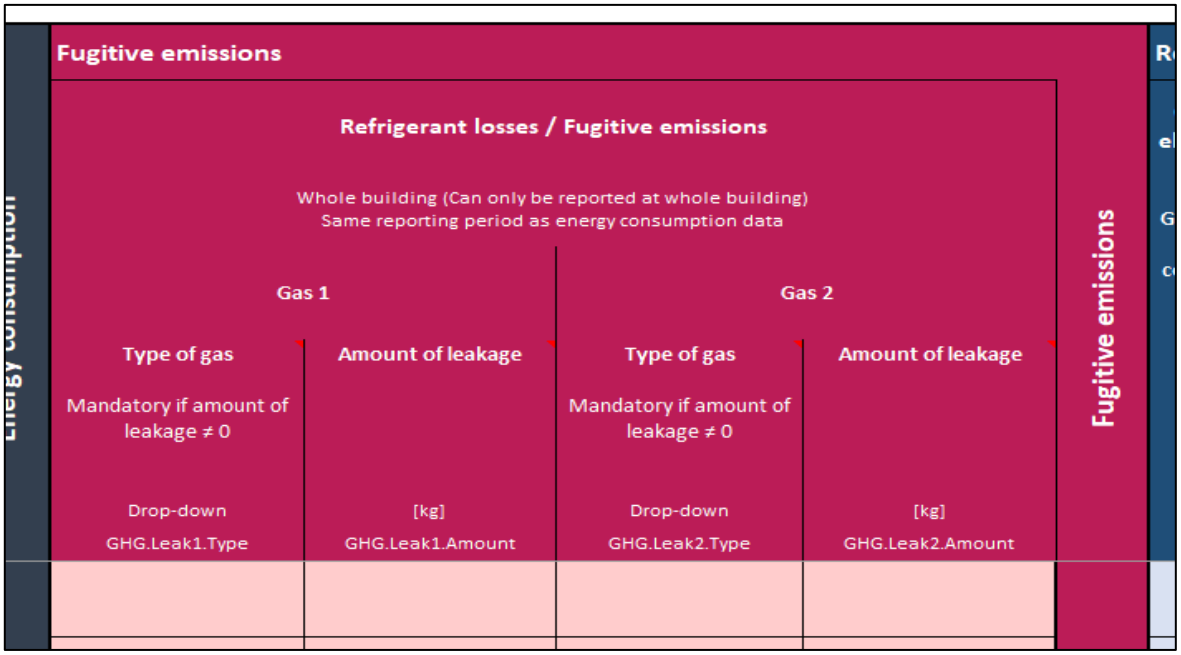


Figure 9: Tool Input Tab, Fugitive emissions input

IMPORTANT:

It is of fundamental importance that users ONLY benchmark the asset performance against the 1.5°C GHGe pathway if the use of F-Gases is also reported for the building. If this is not the case, only the CO_2 pathway must be used.

RENEWABLE ENERGY GENERATION

This section of the *CRREM Risk Assessment Tool* covers renewable energy generated on-site and renewable energy generated purchased for the asset to be analysed. 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 renewable electricity generated on-site from solar PV or wind:

- **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.

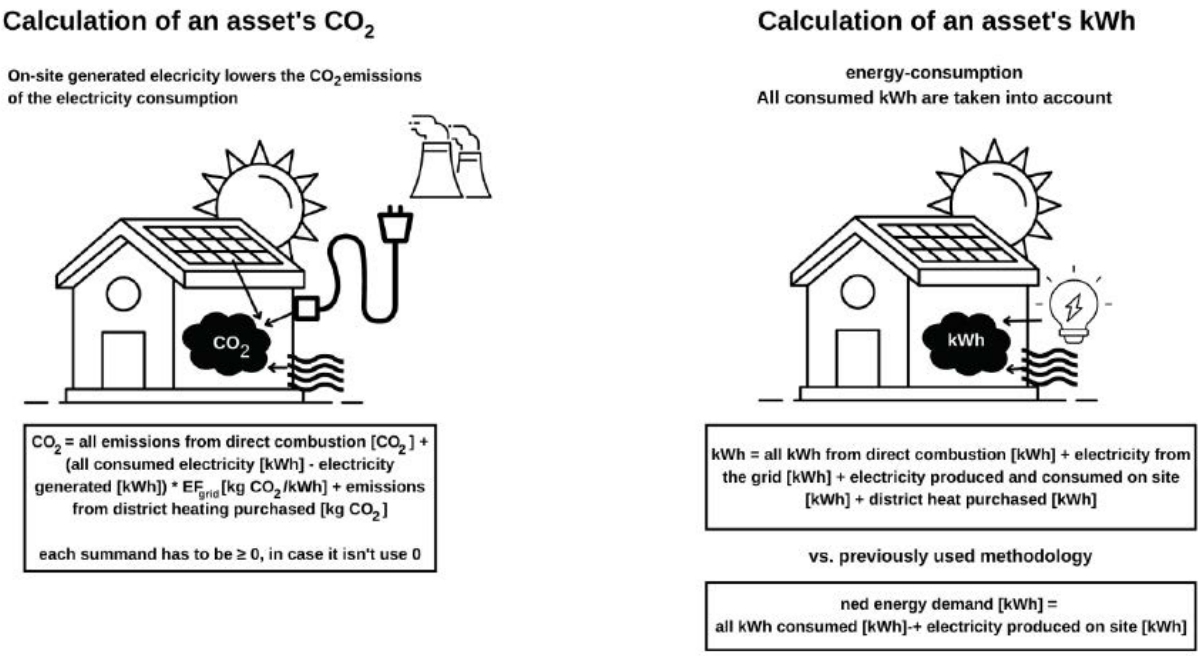
- **Wind energy:** Energy generated by using wind turbines.

Additionally, users can report upon an "other" renewable energy source, 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.

From this version onwards CRREM energy targets do NOT reflect NED (Net Energy Demand) consumption, but the total energy consumed by the property. The use of renewable energy produced on site is in this context important. The energy produced and consumed on site is ADDED to the total energy consumption of the property.

But since the renewable energy produced and consumed on site has an emission factor of Zero it does not contribute to the carbon intensity of the asset. Likewise renewable energy produced on-site and sold back to the grid is further REDUCING the carbon footprint of the building. The following graphs illustrate this in more detail:



Users can also report off-site purchased renewable electricity. This comprises renewable energy that is generated off-site but consumed on-site and select a reporting method of either a location-based approach or a market-based approach.

Biofuels, which can also be considered renewables, need to be reported upon in the "other energy consumption type field". Please note: The asset and portfolio level output display net procured intensities, minus the exported energy.

Generated and consumed on-site	*[kWh]*

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

Requirements: Report upon the renewable energy in terms of kilowatt hour (kWh). Users have the option to report renewable electricity generated through solar or wind and other renewable energy sources generated through heat-pumps or solar thermal.

Rationale: Renewable energy generated and consumed on-site makes electricity costs less dependent upon energy price fluctuations. Further renewable energy generated and consumed on-site directly improves the CO_2/GHG-intensity of the asset (since the EF is Zero). Also, properties have a better positioning regarding self-sufficiency. Note: the energy intensity is showing the same result, regardless, if the energy was produced on-site or purchased from the grid (here: consumption-based view).

Generated on-site and exported	*[kWh]*

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

Requirements: Report upon the renewable energy in terms of kilowatt hour (kWh). Users have the option to report renewable electricity generated through solar or wind and other renewable energy sources generated through heat-pumps or solar thermal.

Rationale: Renewable energy generated on-site and exported can serve as a hedge against energy price fluctuations, furthermore it reduces the carbon intensity of the asset.

Generated off-site and purchased	*[kWh] / Drop-down*

Description: Report upon renewable energy that was generated off-site, consumed on-site and purchased by the landlord or the tenant.

Requirements: Report upon the renewable energy in terms of kilowatt hour (kWh). Users have the option of selecting a reporting method. A location-based approach can be selected or a market-based approach including the emission factor in $kgCO_2$ or kWh.

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.

MARKET VS. LOCATION BASED DATA

Location based emission factors are based on the average emission intensities of the electricity grid (national grid-averages), whereas the marked-based approach reflects the GHG emissions based on emissions by the generators from which the entity purchases electricity.

- Market or location-based data can be selected in the input sheet for renewable energy or entered in the settings sheet.
- For a like-for-like comparison with the pathways we recommend location-based EF. Please also see the GRESB/PCAF/CRREM technical guidance.

Please note: *CRREM* now applies emission factors <u>excluding transmission & distribution losses</u>. *CRREM* is using updated & current emission factors (for the baseline year 2020) for all countries. From 2021 to 2050 the grid decarbonisation is projected.

RENEWABLE ENERGY INPUT:

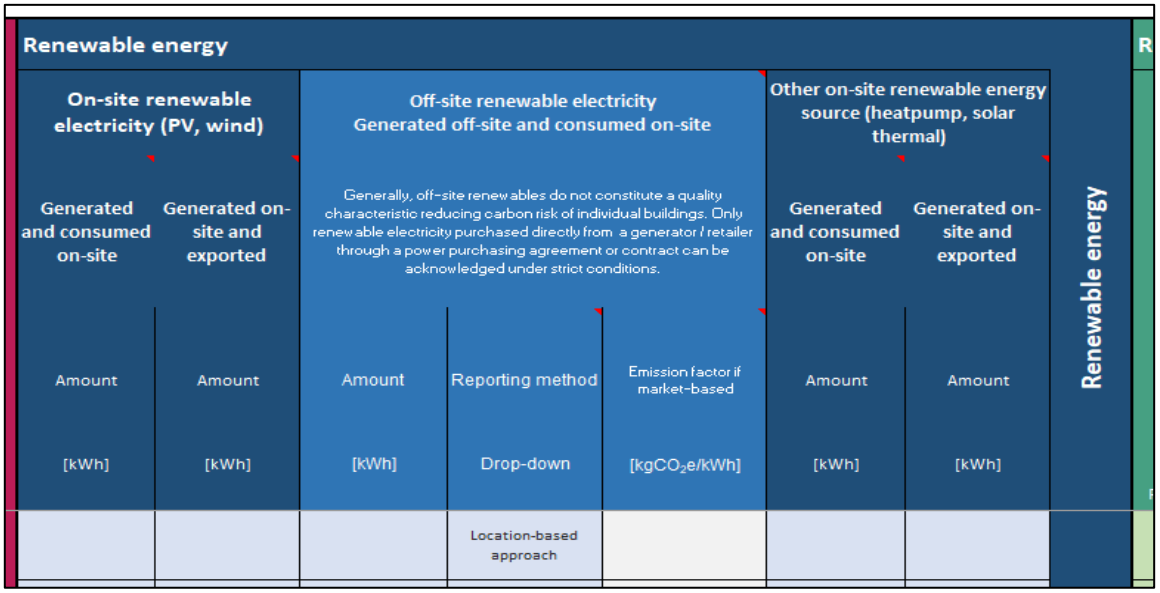


Figure 10: Tool Input Tab, Renewable energy input

Please note: If reporting method is set to **'market-based approach'**, please enter your electricity emission factor here (mandatory). If market-based is selected, the Emission Factor is only for the starting year (2020, 2021 or 2022). The EF development will then follow (rate of change) the market projections/market development for the selected country (in form of the relative change). Please use the settings sheet to input a user-defined EF development until 2050.

CRREM of course also promotes efficient buildings as it is certain that 'buying one's way out' through compensation or 'off-setting' with certificates can only be the last alternative after all other strategic options have been exploited. Energy-saving measures for decarbonization should never be neglected with the net zero strategy achieved exclusively through the purchase of green power. Rather, all options for reducing energy consumption in the building should have been fully utilized beforehand. Therefore, *CRREM* promotes that purchasing 'green' electricity will not improve energy-intensity / efficiency of the property. CRREM generally recommends that off-site renewables do not constitute a quality characteristic reducing carbon risk of individual buildings. Only renewable electricity purchased directly from a generator / retailer through a power purchasing agreement or contract can be acknowledged, however, it will be your internal company decision which what you decide to accept (*CRREM* does not set any specific requirements/ approvals in this case). You can use different credits schemes or PPAs and set the "location-based" approach to the "market-based" and enter your own "user-defined" emission factors.

If users decide to choose the market-based approach, certain minimum conditions should be ensured such as for example options like RECS (Renewable Energy Certificate Systems)[2]. Further, measures such as fixed contracts (green lease) and landlord power also as PPA with renewables would be acceptable. **CRREM also accepts the use of a "sleeved" PPA (direct PPA).**

[2] https://www.e-control.at/marktteilnehmer/oeko-energie/recs or https://www.pwc.de/de/energiewirtschaft/erneuerbare-energien/power-purchase-agreements-ppa.html.

More measures would include:

- Green leases could be included as a building feature
- Landlord electricity can be terminated at any time
- Certificate for the emission factor
- No CO_2 offsets which correct down the EF of the electricity mix

Due to certain investment and tax regulations in various countries that can impede the direct implementation of on-site renewable energy through PV systems by property owners, we make an exception in such cases, departing from the recommended location-based approach. Regarding CRREM's whole building approach, energy generated by a PV system on the property's roof can be subtracted from the carbon footprint, irrespective of whether the system is managed by the property owner or a third party. In our view, without this provision, in many cases there would be no incentive for the installation of PV systems in the building sector. In this context, the tension between target setting, risk management, and carbon accounting becomes very apparent. The approach of deducting emissions from the generated kWh for target setting is acceptable, with risk management it depends on the contract terms. However, in carbon accounting, it should generally not be considered, as it could lead to double accounting.

From a risk management perspective, the following points should be considered in the contract with the operating company of the PV system: The return is linked to the development of the electricity price and thus to carbon prices. The generated electricity would only/primarily be made available to the tenants by a fixed rate and kept in the building by means of storage. In this way, it can be ensured that increased CO2 pricing does not burden the tenants' utility costs and thus the overall budget for renting the space, resulting in lower income for the asset owner.

RETROFIT ACTION

This section of the *CRREM Risk Assessment Tool* enables the user to define generalised retrofit actions by setting year and investment amount intending to improve the energy and carbon performance of the building. Retrofit costs are specific to country and property type.

RF1.YR	Year of retrofit	[Year]
RF1.EUR	Expenses	[€]
RF1.PC	Achieved energy reduction of energy consumption	[%]
RF1.EC	Embodied carbon related to retrofit action	[$kgCO_2e$]

Description: The year in which the asset will undertake a planned capital-intensive retrofit.

Requirements: Define budget to the selected year of which retrofit action is planned. One future retrofit action can be reported.

Rationale: The calculation of the energy and carbon reduction achievable with a certain amount of investment is based on a very general calculation, considering property type and location (country) of a building. Users can enter their own estimation of reduced energy consumption. Further an automatic estimation of embodied carbon related to a retrofit measure is available. Users can provide their own estimation of embodied carbon that will be used to assess the ecological balance of a retrofit measure (comparing embodied carbon and operational savings).

RETROFIT ACTION INPUT:

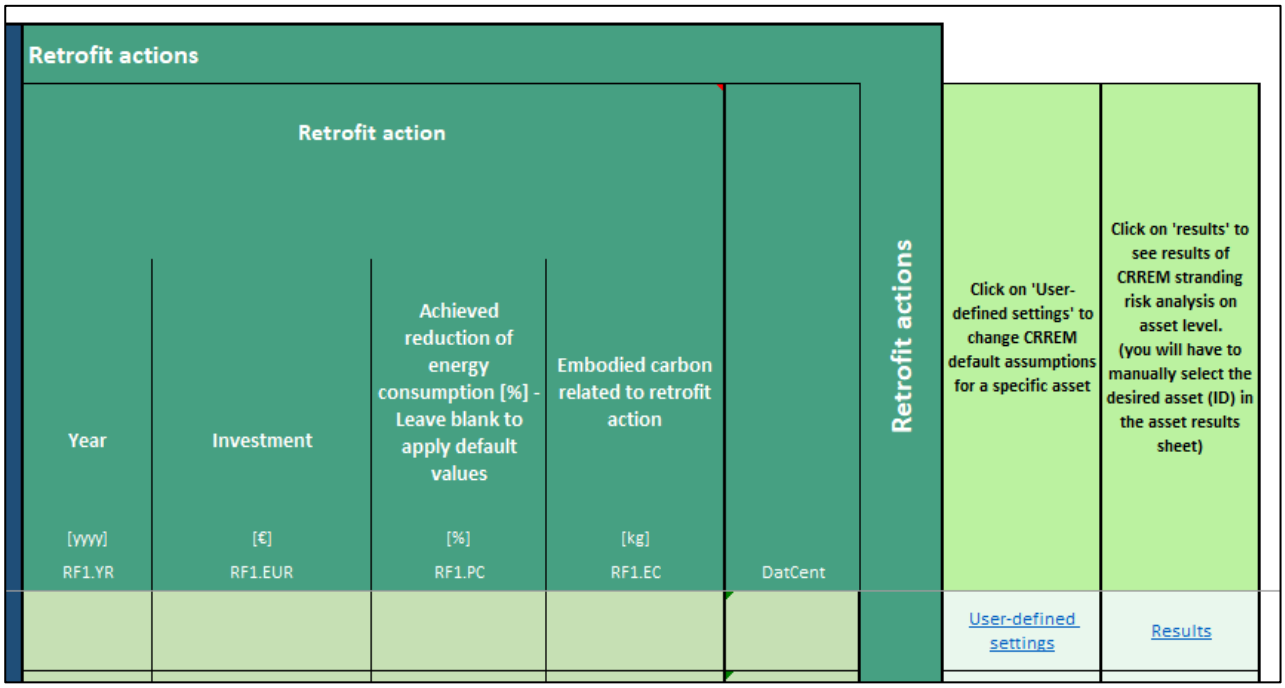


Figure 11: Tool Input Tab, Retrofit action input

Sources: *CRREM* uses data from *DEEP* (https://deep.eefig.eu/). The calculation of the energy and carbon reduction achievable with a certain amount of investment is based on a very general calculation, considering property type and location (country) of a building. Users can enter their own estimation of reduced energy consumption.

Further an automatic estimation of embodied carbon related to a retrofit measure is available. Users can provide their own estimation of embodied carbon that will be used to assess the ecological balance of a retrofit measure (comparing embodied carbon and operational savings).

Retrofit costs: The tool accounts for three different factors regarding retrofit costings:

1. Discounting of future costs: BPIE, Europe's buildings under the microscope
2. Country specific adaptation of costs: ECC European Construction Costs http://constructioncosts.eu/cost-index/ and RLB Euro Alliance https://www.rlb.com/wp-content/uploads/2018/07/European_Construction_Intelligence_2018.pdf
3. Abatement cost curve: *DEEP* (we used *DEEP* data for the derivation of this)
   Calculation in the tool:
   a. *CRREM* tool Back-end BPL: Discounting of future costs
   b. *CRREM* tool Back-end BPO: Annual reduction rate

Embodied carbon: *CRREM* pathways do not cover embodied carbon/ emissions. The *CRREM* decarbonisation pathways are only addressing operational carbon. The only exception regarding analytics that look into embodied carbon emissions is related to an energetic retrofit activity: within the tool, a scenario analysis regarding the financial- and environmental-pay-back is possible by entering one retrofit action which besides related costs and energy savings for the in-use –phase also covers the amount of embodied carbon resulting from the energetic retrofit investment itself. This amount of embodied carbon should be lower compared to the sum of operational savings to ensure a real positive ecological impact.

6 DEFAULT ASSET DATA (SETTINGS)

This sheet is specific for advanced users and allows them to overwrite default data points to tailor the *CRREM Risk Assessment Tool* for each analysed asset regarding a wide range of parameters. *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 and weather.

Normalise consumption data to 100% occupancy rate	*[Yes/No]*

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

Requirements: Select Yes or No. By default, this is set to Yes.

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

References: Normalisation is based upon "average vacant area" as reported in the asset input sheet.

Normalise current heating & cooling degree days	*[Yes/No]*

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

Requirements: Select Yes or No. By default, this is set to Yes.

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.

Climate change projection	*[RCP4.5/RCP8.5]*

Description: The Representative Concentration Pathway (RCP) is a GHG concentration trajectory adopted by the *Intergovernmental Panel on Climate Change* (*IPCC*). The RCP8.5 projects a steep incline in GHG concentration of over 1200 ppm of CO_2-equivalents, while the RCP4.5 estimates a moderate inclusion of 650 ppm CO_2-equivalents until 2100.

Requirements: Default is RCP4.5. RCP8.5 can also be selected.

Rationale: The climate change projections affect the future heating and cooling demand.

References: RCP4.5 is an intermediate scenario, while RCP8.5 is the worst-case scenario.

NORMALISATION SETTINGS:

Default:	Yes	Yes	RCP4.5
Asset ID	Normalise consumption data to 100% occupancy rate [yes/no]	Normalise heating and cooling consumption to weather in year of consumption [yes/no]	Climate change projection (affects future heating and cooling demand)
1	Yes	Yes	RCP4.5

Figure 12: Tool Settings tab, normalisation settings

ELECTRICITY EMISSION FACTORS

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

Description: Enables the user to apply default or user-defined emission factor for electricity consumption with an option to either set the value for each year manually or to set to 2020 value and annual rate of change.

Requirements: Provide the alternative electricity grid carbon intensity factors or an annual rate of change. Values can also be entered for each year up to 2050. Please note that for all assets with entered emission factors of zero (user-defined), there is no corresponding consumption calculated.

Rationale: Buildings can have unique electricity grid intensity factors.

GHG emission factor for district heating or cooling *[kgCO₂/kWh]*

Description: Alternative emission factor for district heating. Heating always follows the selected development of the EF for electricity. The emission factor develops analogously along the decarbonisation of electricity, the EF is linked to the ratio to electricity from an EU/UK average.

Requirements: Provide the alternative district heating intensity factors. In order to input the EF development until 2050, the users can overwrite the values in the back-end sheet.

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

EMISSION FACTOR SETTINGS:

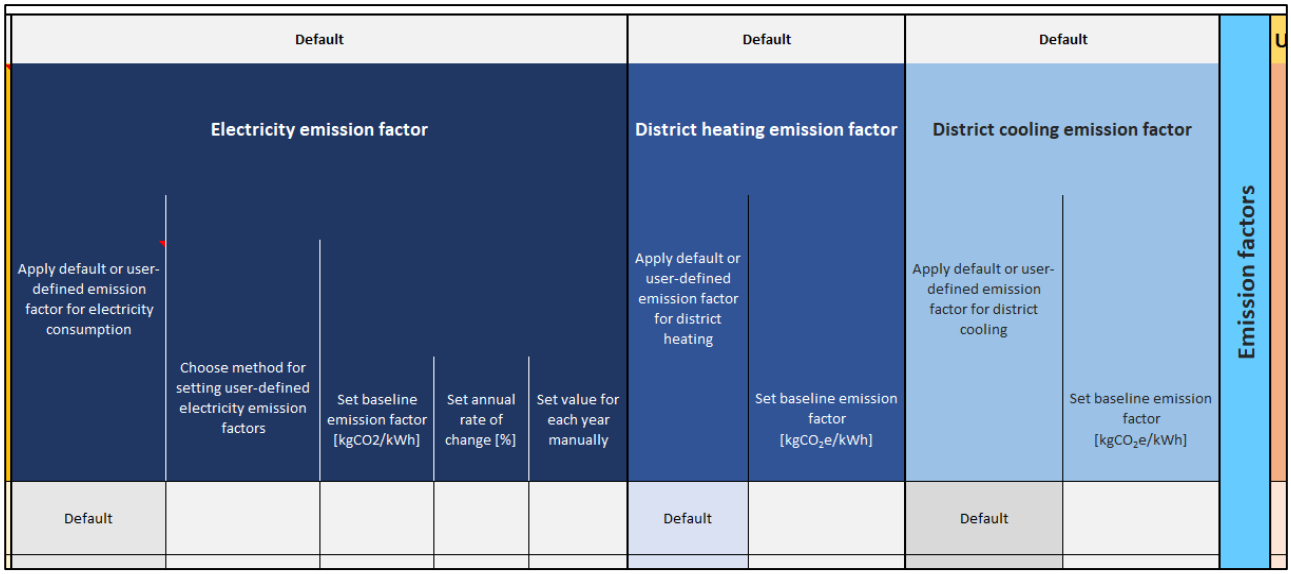


Figure 13: Tool Settings tab, user-defined emission factor settings

USER-DEFINED 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. Please note that all energy prices are market averages, including VAT. Elements covered:

- Price per kWh gas consumption [€]
- Annual price increase per kWh gas 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 "other source" consumption [€]
- Annual price increase per kWh "other source" consumption [%]

ENERGY PRICE SETTINGS:

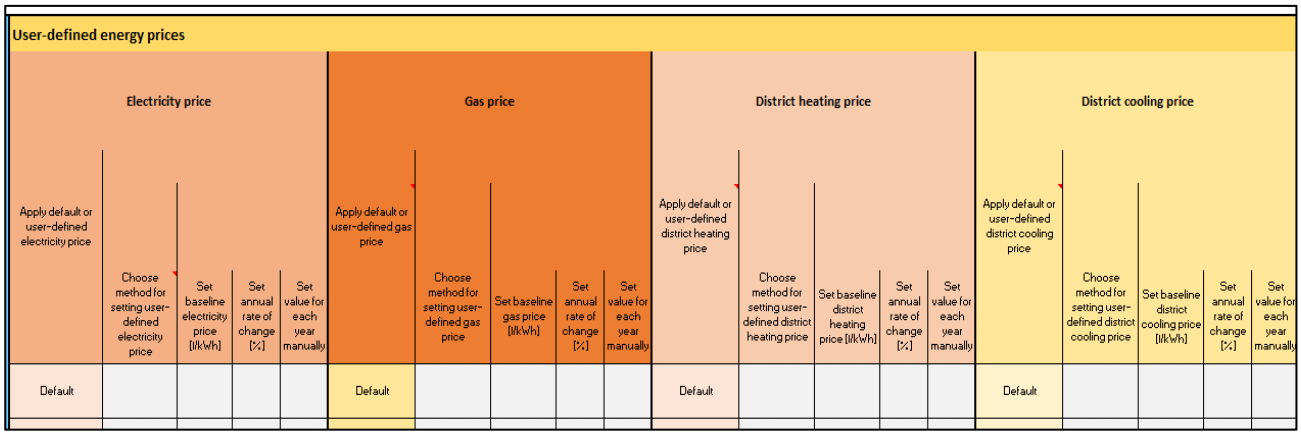


Figure 14: Tool Settings tab, user-defined energy price settings

USER-DEFINED CARBON PRICES

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

- 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 [€/tCO_2]
- Climax carbon price in target year [€/tCO_2]
- Type of growth path ('Linear' / 'Constant growth factor')
- Annual growth of carbon price [%]

Carbon pricing will be related to the so-called excess emissions in the tool and the absolute amount per year will be discounted to derive a present value (that could be e.g. related to potential retrofit-cost which might be sufficient to avoid the expected carbon pricing).

Please note: The default carbon prices in the tool are not static but based on scientific projections (currently starting at 32 EUR/t in 2023 and ending at 250 EUR/t in 2050). Users are encouraged to come up with their own assumptions regarding the future carbon pricing environment their properties might be located in. Besides company specific "shadow carbon pricing" also the current regulation including defined step-ups for carbon prices in the different countries can be inserted in the settings sheet.

Source: BloombergNEF (2022): Science Based Targets initiatives (SBTI) scenario: limits supply to removal offsets like reforestation and nascent technologies such as direct air capture.

Further sources include:

- CDP, 2021: Putting a price on carbon – The state of internal carbon pricing by corporates globally
- UNEP FI / PRI, 2021: Discussion paper on governmental carbon-pricing

USER-DEFINED DISCOUNT RATES

Enables users to choose default or user defined rate for valuing future spending and savings. Including:

- Discount rate for valuing future spending and savings (default: 3%)

CARBON PRICES & DR SETTINGS:

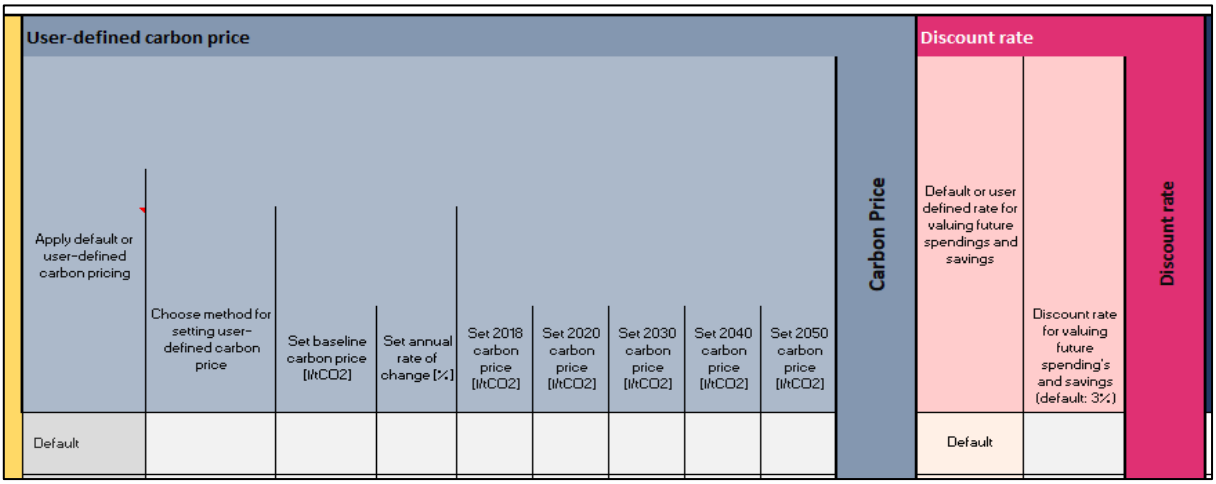


Figure 15: Tool Settings tab, user-defined carbon price and discount rate settings

MARKET VS. LOCATION BASED DATA

Location based emission factors are based on the average emission intensities of the electricity grid (national grid-averages), whereas the marked-based approach reflects the GHG emissions based on emissions by the generators from which the entity purchases electricity.

- Market or location-based data can be selected in the input sheet for renewable energy or entered in the settings sheet.

USER-DEFINED DECARBONISATION PATHWAYS

Enables users to enter individual decarbonisation pathways for each asset. This enables the user to make own assumptions and benchmark individual assets or the portfolio against own targets instead of the given *CRREM* 1.5°C/1.5°C GHGe/2°C pathways.

- User-defined decarbonisation pathway from 2020-2050 in terms of $kgCO_2e/m^2$.

USER DEFINED DECARBONISATION PATHWAY SETTINGS:

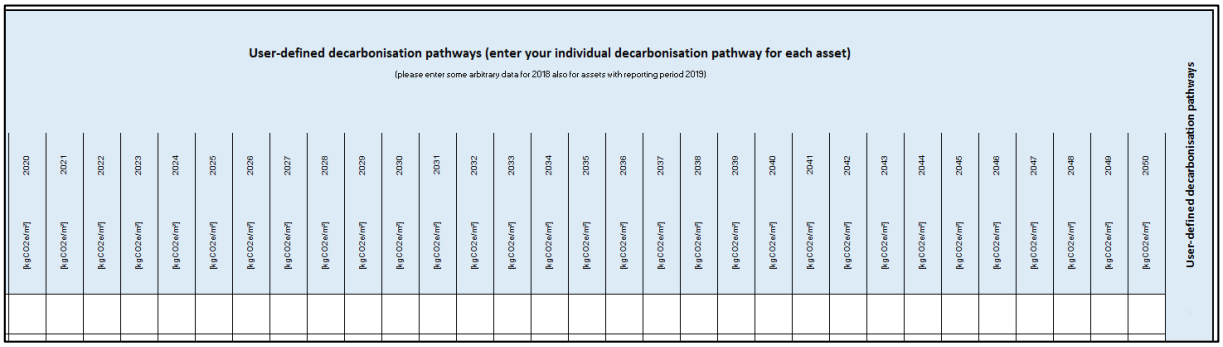


Figure 16: Tool Settings tab, user-defined decarbonisation settings

COUNTRY SPECIFIC DEFAULT VALUES

Following the idea of a transparent tool, all calculations are carried out in the back-end sheet, enabling users to easily understand the structure. Country specific default values can be viewed in the back-end sheet of the tool. These can then be **adjusted to user-specific values in the settings sheet of the tool.**

Default values used include:

Electricity EF	Back-end A 22-A 51
District Heating EF	Back-end ratio J 123 to Electricity EF UK
Electricity Price	Back-end AVH 33
Gas Price	Back-end AVH 96
Oil Price	Back-end AVH 127
Coal Price	Back-end AVH 344
Wood Chip Price	Back-end AVH 187
Pellets Price	Back-end AVH 253
District Heating Price	Back-end AVH 344
Carbon Price (€/Kg)	Back-end AVH 439
Carbon Price Development	Back-end CVQ

7 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, weight/mass and volume, enabling the calculation of required values.

Energy consumption by burning natural gas can be entered either in kilowatt hour (kWh) or square meters (m^2) directly in the Asset input data sheet. All other energy sources must be entered in kWh.

Floor area input data can be entered in square meter (m^2). Data on energy consumption or floor area based on other units must be converted.

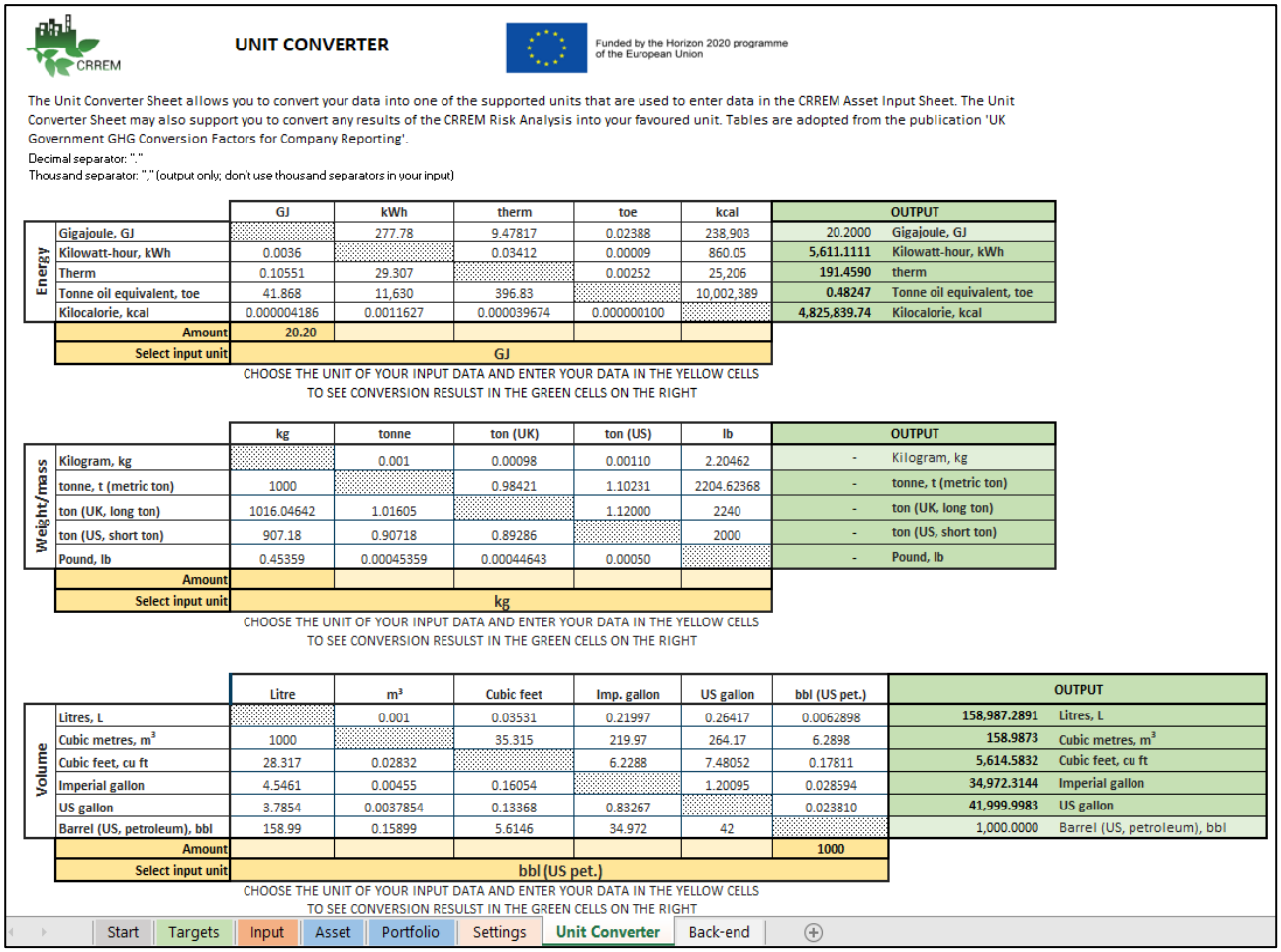
The *CRREM Unit conversion tool* enables users to do this conversion directly in the *CRREM* tool for a wide range of the most common units including the possibility to take account of common unit prefixes like *kilo* or *mega. The following values can be converted:*

Energy				
Kilowatt hour (kWh)	Gigajoule (GJ)	British thermal unit (therm)	Tonne oil equivalent (toe)	Kilocalorie (kcal)

Weight / Mass				
Kilogram (Kg)	tonne (t)	ton (UK, long ton)	ton (US, short ton)	Pound (lb)

Volume					
Cubic metre (m^3)	Litre (L)	Cubic feet (cu ft)	Imperial gallon (Imp.gal)	American gallon (US.liq.gall)	American barrel (bbl)

UNIT CONVERTER TAB:



UNIT CONVERTER

Funded by the Horizon 2020 programme of the European Union

The Unit Converter Sheet allows you to convert your data into one of the supported units that are used to enter data in the CRREM Asset Input Sheet. The Unit Converter Sheet may also support you to convert any results of the CRREM Risk Analysis into your favoured unit. Tables are adopted from the publication 'UK Government GHG Conversion Factors for Company Reporting'.

Decimal separator: "."
Thousand separator: "," (output only; don't use thousand separators in your input)

		GJ	kWh	therm	toe	kcal	OUTPUT	
Energy	Gigajoule, GJ		277.78	9.47817	0.02388	238,903	20.2000	Gigajoule, GJ
	Kilowatt-hour, kWh	0.0036		0.03412	0.00009	860.05	5,611.1111	Kilowatt-hour, kWh
	Therm	0.10551	29.307		0.00252	25,206	191.4590	therm
	Tonne oil equivalent, toe	41.868	11,630	396.83		10,002,389	0.48247	Tonne oil equivalent, toe
	Kilocalorie, kcal	0.000004186	0.0011627	0.000039674	0.000000100		4,825,839.74	Kilocalorie, kcal
	Amount	20.20						
	Select input unit	GJ						

CHOOSE THE UNIT OF YOUR INPUT DATA AND ENTER YOUR DATA IN THE YELLOW CELLS
TO SEE CONVERSION RESULST IN THE GREEN CELLS ON THE RIGHT

		kg	tonne	ton (UK)	ton (US)	lb	OUTPUT	
Weight/mass	Kilogram, kg		0.001	0.00098	0.00110	2.20462	-	Kilogram, kg
	tonne, t (metric ton)	1000		0.98421	1.10231	2204.62368	-	tonne, t (metric ton)
	ton (UK, long ton)	1016.04642	1.01605		1.12000	2240	-	ton (UK, long ton)
	ton (US, short ton)	907.18	0.90718	0.89286		2000	-	ton (US, short ton)
	Pound, lb	0.45359	0.00045359	0.00044643	0.00050		-	Pound, lb
	Amount							
	Select input unit	kg						

CHOOSE THE UNIT OF YOUR INPUT DATA AND ENTER YOUR DATA IN THE YELLOW CELLS
TO SEE CONVERSION RESULST IN THE GREEN CELLS ON THE RIGHT

		Litre	m^3	Cubic feet	Imp. gallon	US gallon	bbl (US pet.)	OUTPUT	
Volume	Litres, L		0.001	0.03531	0.21997	0.26417	0.0062898	158,987.2891	Litres, L
	Cubic metres, m^3	1000		35.315	219.97	264.17	6.2898	158.9873	Cubic metres, m^3
	Cubic feet, cu ft	28.317	0.02832		6.2288	7.48052	0.17811	5,614.5832	Cubic feet, cu ft
	Imperial gallon	4.5461	0.00455	0.16054		1.20095	0.028594	34,972.3144	Imperial gallon
	US gallon	3.7854	0.0037854	0.13368	0.83267		0.023810	41,999.9983	US gallon
	Barrel (US, petroleum), bbl	158.99	0.15899	5.6146	34.972	42		1,000.0000	Barrel (US, petroleum), bbl
	Amount						1000		
	Select input unit	bbl (US pet.)							

CHOOSE THE UNIT OF YOUR INPUT DATA AND ENTER YOUR DATA IN THE YELLOW CELLS
TO SEE CONVERSION RESULST IN THE GREEN CELLS ON THE RIGHT

Start | Targets | Input | Asset | Portfolio | Settings | Unit Converter | Back-end

Figure 17: Tool Unit Converter Tab

8 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.

NEW: CRREM has now published a 1.5°C GHGe pathway which includes all other GHGs in regard to fugitive emissions/ F-gases from i.e. cooling equipment's, HVAC etc. Users may benchmark their asset performance against the GHGe pathway if data is reported in the "Input – Fugitive Emissions" section.

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 (see graph below) with the decarbonisation target pathway based on the assets building type and location (country). The user can choose which global warming target (1.5°C or 1.5°C all GHG) 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-defined values). The diagram displays the potential year of stranding (red circle) when the asset's GHG intensity is higher than the decarbonisation target. Any subsequent emission above the permissible values of the selected pathway (so called 'excess emissions') are used as one of the risk indicators. The economic obsolescence is associated with the stranding date; the higher the excess emissions, the greater the probability of economic obsolescence occurring. A further risk-indicator is also the Value at Risk (CVaR) calculated from the GAV, however, please note that the CVaR is only the risk associated with the negative value and hence not a simulation (as such terms often indicate).

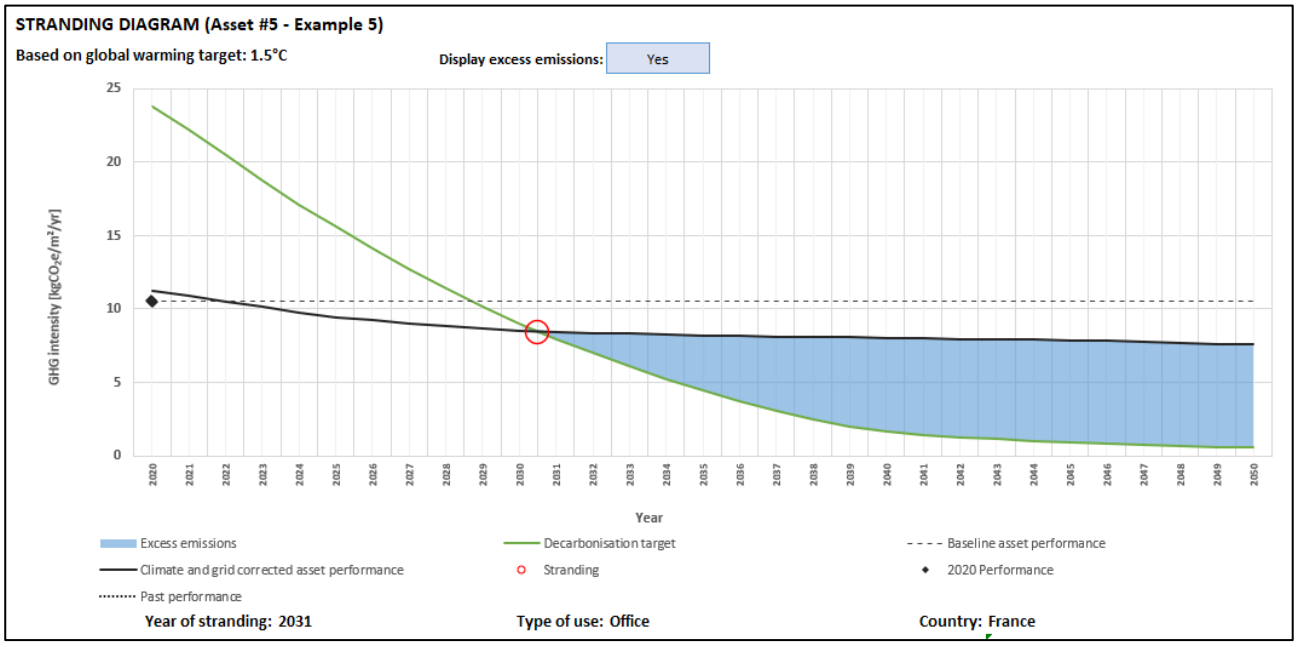


Figure 18: Asset-level output - Stranding diagram

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).

Further key findings are presented, such as:

- estimated baseline annual energy costs,
- baseline whole building GHG emissions and intensity,
- cumulative emissions until 2050,
- the remaining emissions budget according to decarbonisation targets,
- the accumulated amount of GHG emissions surpassing the decarbonisation target (these “excess emissions” can optionally be visualised on the stranding diagram),
- excess emissions per floor area,
- costs of retrofitting to comply with decarbonisation pathway,
- payback and point of break-even after retrofit investments,
- the monetary costs of these emissions assuming a certain carbon price.

Figure 19: Asse-level output – Stranding diagram with retrofit scenario

The graph above shows a further output generated on the asset level. The dashed line represents the asset CO2 or GHG intensity up until 2050 without any planned retrofit measures, whereas in comparison the black line shows the GHG intensity pathway with retrofit measures. The new (later) point of stranding is indicated (red circle) and excess emissions displayed for the case of retrofit actions planned. If the excess emissions are multiplied by a carbon price (€/kgCO_2), this results in increasing costs due the growing decarbonisation requirements, enabling estimates of imminent financial damage. Higher excess emissions lead to higher energy and carbon costs and therefore require higher retrofitting costs. Besides asset underperformance, the strategic timing of retrofit actions should also be subject to the refurbishment cycle (exploitation of possible synergy effects), availability and the timing of future sales (if intended).

The graph below (figure 19) illustrates the energy reduction pathway in contrast to the country and property-type specific energy target. This graph is a further important indicator in regards to asset performance in addition to the stranding diagram as building GHG intensity may be low, however, still have a high energy intensity.

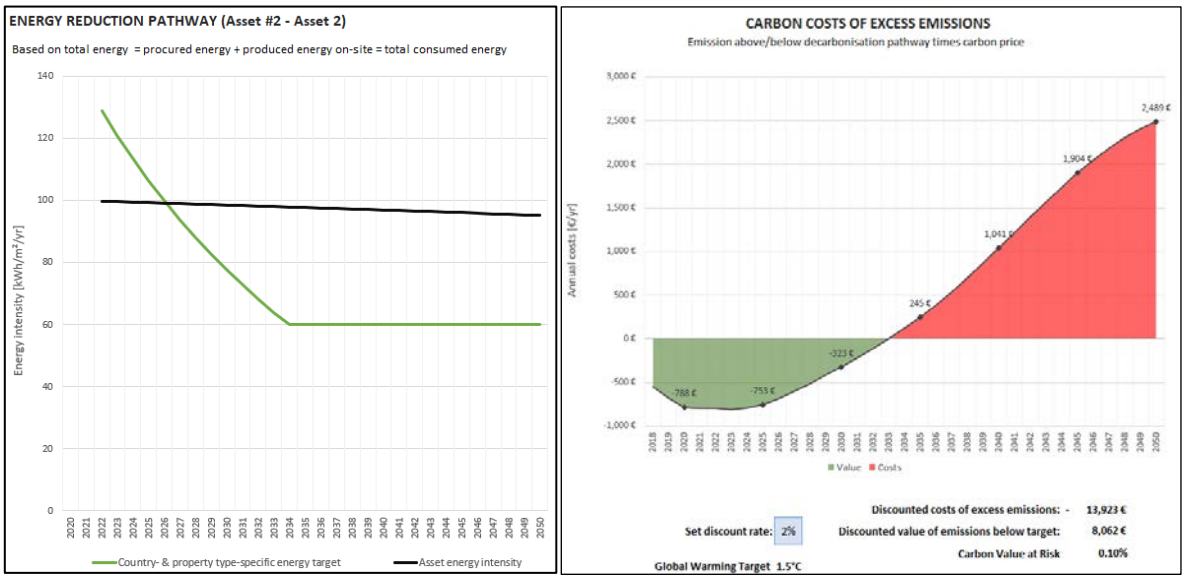


Figure 20 (left): Asset-level output - Energy reduction pathway
Figure 21 (right): Asset-level output - Carbon costs of excess emissions

Further results on the asset level include the representation of the carbon costs of excess emissions per year (see figure 20). Analogous to the NY City model with penalties applied for each ton of emissions above the limit (and possibly of trading emission credits). The carbon costs of excess emissions are also available on an aggregated level in the portfolio analysis. 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.

Aspects for data quality & accuracy improvement:

- Information regarding current vacancy
- Availability of the electricity usage for the entire building (tenant consumption)
- Input of individual Emission factors
- Prioritization regarding GAV (Gross Asset Value)
- Building retrofit scenarios / current state of retrofit-status
- Default values, e.g. company internal carbon shadow prices

9 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 are specifically 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, reporting year or territorial units (countries or sub-national level).

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).

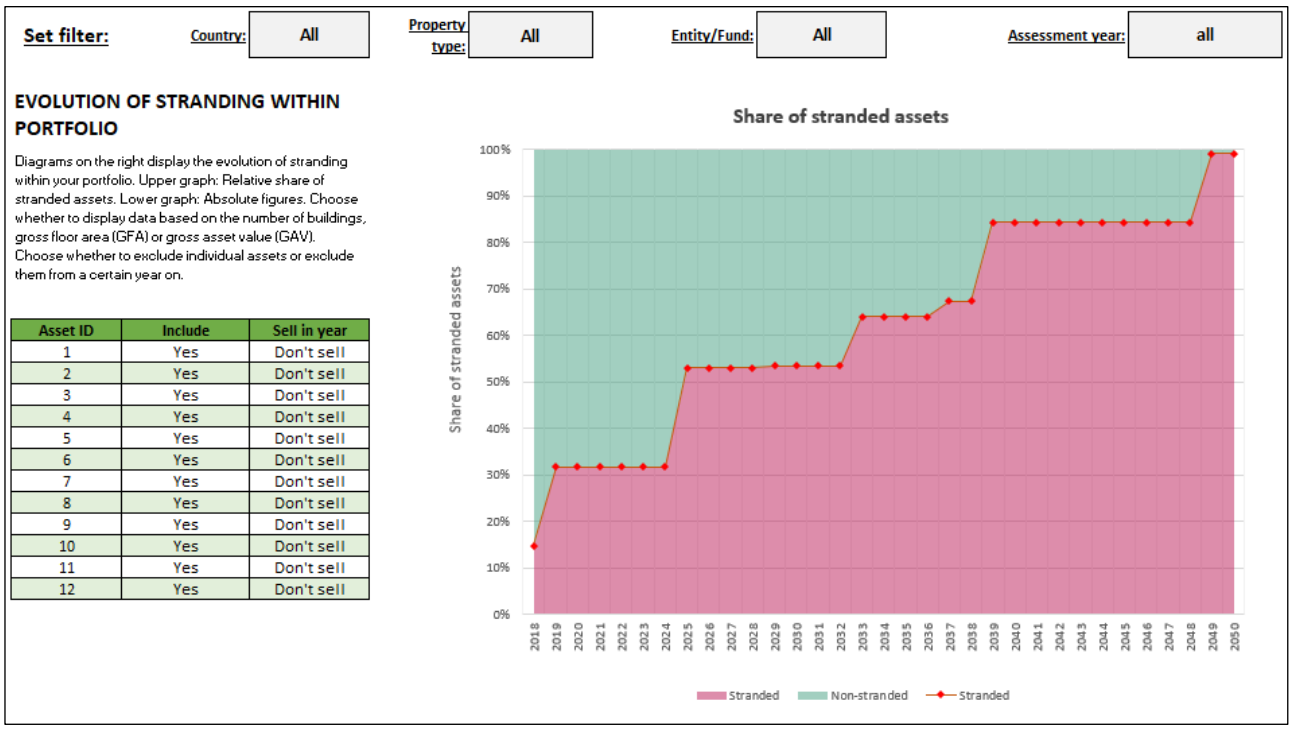


Figure 22: Portfolio-level output – Evolution of stranding within portfolio

On an optional basis, the effect of a sale of individual properties at a certain point in time can also be analysed. The *CRREM* tool portfolio assessment accounts for this fact by providing users with the option to select the year in which they want to sell the asset. Subsequently, the selected assets will not be taken into further consideration. Further analysis includes the presentation of the GHG intensity (see graph below) of the selected portfolio (black line), benchmarking it against the floor-weighted decarbonisation pathways (orange line: all GHGe, blue: 1.5°C). Planned retrofit measures will be visible as the GHG intensity improves in that given year. The dashed line shows the portfolio pathway without any planned future retrofit measures.

CRREM calculations for abatement costs aim to provide a reference for investors to assess the potential risk and possible investment requirements for specific assets. The aggregated value at portfolio level also provides *CRREM* users with a valid reference to help them assess their exposure and expected level of investment.

In relation to abatement costs, *CRREM* follows the approach that properties with low energy efficiency and correspondingly high carbon emissions will also face decreased marketability. Please note: in the graph below, the total emissions are displayed against the total floor area, a weighting for GAV is not accounted for.

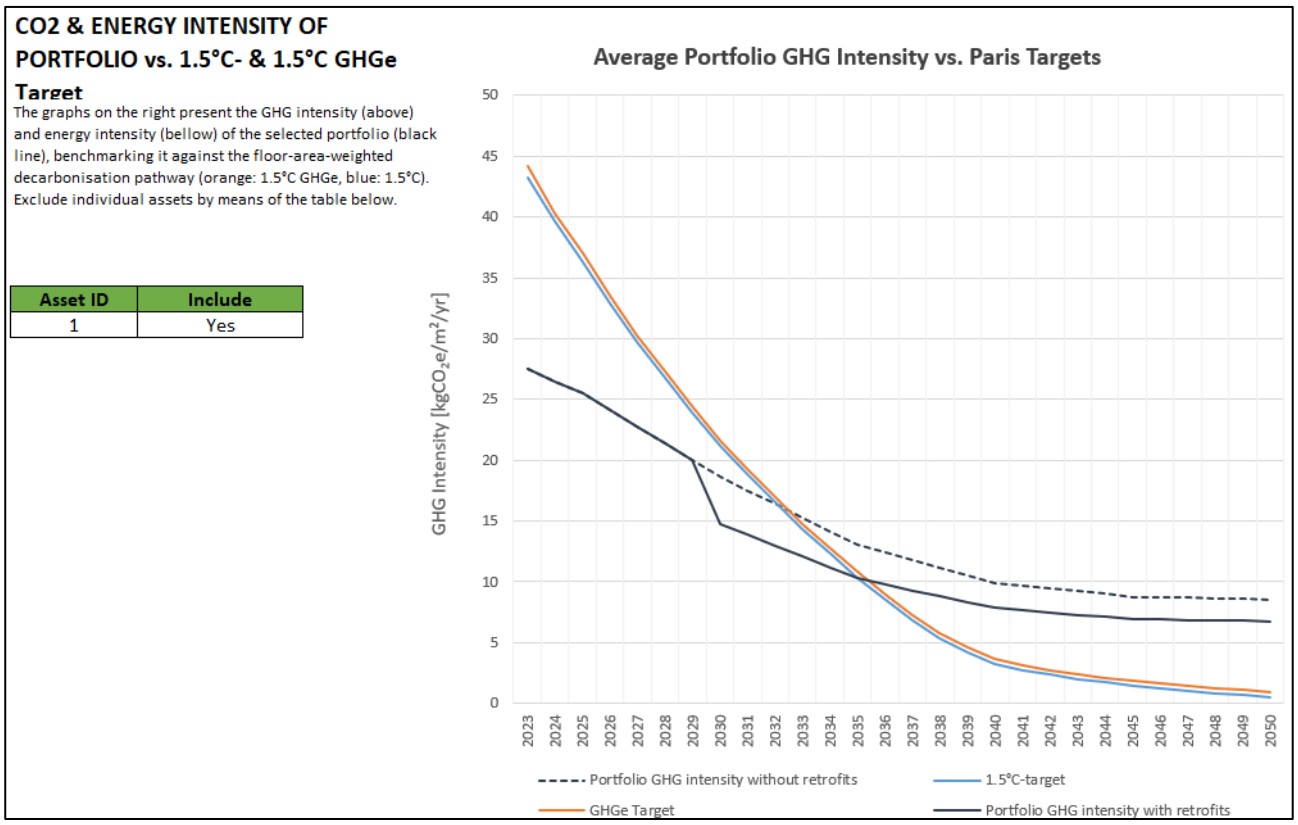


Figure 23: Portfolio-level output – Average GHG & Energy intensity of portfolio against the Paris Targets

When applying the CRREM pathways, it is important to recognize the significant variation in energy demand among individual properties. Special consideration must be given to energy-intensive sub-property types that have maximized their energy efficiency and on-site renewable energy capacity yet remain above the CRREM trajectory. In such cases, properties may still meet the 1.5-degree target if they have achieved peak efficiency and renewable energy production. When interpreting the results of a CRREM analysis, this consideration is critical because the baseline values of the CRREM pathways are derived from the overall market intensity of all properties within a sector.

10 ADDITIONAL RESOURCES

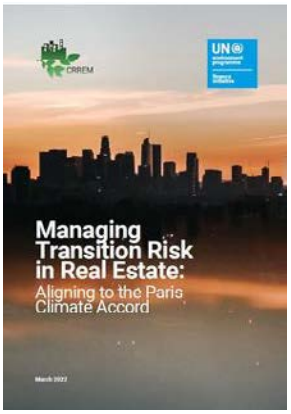
The development of the *CRREM* tool has been underpinned by significant academic research. For this, *CRREM* has identified a wide range of academic articles and other resources, relevant for understanding carbon risk in real estate. A selection of these readings can be found on the *CRREM* website (available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

Accounting and reporting of financed GHG emissions from real estate operations

The purpose of this document is to provide stakeholders with transparent, consistent, harmonized guidelines for property-related emissions. Such guidelines are crucial to the credibility of resulting information and the subsequent decision-making by investors.

Managing Transition Risk in Real Estate: Aligning to the Paris Climate Accord – CRREM & UNEP FI Report

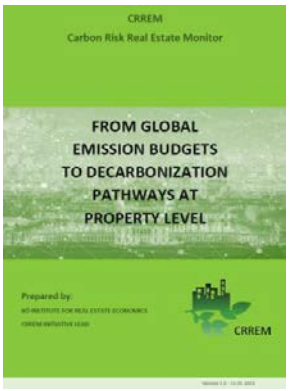


The findings in this report offer both opportunities and warnings for financial institutions. The firms that capitalise on the low-carbon transition will find themselves in a position to thrive in the years ahead. However, firms that avoid the imperative of change will find themselves increasingly at risk and potentially holding stranded assets. Beyond the actions of any one firm, the decarbonization of the real estate sector is a must for our climate and our planet.

How to manage net zero targets with CRREM

This document provides guidelines on the use of the Carbon Risk Real Estate Monitor (CRREM) pathways and on the tool for the European Real Estate Association (EPRA) members, promoting and representing the European public real estate sector with more than 280 members, covering the entire spectrum of the listed real estate industry. An overview of the CRREM initiative is presented, including key benefits regarding assessment and climate risk analysis, the implementation of mitigation strategies for tackling transition risks, and setting decarbonization targets aligned with the recommendations of the Task Force on Climate-related Financial Disclosures (TCFD).

CRREM Methodology and downscaling documentation



This documents provides insights to the full CRREM methodology on how the decarbonisation pathways have been derived from the global emission budget to decarbonization pathways at property-level.

Further, all sources used are listed in the appendix.

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.

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 the Construction and Real Estate Sector Supplement Disclosure.

CRREM DEFAULT DATA – Sources

	EU Tool Version	US Tool Version	Asia Pacific Tool Version
CRREM Pathways	Update 2023 (V2) Link: www.crrem.eu/tool	Update 2023 (V2) Link: www.crrem.eu/tool	Update 2023 (V2) Link: www.crrem.eu/tool
Emission Factors	Update 2023 (V2) Carbon footprint (March 2022): Country specific electricity grid greenhouse gas emission factors. Online: www.carbonfootprint.com	Update 2023 (V2) Carbon footprint (March 2022): Country specific electricity grid greenhouse gas emission factors. Online: www.carbonfootprint.com	Update 2023 (V2) Carbon footprint (March 2022): Country specific electricity grid greenhouse gas emission factors. Online: www.carbonfootprint.com
CO_2 Prices	Update 2023 (V2) BloombergNEF (2022): Science Based Targets initiatives (SBTI) scenario: limits supply to removal offsets like reforestation and nascent technologies such as direct air capture.	Update 2023 (V2) BloombergNEF (2022): Science Based Targets initiatives (SBTI) scenario: limits supply to removal offsets like reforestation and nascent technologies such as direct air capture.	Update 2023 (V2) BloombergNEF (2022): Science Based Targets initiatives (SBTI) scenario: limits supply to removal offsets like reforestation and nascent technologies such as direct air capture.
Energy Prices	Update 2023 (V2) Eurostat (2023): Electricity & Gas prices https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20221031-1	Update 2023 (V2) -	Update 2023 (V2) -
Retrofit data	Update 2020 (V1) Discounting of future costs: BPIE, Europe's buildings under the microscope, Country specific adaptation of costs: ECC European Construction Costs http://constructioncosts.eu/cost-index/ and RLB Euro Alliance https://www.rlb.com/wp-content/uploads/2018/07/European_Construction_Intelligence_2018.pdf, Abatement cost curve: *DEEP* (we used *DEEP* data for the derivation of this)	Update 2020 (V1) Discounting of future costs: BPIE, Europe's buildings under the microscope, Country specific adaptation of costs: ECC European Construction Costs http://constructioncosts.eu/cost-index/ and RLB Euro Alliance https://www.rlb.com/wp-content/uploads/2018/07/European_Construction_Intelligence_2018.pdf, Abatement cost curve: *DEEP* (we used *DEEP* data for the derivation of this)	Update 2020 (V1) Discounting of future costs: BPIE, Europe's buildings under the microscope, Country specific adaptation of costs: ECC European Construction Costs http://constructioncosts.eu/cost-index/ and RLB Euro Alliance https://www.rlb.com/wp-content/uploads/2018/07/European_Construction_Intelligence_2018.pdf, Abatement cost curve: *DEEP* (we used *DEEP* data for the derivation of this)
HDD / CDD	Update 2020 (V1) Eurostat 2020: Heating and cooling degree days – statistics, online: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Heating_and_cooling_degree_days_-_statistics Spinoni, J., Vogt, J. V., Barbosa, P., Dosio, A., McCormick, N., Bigano, A., Füssel, H.-M. (2018): Changes of heating and cooling degree-days in Europe from 1981 to 2100. In: International Journal of Climatology, Vol. 38, Suppl. 1, p. e191-e208.	Update 2020 (V1) -	Update 2020 (V1) -

APPENDIX A: ACRONYMS & ABBREVIATIONS

ABBREVIATION	MEANING	ABBREVIATION	MEANING
bn	Billion	**IIGCC**	Institutional Investors Group on Climate Change
°C	Degrees Celsius	**IPCC**	Intergovernmental Panel on Climate Change
CH_4	Methane	**IEA**	International Energy Agency
CO_2	Carbon dioxide	**kg**	Kilogram
$CO_2e(q)$	Carbon dioxide equivalent	**KPI**	Key performance indicator
CRREM	Carbon Risk Real Estate Monitor	**kWh**	Kilowatt hour
CRE	Commercial	**m^2 or sqm**	Square metres
DH	District Heating	**N_2O**	Nitrous oxide
ESG	Environmental, social and governance	**NDC**	Nationally Determined Contribution
EF	Emission Factor	**NED**	Net energy demand
EU	European Union	**PFC**	Perfluorocarbons
EUI	Energy Use Intensity	**RMF**	Residential Multi Family
EUR	Euro	**RSF**	Residential Single Family
F-Gas	Fluorinated gas	**SBTi**	Science Based Targets initiative
GHG	Greenhouse gas	**SDA**	Sectoral decarbonization approach
GIA	Gross Internal Area	**SF_6**	Sulphur hexafluoride
GR	Growth rate	**TCFD**	Task Force on Climate-related Financial Disclosures
GRESB	Global Real Estate Sustainability Benchmark	**TWh**	Terawatt hours
Gt	Gigaton	**T&D**	Transmission & Distribution (losses)
HDD/CDD	Heating degree days/Cooling degree days	**vs**	versus
HH	Household	**RE**	Real Estate
HFC	Hydrofluorocarbons	**Yr**	Year

APPENDIX B: FREQUENTLY ASKED QUESTIONS

GENERAL QUESTIONS

1. ***Who should use the CRREM Risk Assessment Tool?***
   CRREM: The *CRREM Risk Assessment tool* helps asset owners and managers to understand the long-term transition risks of their real estate investment portfolios. Climate change might endanger the business portfolios 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 CO_2 within their portfolio must be sufficient to fulfil 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* will help users to assess the carbon risks of commercial and residential real estate equity investments based on property specific decarbonisation pathways ensuring that assets are aligned with the Paris climate targets. Should you have any questions regarding data input or asset/portfolio-level output, please do not hesitate to contact us at info@crrem.eu.
2. ***Will the CRREM Risk Assessment Tool also cover non-EU countries or residential assets?***
   CRREM: Yes, CRREM currently covers 44 countries globally (including commercial and residential). A pathway for all non-covered countries will also be published.
3. ***Is the CRREM Risk Assessment tool free?***
   CRREM: 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.
4. ***We would like to integrate the CRREM model with our analytics software. How can this be achieved?***
   CRREM: The CRREM consortium drafted a "CRREM Licensing Agreement" as besides investors and asset managers using the resources for their internal purposes more and more service providers are referring to CRREM-pathways in their solutions. The license agreement will ensure that these organizations refer to CRREM in an aligned way. If you would like more information, please contact crrem@iioe.at.

CRREM TOOL

1. ***How is the Carbon value at Risk calculated? What is the meaning of this Indicator?***
   CRREM: A further risk indicator based on the Gross Asset Value (GAV) is the calculation of the net present value (NPV) of these future cash flows (so-called 'Carbon Value at Risk'). The CVaR enables a comparison of the stranding risks of multiple assets. The tool uses separate country average default values for the carbon and energy prices (for the different energy-types), these can be adjusted to user-defined values in the settings sheet.

2. ***Can residential buildings be evaluated with the CRREM tool?*** CRREM: We developed a short guide "How to use the tool for non-covered countries" available via. https://www.crrem.eu/tool/ - you may use this to also insert the residential pathways. The original *CRREM* tool was to analyze commercial assets only. Please contact Julia.wein@iioe.at or crrem@iioe.at if you require further assistance! (CRREM has already developed residential pathways, you may download these via https://www.crrem.org/pathways/.)

3. ***Does renewable energy procurement from guaranteed origins (e.g.PPA and RECs) get recognised and help with extending out the stranding risk in the CRREM model?***
   CREM: CRREM of course also promotes efficient buildings as it is certain that 'buying one's way out' through compensation or 'off-setting' with certificates can only be the last alternative after all other strategic options have been exploited. Energy-saving measures for decarbonization should never be neglected with the net zero strategy achieved exclusively through the purchase of green power. Rather, all options for reducing energy consumption in the building should have been fully utilized beforehand. Therefore, CRREM promotes that purchasing 'green' electricity will not improve energy-intensity / efficiency of the property. Therefore, CRREM generally recommends that off-site renewables do not constitute a quality characteristic reducing carbon risk of individual buildings. Only renewable electricity purchased directly from a generator / retailer through a power purchasing agreement or contract can be acknowledged, however, it will be your internal company decision which what you decide to accept (CRREM does not set any specific requirements/ approvals in this case). You can use different Credits schemes or PPAs and set the "location-based" approach to the "market-based" and enter your own "user-defined" emission factors.

4. ***Why does the GHG intensity decreases over time? (because more estimated renewable energy in the grid mix?)*** CRREM: The asset baseline performance may improve (decrease) automatically over time as CRREM also considers two factors A) change in climate (change in Heating- and cooling-degree days (HDD/CDD)) and B) projected grid decarbonisation over time.

5. ***Why is there no input mask for Water and waste?***
   CRREM: CRREM only considers operational emissions / operational carbon, therefore waste & water is not included in the analysis.

6. ***How can I take my combined heat and power plant (BHKW) into consideration?***
   CRREM: The output for electricity and heat can be entered separately in the respective energy procurement sections in kWh for the whole building. As a number of BHKW are more environmentally friendly, using more limited resources, you can of course also enter your user-defined emission factors in the "settings" sheet (as it is not a renewable energy source in principle, but it is an energy-efficient technology and can also be operated with renewably produced fuels).

7. ***Fugitive emissions: Our type of gas is not available as an option? How do I add it as an option?***
   CRREM: You can easily insert the missing gas, please use the back-end to overwrite one of the current options. Please do this in C138 and D138 (D138 is the global warming potential (conversion which the tool uses to convert the other GHG to CO_2).

8. ***What is specifically meant with "Off-site renewable electricity generated off-site and consumed on-site"? Does this also include a regular renewable electricity contract?***
   CRREM: Correct, this would include for example contracts or PPA's & RECs. CRREM does not set any specific requirements/ approvals in this case). You can use different Credits schemes or PPAs and set the "location-based" approach to the "market-based" and enter your own "user-defined" emission factors. However, CRREM of course also promotes efficient buildings as it is certain that 'buying one's way out' through compensation or 'off-setting' with certificates can only be the last alternative after all other strategic options have been exploited.

9. ***How is tenant data being reflected in the CRREM analysis? Is tenant energy consumption (electricity + heating) expected to be fully included in the data input? If yes, is there a way to account for tenant data that I do not have access to, e.g. tenant-controlled electricity data?***

CRREM: CRREM always refers to the "whole building" which means the entire building area including the common area and tenant space. If you are unable to collect tenant-controlled data, then the tool has the option of stating the "data coverage" compared to the "maximum coverage" (Input sheet AF-AH). The tool then extrapolates any missing area. In the future transparency can be increased by e.g., implementing "green-leases" etc.

10. ***How do I choose the method for setting the user-defined electricity emission factors?***
CRREM: CRREM of course also promotes efficient buildings as it is certain that 'buying one's way out' through compensation or 'off-setting' with certificates can only be the last alternative after all other strategic options have been exploited. Energy-saving measures for decarbonization should never be neglected with the net zero strategy achieved exclusively through the purchase of green power. Rather, all options for reducing energy consumption in the building should have been fully utilized beforehand. Therefore, CRREM promotes that purchasing 'green' electricity will not improve energy-intensity / efficiency of the property. Therefore, CRREM generally recommends that off-site renewables do not constitute a quality characteristic reducing carbon risk of individual buildings. Only renewable electricity purchased directly from a generator / retailer through a power purchasing agreement or contract can be acknowledged, however, it will be your internal company decision which what you decide to accept (CRREM does not set any specific requirements/ approvals in this case). You can use different Credits schemes or PPAs and set the "location-based" approach to the "market-based" and enter your own "user-defined" emission factors.

11. ***Is there a uniform regulation on what is included in the energy consumption, e.g., lighting, etc.?***
CRREM: CRREM used the "whole-building" approach. Therefore, for example all appliances (PCs etc.) and lightings etc. should be considered.

12. ***Is there any plan to switch to the "market-based" approach with regards to calculating emissions in the future?*** CRREM: if possible, you should use the location-based factors as in the tool, which will allow the best "like-for-like" comparison and optimization on the asset. We recommend to use the location-based factors. However, in the tool we will keep the option for all users to switch to the market-based approach if they wish. The emission factors can be overwritten in the settings sheet.

CRREM DECARBONIZATION PATHWAYS

1. ***Will there be pathways for additional countries?***

CRREM: We have added further granularity to USA & Australia. For both countries there are now sub-regional pathways (AUS: 6 climate zones, USA: top 15 cities covered). Further, we have added the property-type: Industrial dist. Warehouse cooled. In the next year we further plan to expand for Asia-Pacific & USA.

APPENDIX C: TERMS & DEFINITIONS

STRANDED ASSETS / STRANDING

The term 'stranding risk' comprises potential write-downs due to direct climate change impacts and devaluations related to the transition to a 'low-carbon economy'. These risks might amount to trillions of euros and result in a growing liability of company leaders and an increasing fiduciary responsibility of fund managers. In particular regarding long-term investments, stranding risks require increased board attention. Stranded assets in the build environment are properties that will be increasingly exposed to the risk of early economic obsolescence due to climate change because they will not meet (potential) future regulatory efficiency standards or market expectations. These buildings will become less marketable and may require costly refurbishment measures.

For further information, please also see "CRREM Definition of Terms" via. https://www.crrem.eu/tool/.

GHG PATHWAY

In addition to the CO_2-intensity pathway, the CRREM initiative has also published country-and property-type specific pathways which account for the other GHGs (known as refrigerant losses respective to the real estate sector). The add-on for the respective European and Non-EU countries is displayed in terms of $KgCO_2$"e" per square meter in 2020 – 2050. F-Gases at a country level are assigned to the Commercial and Residential Sector and given an extra allowance.

Please note: It is of fundamental importance that this allowance is only granted as long as the use of F-Gases is also reported for the building. If this is not the case, only the CO_2 pathway must be used. (For further information, please see our methodology document chapter 6 "INTEGRATION OF F-GASES & OTHER GHG'S IN THE BUILDING SECTOR").

PRIMARY VS: END-ENERGY

END-ENERGY: also known as final energy consumption, is the amount of heat and electricity consumed by a building as reflected in your utility bills/ meter readings. End-energy may be delivered to a building in two different methods: A) direct combustion on-site to create heat and electricity or B) via procured electricity from the grid or heat received from a district heating system.

PRIMARY ENERGY: is the total amount of raw fuel that is required to operate the building. This also includes all transmission, delivery and production energy/losses. The difference relates mainly to what the energy sector needs itself and to transformation and distribution losses.

MARKET VS. LOCATION-BASED

Location based emission factors are based on the average emission intensities of the electricity grid (national grid-averages), whereas the marked-based approach reflects the GHG emissions based on emissions by the generators from which the entity purchases electricity. Buying "green" electricity will not improve energy-intensity / efficiency of the property.

The GHG Protocol defines two calculation methods for the measurement of scope 2 emissions:

(1) The location-based method quantifies scope 2 GHG emissions based on average emissions intensity of the electricity grids within which the energy consumption occurs. Emission factors (EFs) are often defined using national boundaries, but can also be based on subnational, or even local, boundaries.

(2) The market-based method quantifies scope 2 GHG emissions based on emissions associated with the generators from which the entity purchases electricity. As such, the market-based method reflects the choices an entity makes on its electricity supply.

The table below shows some benefits and drawbacks between the two methods.

	Location-based	Market-based
Benefits	Benefits to financial institutions • Provides more comparability on energy performance, particularly when isolated to a single region Benefits to low-carbon transition • Incentivizes energy reduction and energy efficiency measures • Incentivizes on-site renewable energy generation	Benefits to financial institutions • Allows for credible use of off-site renewable energy to progress towards net-zero goals Benefits to low-carbon transition • Incentivizes use of/switch to low-carbon energy options (including both on-site and off-site renewable energy) by landlord and tenants • Incentivizes energy reduction and energy efficiency measures
Drawbacks of relying on a single method	Drawbacks to financial institutions • Does not account for active renewable energy procurement, which is invariably a part of any net-zero initiative, framework, or commitment for real estate Drawbacks to low-carbon transition • Could remove accounting incentive for renewable energy purchasing and, consequently, reduce the demand signal in renewable energy markets and the amount of renewable energy on the grid • Could result in freeloading on decarbonization actioned by the energy sector, and decreased incentive for energy reduction measures	Drawbacks to financial institutions • In the absence of robust residual EFs, market-based methods could potentially lead to double-counting of renewable energy use Drawbacks to low-carbon transition • Could lead actors to emphasize their use of low-carbon energy procurement options at the expense of pursuing energy reduction and energy efficiency measures

SCOPE 1,2 & 3

According to the GHG protocol, the boundary of each scope is:

SCOPE 1 EMISSIONS: Emissions from sources the organisation owns or controls. These are direct GHG emissions and they are released by (1) generation of electricity, heat or steam on site, (2) chemical processing, (3) transportation of materials, products, waste and employees in company owned vehicles, and (4) fugitive emissions from intentional or unintentional releases.

SCOPE 2 EMISSIONS: Indirect emissions from the generation of purchased electricity, steam, heat or cooling generated by others, which is consumed in the organisation's owned or controlled equipment or operations. The amount of electricity consumed can be controlled by the company, but the carbon emitted in the generation of the electricity as well as the losses through transmission and distribution are outside the control of the organisation. Note: These emissions (Scope 2 for the company consuming electricity) are accounted as direct Scope 1 emissions in the carbon reporting of electricity providers.

SCOPE 3 EMISSIONS: Indirect emissions from any other downstream or upstream activity. Accounting and reporting Scope 3 emissions is optional according to the GHG Protocol.

APPENDIX D: DIFFERENCES TO GRESB

The *CRREM* tool offers additional asset-level and portfolio-level evaluations and output calculations to those that use only the data that GRESB collects and supports. In order to take advantage of such calculations, users have the option to input additional information into the *CRREM* tool or edit the information that GRESB uses. Appendix D lists all additional input that users can enter after using the automated *CRREM* tool download function from GRESB in order to increase the types of data output available.

Entity

An optional field that can be used to categorize the analysis of assets amongst property managers, funds, separate accounts, or other entities. This is optional field can be filled in subsequent to the GRESB download function to enable further aggregation.

Air Conditioning

The users can additionally define if air conditioning is used in a specific asset. This field is optional, however, providing information on the existence of an air conditioning system enables the Tool to provide better estimations on the future effect of increasing cooling demand in buildings.

Energy Consumption

GRESB does not collect data on the type of fuels used, and in its pre-fill function, all fuel use is assumed to be natural gas. If a user knows that a particular asset uses a different type of fuel (such as fuel oil), he or she may then edit the pre-filled areas to reflect this.

GRESB imports all district heating and cooling into CRREM District Heating input, as GRESB does not delineate between district heating and district cooling. If users know the split between their district heating and cooling, they should edit the pre-filled areas to reflect this.

Fugitive Emissions

After the GRESB download, users can additionally enter fugitive emissions. The CRREM tool allows users to report on the type of gas and the amount of the leakage in terms of kg. Amount reported will apply for each year, from the reporting year through 2050.

Renewable Energy

GRESB does not differentiate between different types of renewable energy sources. Therefore, all renewable energy collected from GRESB is assumed to fall under the “PV, wind” inputs of the CRREM tool. Users may adjust this subsequent to the Tool download from the GRESB Portal.

Location-Based vs. Market-based

CRREM additionally allows the option to select location-based as the reporting method. If the market-based method is selected individual emission factors should be entered as disclosed by your energy provider.

Retrofit Actions

GRESB allows participants to report on the implementation of a variety of energy efficiency measures in the last three years. GRESB does not translate these into Retrofit Action inputs in the CRREM tool because the effects on energy consumption should already be accounted for in the reported data, which is then used to fill in the CRREM tool. The CRREM tool allows users to define retrofit measures in the future. GRESB members may add a future retrofit action following the Tool download.