Sustainable Real Estate
University Seminar – „CRREM“

Regensburg

09.06.2020

WP9 Task 9.4

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

CRREM

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Profitability/ Anyway-costs

Embodied carbon

Carbon accounting and reporting

Regulated vs. unregulated emissions

Change of emissions factors, heating/cooling load, prices

BUILDINGS

and

CLIMATE PROTECTION

More than saving energy

Scope 1,2,3

Strategic options (Sell, Hold, Retrofit – Timing)

Carbon pricing

Investor/Tenant/ Occupancy

GHG savings

Carbon budget downscaling

Liability

Predictability/Reliability of regulation

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Agenda

1. Introducing the CRREM project
2. Specific Issues regarding Carbon Risk (Q&A)
3. Case Study: Calculating carbon emissions & stranding risks
4. What's new?

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Project title: **CRREM: Carbon Risk Real Estate Monitor - Framework for science based decarbonisation pathways, toolkit to identify stranded assets and push sustainable investments**

Duration: February 2018 – January 2021

Funding: EU H2020 framework programme

General objectives:

- Downscaling & transparency: Breaking down global GHG emissions budget by sector, company and property level for more transparency and capacity building
- Strategic implication of "Stranded assets": Defining areas for improvement and strategic options
- Framework, toolkits & methods: Making decarbonisation in the commercial real estate sector measurable

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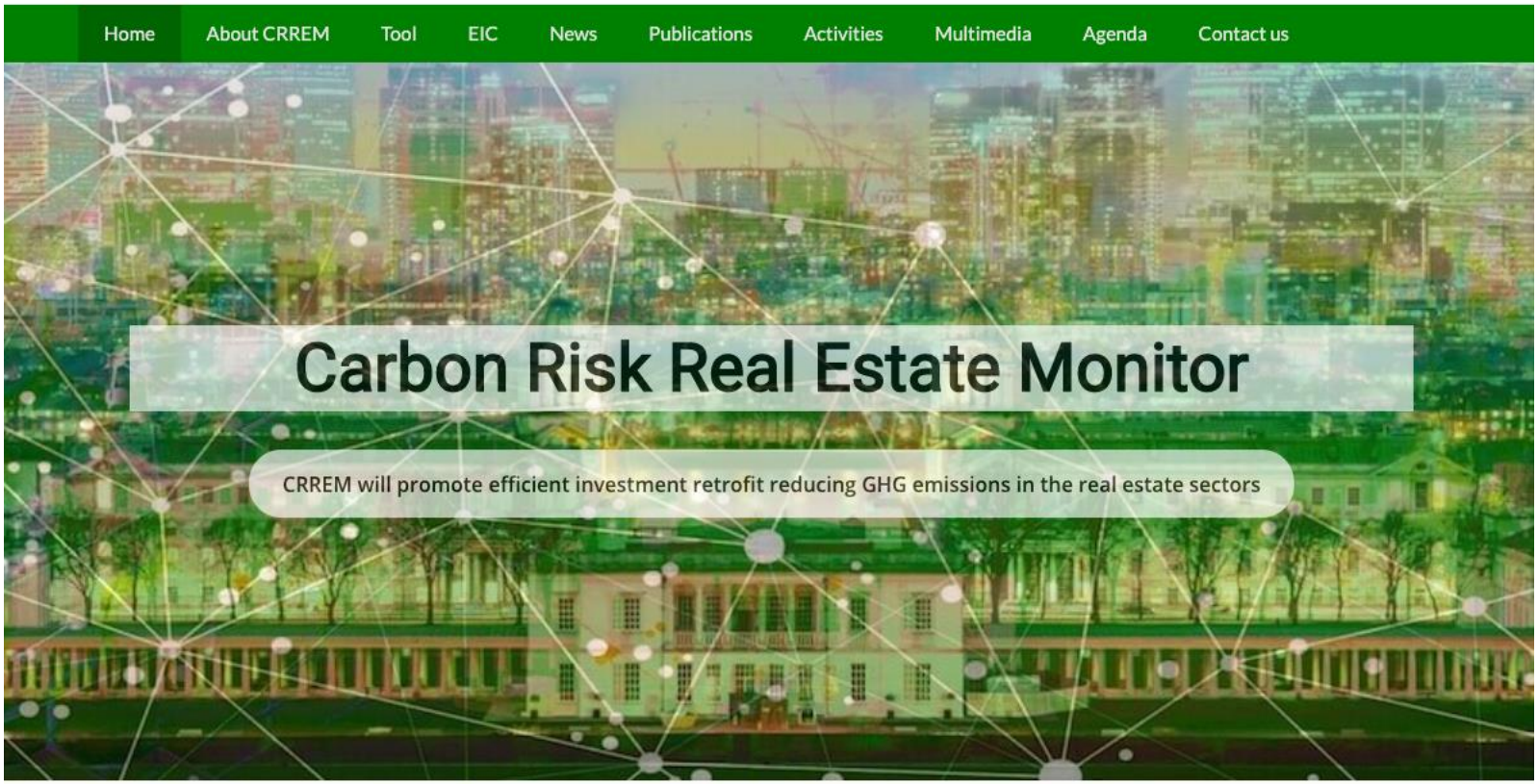
CRREM Project homepage: www.crrem.eu



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Fundamental questions and answers regarding carbon counting:

1. Why is Carbon Dioxide so relevant to limit climate change? What does the term “Decarbonisation” refer to?
2. Why is it important to focus on real estate to limit / reduce emissions?
3. How can carbon emissions be assessed for real estate and what might be important when doing so?
4. How can real estate investors benchmark the carbon footprint and derive targets for decarbonisation? What must be addressed when setting targets on a timeline until 2050?
5. Corporate carbon risk management:
   A. Is the carbon footprint and potential decarbonisation effecting the risk-return profile?
   B. Explain the concept of stranded real estate assets.
   C. How could carbon risk be managed effectively?
   D. What about carbon pricing? Is real estate affected in that respect?
   E. How do you assess an energetic retrofitting?
6. What are (relevant) guidelines and regulations?

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1. Why is Carbon Dioxide so relevant to limit climate change? What does the term "Decarbonisation" refer to?:

- Dramatic rise in the atmospheric concertation (PPM) of carbon dioxide and other GHGs compared to the preindustrial level
- Paris Climate Agreement: Limit global warming to below 2° C; or even 1.5° C
- The remaining **emission budget** until 2050 in order to limit the global warming is about **669 $GtCO_2e$ (1.5°C)** and **784 $GtCO_2e$ (2°C).**
- However, with current emission pledges, this budget will be consumed by 2036 (14 years prior to 2050) and the global warming will reach approx. 3° C
- Decarbonisation: the profound transformation of the economy from fossil fuels towards a sustainable, renewable energy-based economy which involves considerable transition risks.
- These global carbon budgets need to be broken down into decarbonisation pathways for different economic sectors (including real estate) and countries to allocate carbon reduction responsibilities.

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2. Why is it important to focus on real estate to limit / reduce emissions?:

- The real estate industry is among the highest emitters of GHG accounting for approx. 30 % of total GHG emissions and therefore plays a crucial role in future mitigation efforts.
- Emissions resulting form the operation of buildings have to be taken into account as well as those originating from construction and refurbishment activities (embodied carbon).
- Existing housing stock drives energy consumption and operational expenditures significantly:
  - 35 % of buildings are older than 50 years
  - 40 % of energy consumption caused
- Population growth and economic growth drive the construction activities and have to be considered as well, further rising the GHG emissions of the sector.

- In contrary, the real estate industry faces relatively low abatement costs for energetic retrofit measures (i.e. low hanging fruits) in comparison with other sectors.
- **Abatement costs:** costs of reducing energy consumption / carbon emissions by a certain amount.

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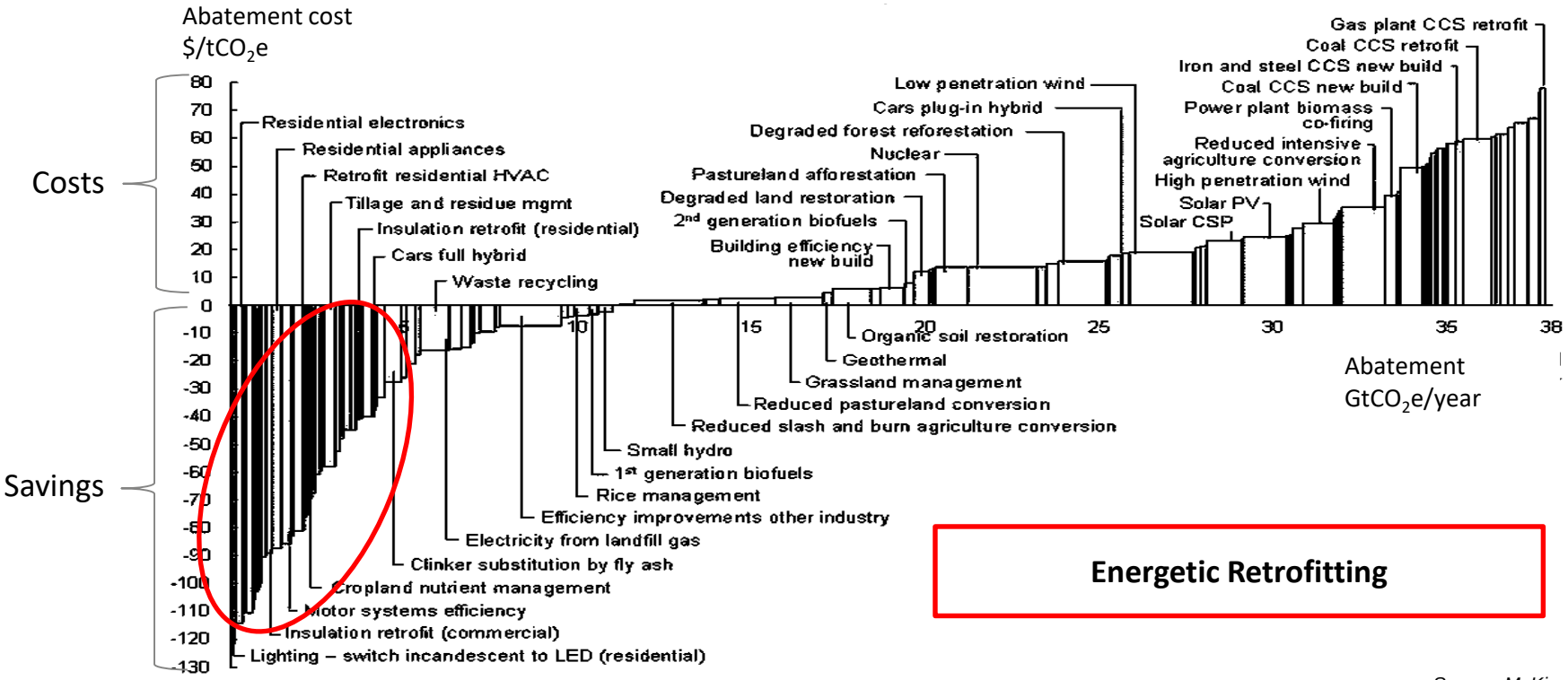
2. Why is it important to focus on real estate to limit / reduce emissions?:

The abatement cost curve provides a "map" of carbon reduction opportunities

Cost of Abatement, 2030, €/tCO2e



Source: McKinsey, 2011

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3. How can carbon emissions be assessed for real estate and what might be important when doing so?:

1. Data requirements:
   - First insights: operational carbon emissions during the usage phase have to be considered, especially those originating form the consumption of electricity or cooling and heating of the building
   - It‘s important to focus on the data for the whole building and therefore consider the data of both owner and tenants (regardless of who pays the energy bills).
   - The so-called ‘tenant-investor-dilemma’ is not only relevant for the process of data gathering, but also for the cost-benefit distribution of certain retrofit measures.
2. Consumption vs. emissions:
   - In a second step, the energy consumption data has to be transformed into GHG emission data via the use of so-called **emission factors**.
   - These emission factors state how much GHG emissions (in kg CO2e) are released by the consumption of one unit of a specific energy source (e.g. Oil, Gas etc.)
   - While the emission factors are fixed values for Oil and Gas, they differ significantly for the electricity market depending in the building location (country-specific or even regional variations) and vary over time.

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3. How can carbon emissions be assessed for real estate and what might be important when doing so?:

3. Adjustment process / possible influences:
   - Vacancy rates
   - Usage type and mixed property
   - Weather in the year of assessment
   - Risk assessment requires future perspective: Change of electricity emission factor (grid decarbonization) and effect of climate change on heating and cooling demand.

4. Saving climate by energetic retrofits (?):
   - Yes, since new construction rate is approx. < 2% BUT: Embodied carbon has to be considered as well.
   - **General rule for retrofits: Always choose the retrofit measure with the maximum abatement efficiency.**

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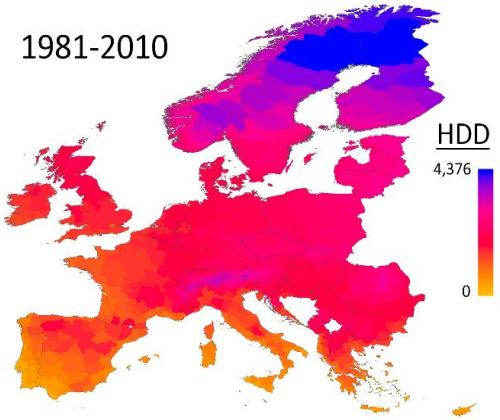
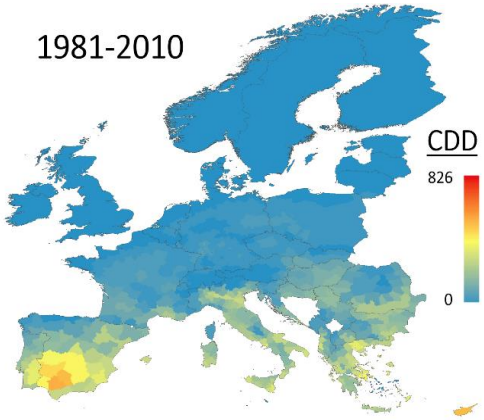
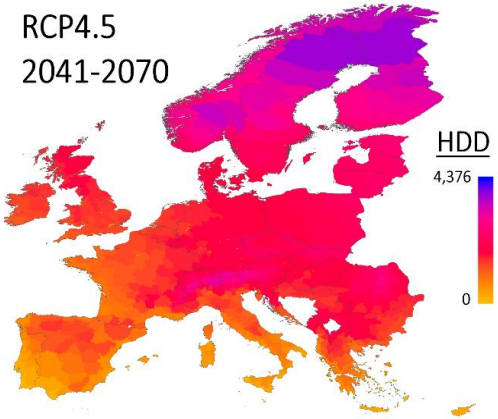
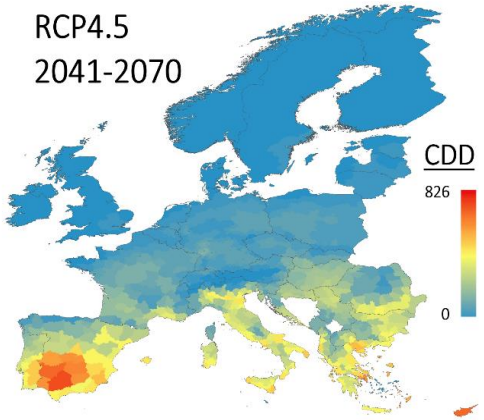
Specific Issues

Consideration of effects of changing heating and cooling loads and electric grid decarbonisation









Source: Spinoni et al. (2018), own calculation and presentation.

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3. How can carbon emissions be assessed for real estate and what might be important when doing so?:

5. Scopes - Operational and embodied carbon:
   - CO_2 vs. CO_2e: Other greenhouse gases have to be considered as well (e.g.: CH_4, N_2O, etc.)
   - Scopes 1,2,3
6. What‘s the benchmark the sector should use?:
   - Carbon intensity (annual emissions per floor area or per revenue)
   - kgCO2e/m²/a or $kgCO_2e$/€/a
7. Which template should be used for the data collection?:
   - There are already enough IT-systems and initiatives
   - Generally, do not re-invent the wheel, use existing schemes.
   - Example: EPRA, GRESB, GRI etc.
8. External data:
   - Emission factors and HDD/CDD required (database!)
9. Discussion in Carbon offsetting
   - Location vs. market-based approach

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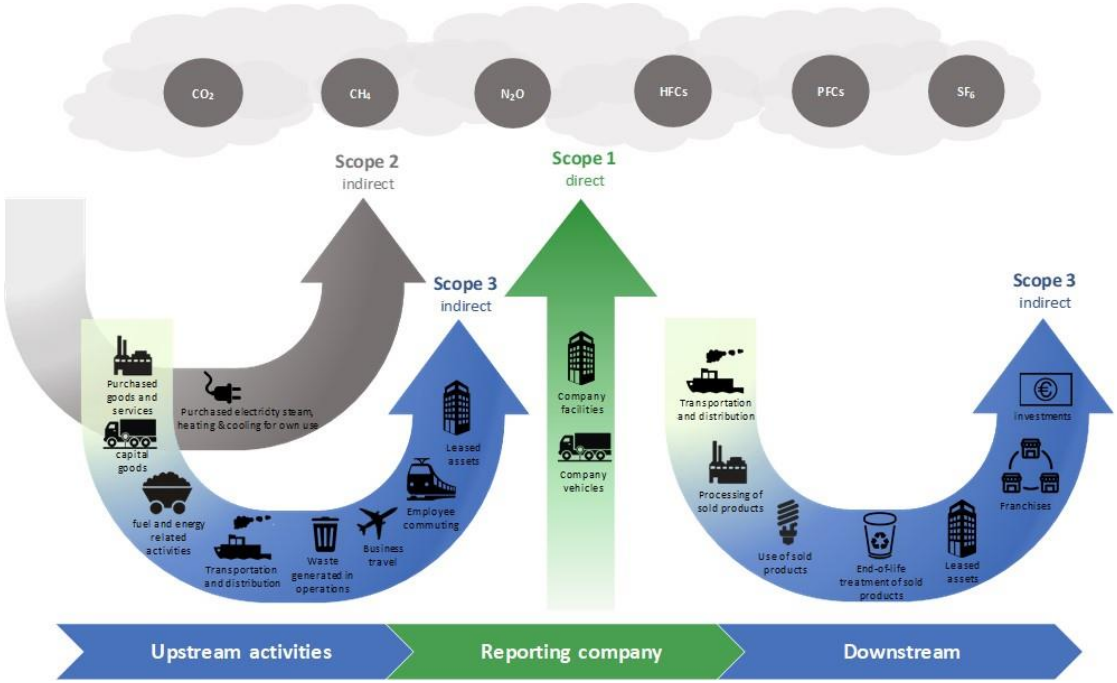
What needs to be addressed for deriving a KPI for RE carbon?

- GHG Protocol: Standards for assessment, accounting and reporting of GHG emissions (World Resources Institute WRI & World Business Council for Sustainable Development WBCSD)
- Accounting: Energy consumption (fuels, electricity), conversion to GHG with emissions factors. Challenge: lack of tenant data (esp. electricity consumption)
- Reporting: Emission scopes 1, 2, 3
- S1: Direct emissions from burning fuels or leakages
- S2: Indirect emissions from energy consumption
- S3: Indirect emissions from upstream and downstream processes



Source: GHG Protocol, 2013.

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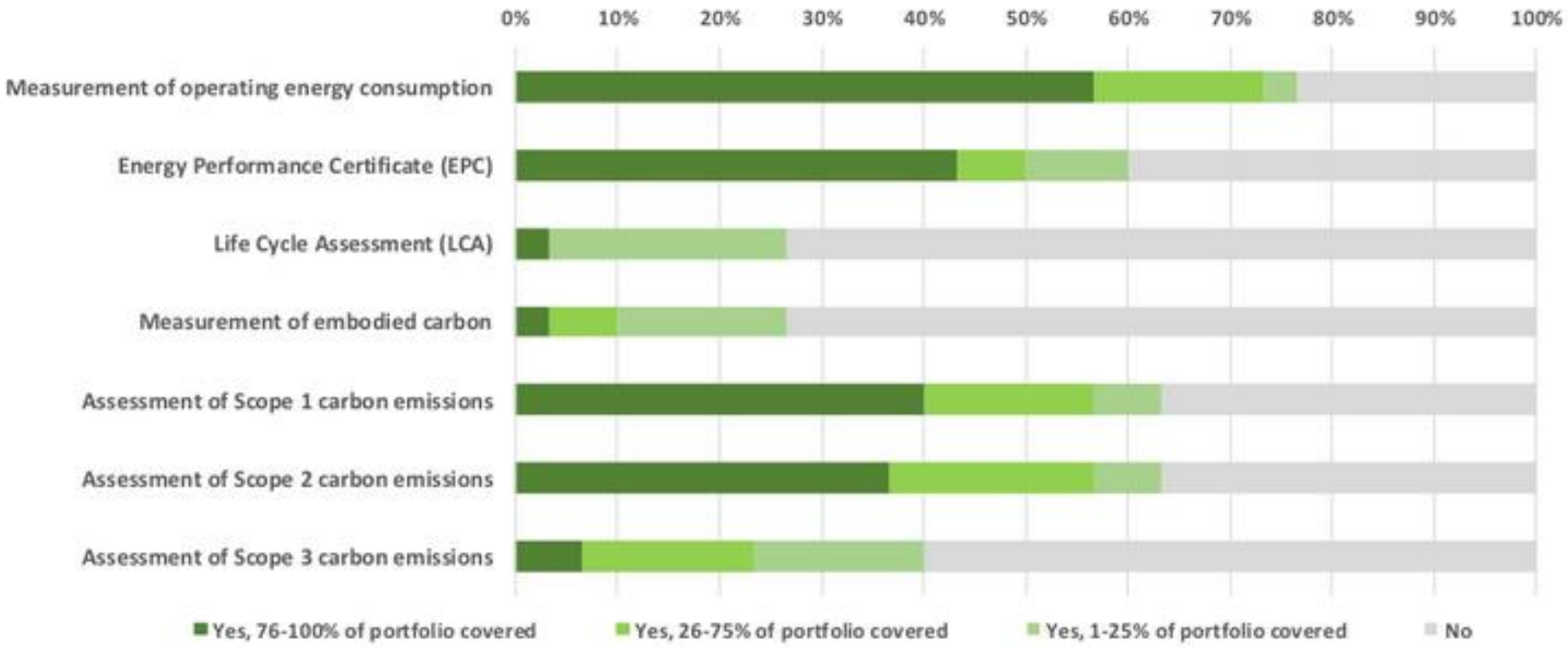
Status quo of carbon risk integration in corporate strategies



Source: CRREM, 2019.

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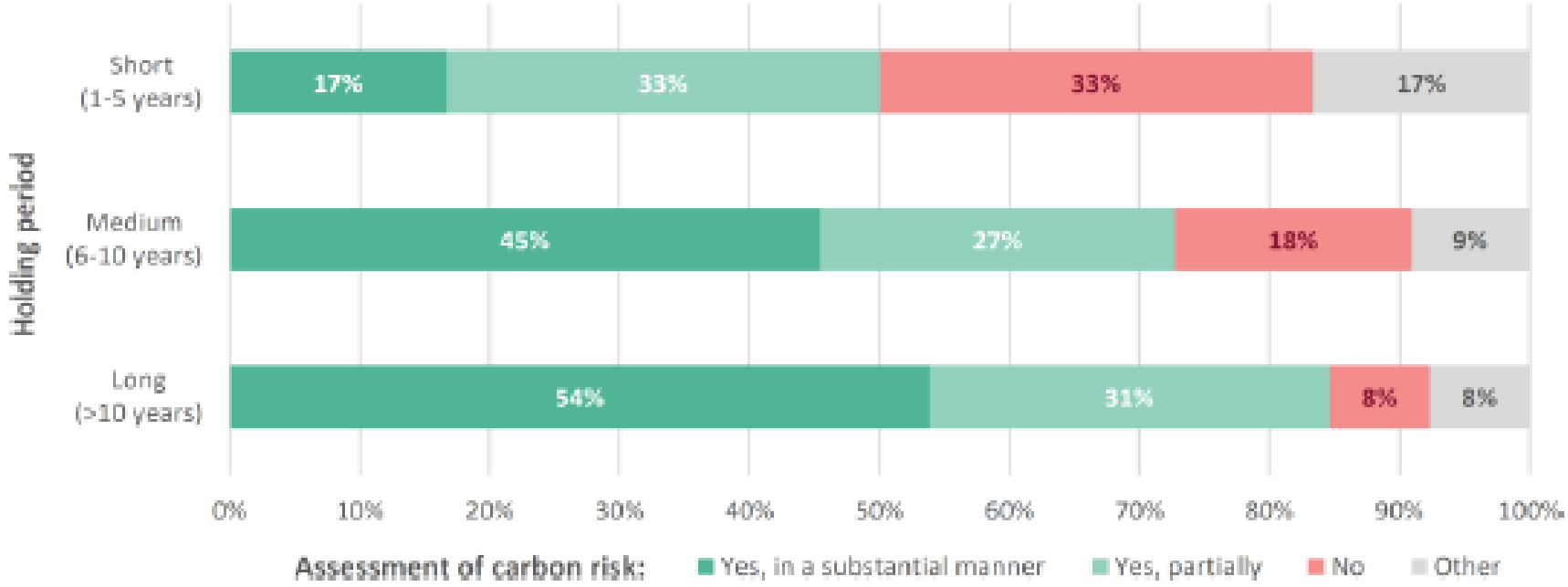
Status quo of carbon risk integration in corporate strategies

Figure D-3: Impact of preferred holding periods on extent of carbon risk assessment



Source: CRREM, 2019.

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4. How can real estate investors benchmark the carbon footprint and derive targets for decarbonisation? What must be addressed when setting targets on a timeline until 2050?:

- CRREM – Carbon Risk Real Estate Monitor:
  - Decarbonisation targets for various countries and usage types on property level
  - Emission factors and adjustment for HDD/CDD are implemented automatically
  - Automatic adjustment of occupancy (vacancy rates)
  - Possibility to calculate energy costs and carbon costs (excess emissions)
  - Simulation of retrofit measures
  - Simulation of different mitigation scenarios (1.5 vs. 2 degree)
  - Default and user-defined assumptions
- Timeline: Consideration of side effects:
  - Grid decarbonisation is evolving,
  - Effects of climate change on HDD/CDD
  - Timing of retrofit measures

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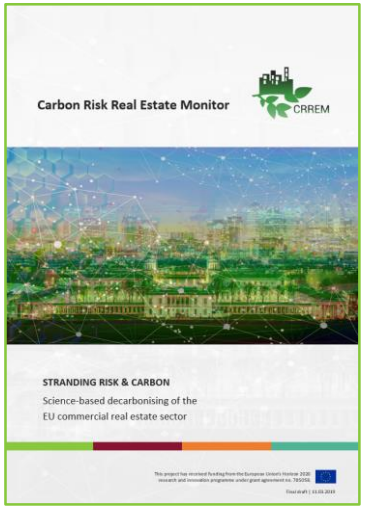
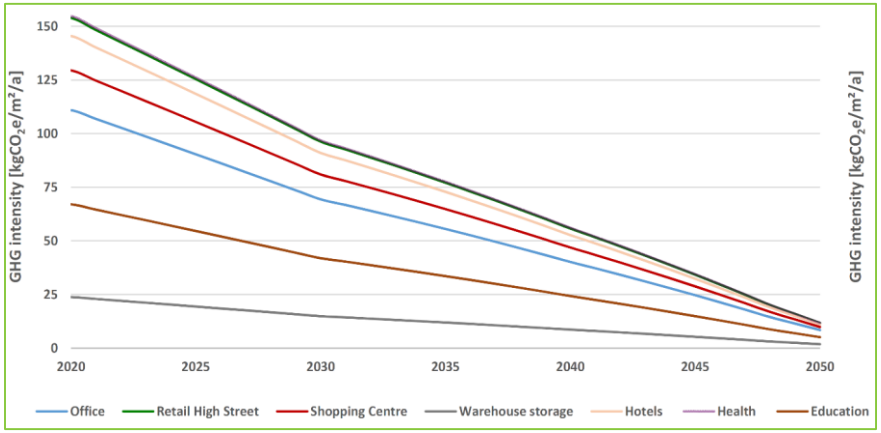
Report: “Stranding Risk & Carbon - Science-based decarbonizing of the EU commercial real estate sector”

KEY FINDINGS



- At the current rate of emissions the EU commercial real estate 1.5°C carbon budget for 2050 will be consumed 14 years ahead of schedule in 2036.
- EU’s current carbon reduction pledges will lead to an above 2°C global warming scenario.
- Buildings will need to reduce their carbon emissions by more than 80% until 2050.

GHG TARGETS DISAGGREGATED BY COUNTRY AND BUILDING USE TYPE



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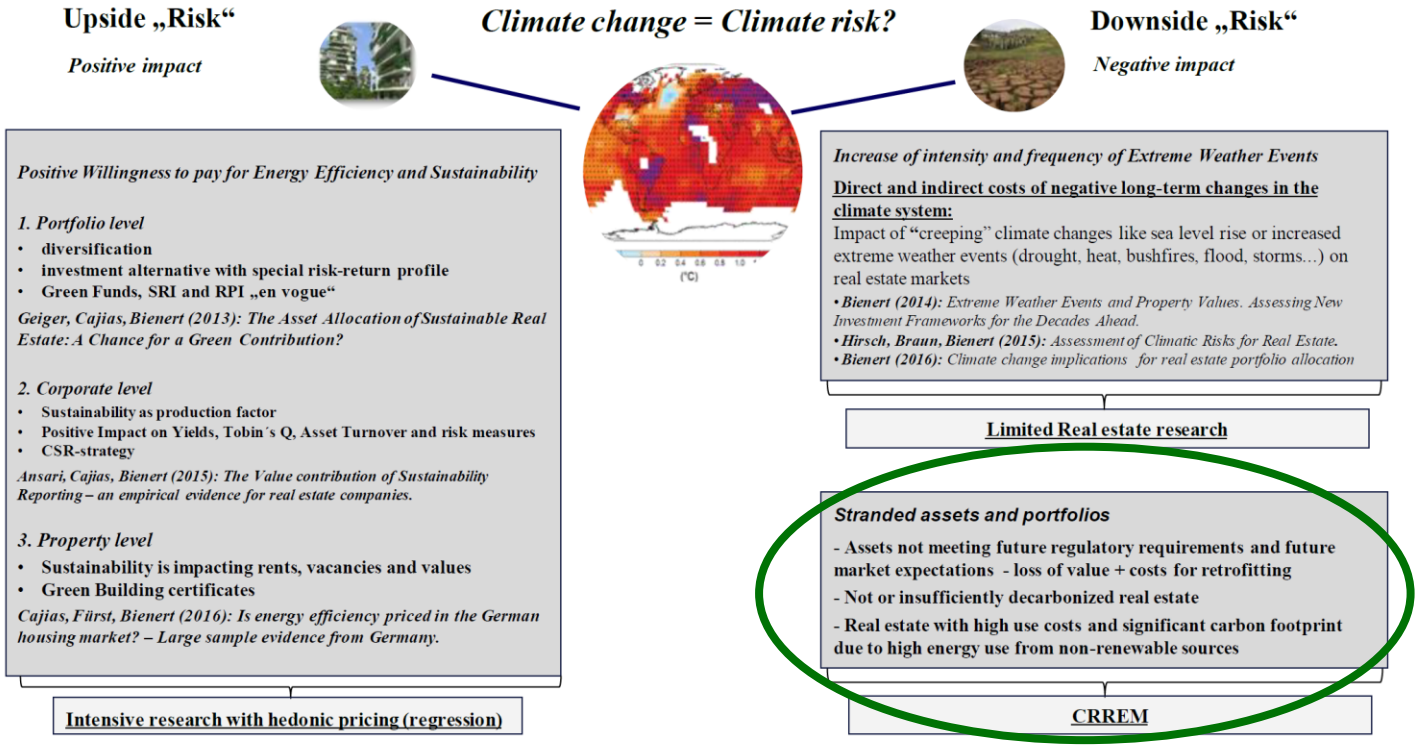
5. Corporate carbon risk management:

A. Is the carbon footprint and potential decarbonisation effecting the risk-return profile?

- Transition risk and brown discount, not just pure present values but derived from hedonic pricing
- Stranding risk and potential carbon pricing



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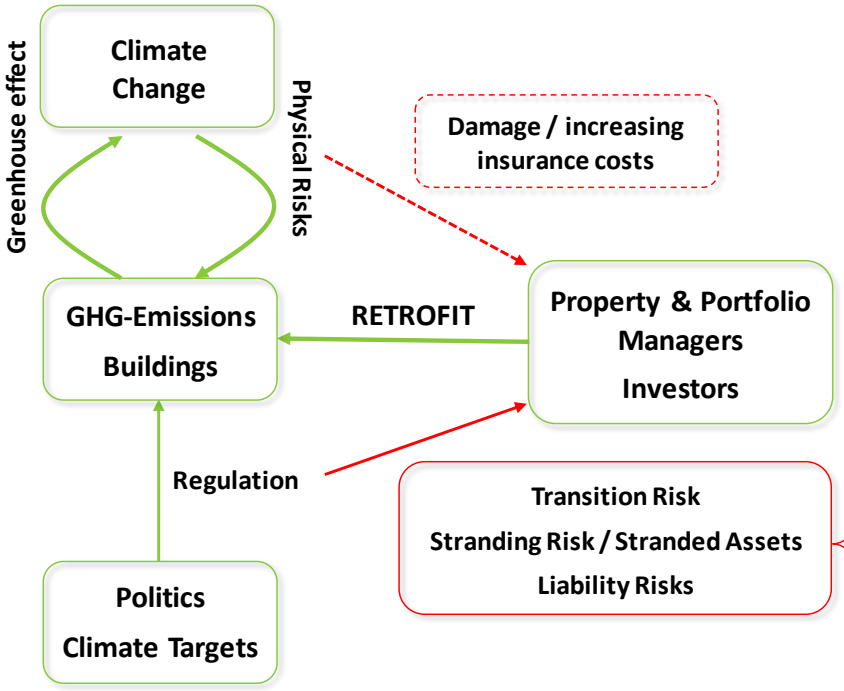
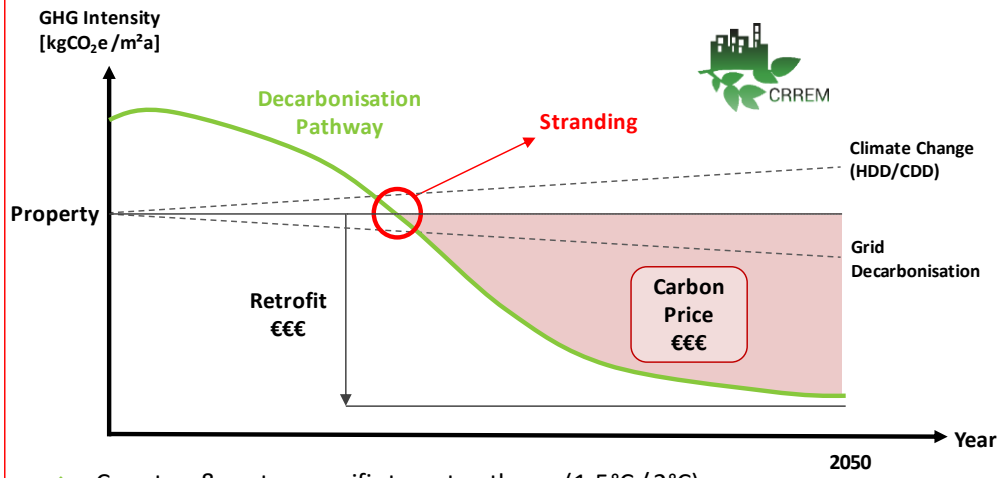
5.B. Explain the concept of stranded assets.



CRREM: Identification of Stranded Assets / Stranding Risks



- Country- & sector specific target pathway (1,5°C / 2°C)
- KPI: Greenhouse Gas Intensity ($kgCO_2e/m^2/a$)
- Stranding when target ceiling is exceeded → Stranding Risk
  - Retrofit costs
  - Costs of (excess) emissions (Carbon price)
- Heating & cooling demand + Grid decarbonisation → Future emissions

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5. Corporate carbon risk management:

C. How could carbon risk be managed effectively?

- transparency about own consumptions and emissions
- knowledge about targets and current industry best practise
- monitoring & benchmarking of own results
- undertaking retrofits/refurbishments to optimize carbon footprint

D. What about carbon pricing? Is real estate effected in that respect?

- currently real estate in Europe NOT included in the ETS but EPBD
- ongoing discussion about carbon tax and pricing
- “excess emissions” once stranded might be calculated as the maximum euro amount for refurbishment budget

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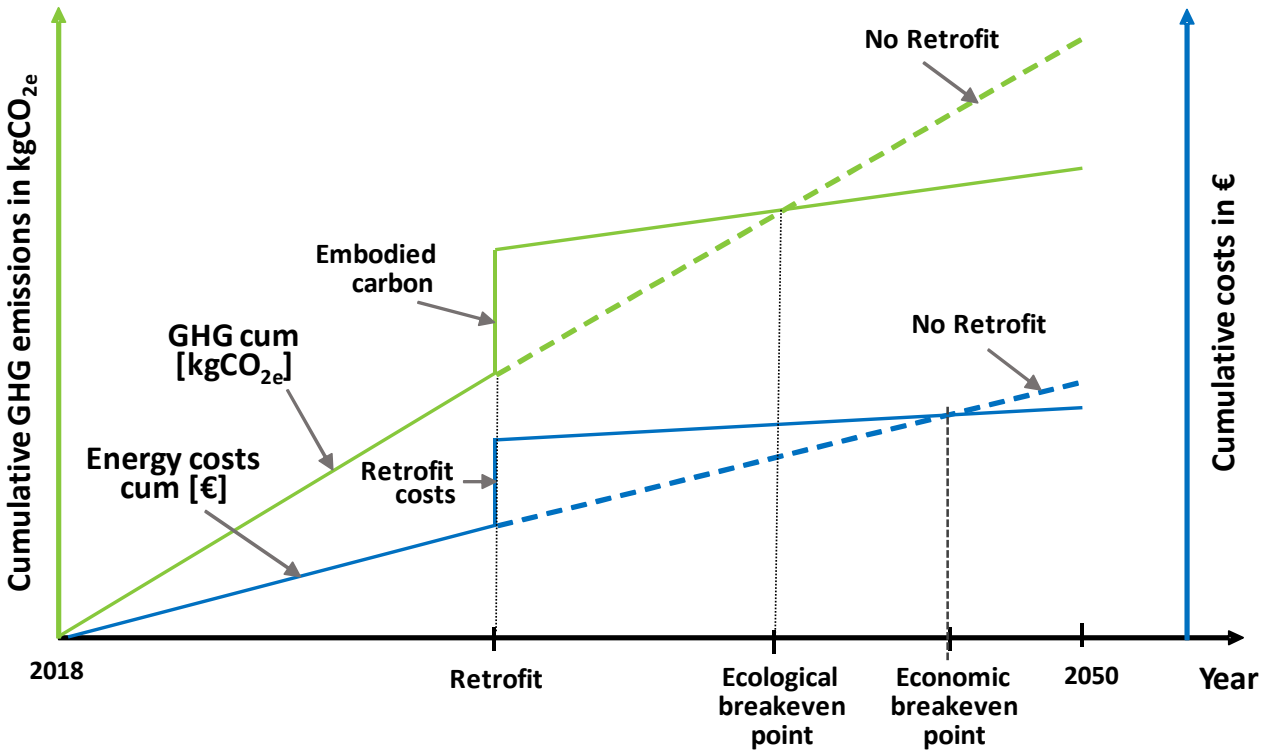
5.E. How do you assess an energetic retrofitting?

Economical: Annual energy cost savings vs. Investment costs: Assessment of net present value of energetic retrofit measure

Ecological: Annual GHG emission savings vs. embodied carbon → Supplementing the economic break-even point with an ecological one

Embodied carbon of retrofit measures is not included in corporate reporting so far



Source: CRREM

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5.E. How could asset management manage risk? The CRREM approach

USER INPUT

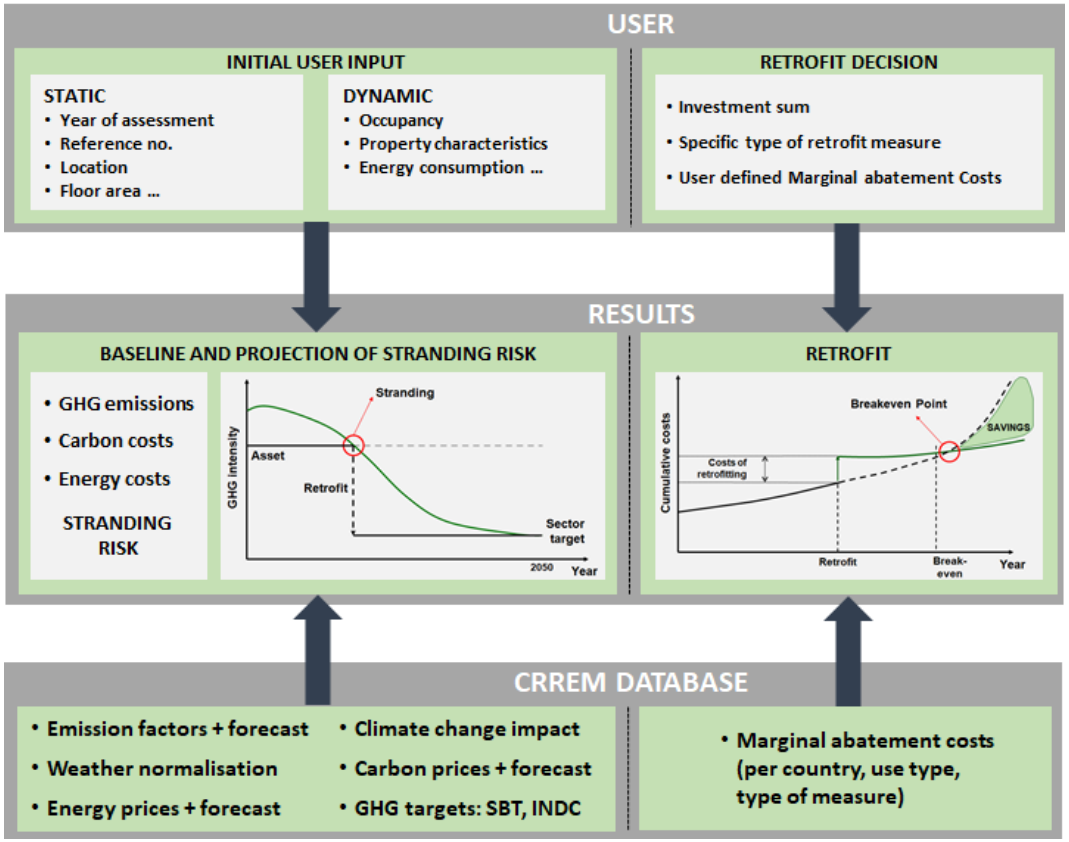
- Property characteristics: Location, year of construction, energetic characteristics, occupancy, energy consumption
- User assumptions: Discounting, carbon price, energy prices, abatement costs, own…

RESULTS

- 'Stranding Diagramm', stranding risk, costs of retrofits necessary to meet targets, carbon costs, asset level, portfolio…

DATABASE

- GHG reduction targets, emission factors, weather normalisation, energy prices, carbon price, HDD/CDD, abatement costs, grid decarbonisation…



Source: CRREM

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6. What are (relevant) guidelines and regulations?:

- Carbon Disclosure Project
- GRESB
- INREV
- EPRA
- GRI: Global Reporting Initiative
- etc.

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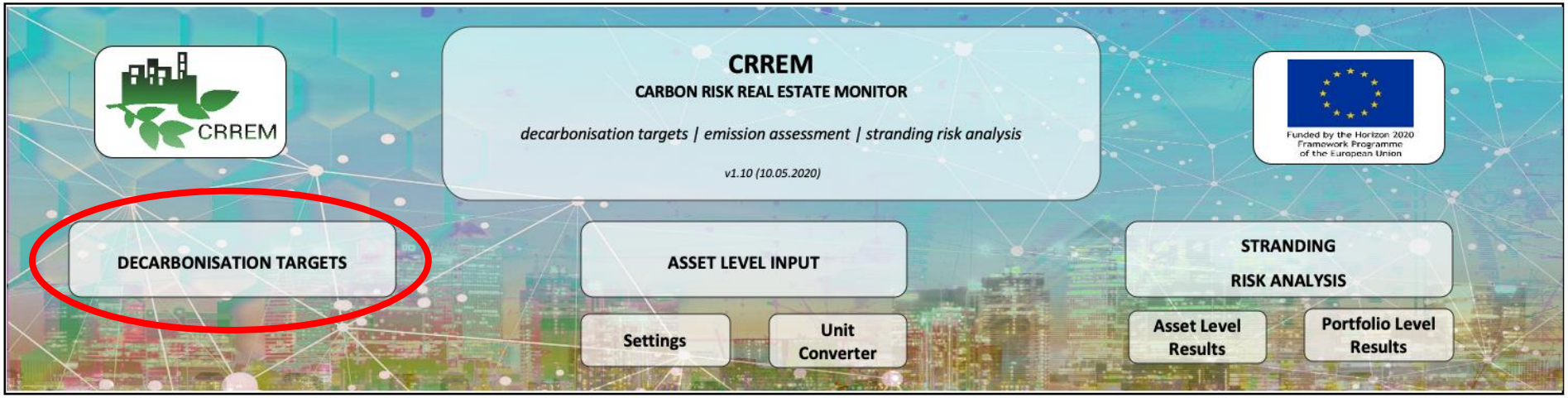

Click the desired functionality. **Stranding risk analysis** requires **input data on asset level**.
Decarbonisation targets for different property types and each EU member state can be viewed without entering specific asset data.
Click the **CRREM logo** on any sheet to return to this summary.

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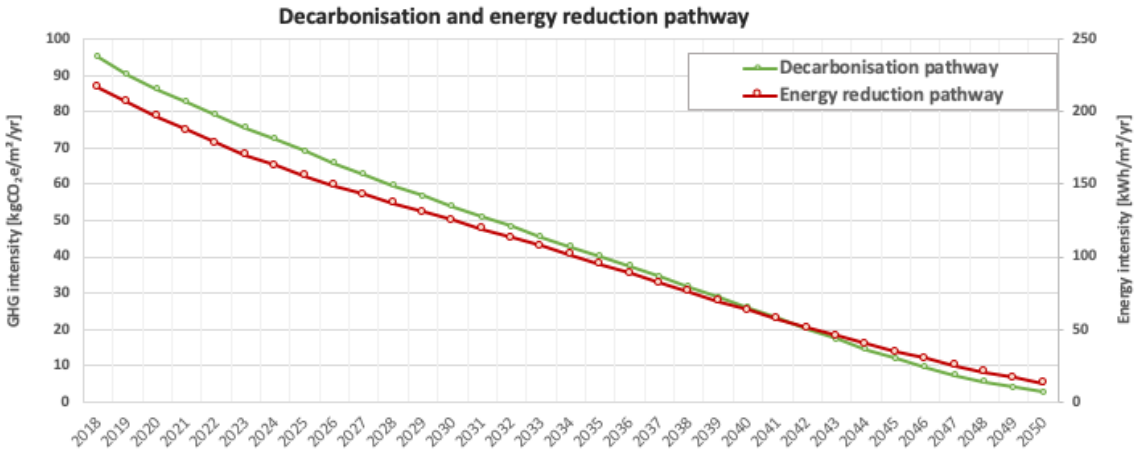
DECARBONISATION TARGET TOOL

The CRREM Decarbonisation Target Tool offers the possibility to assess country- and building-type-specific GHG intensity and energy reduction pathways aligned to limiting global warming to 1.5°C or 2°C

Funded by the Horizon 2020 Framework Programme of the European Union



Global warming target:	1.5°C
Country:	Germany
Type of use:	Office

Whole building GHG intensity pathway:

Year	$kgCO_2e/m^2/yr$	Year	$kgCO_2e/m^2/yr$
2018:	95,0	2035:	40,2
2019:	90,3	2036:	37,5
2020:	86,3	2037:	34,7
2021:	82,6	2038:	31,9
2022:	79,1	2039:	29,0
2023:	75,7	2040:	26,1
2024:	72,4	2041:	23,1
2025:	69,1	2042:	20,2
2026:	65,9	2043:	17,3
2027:	62,7	2044:	14,6
2028:	59,7	2045:	12,0
2029:	56,7	2046:	9,6
2030:	53,8	2047:	7,5
2031:	51,0	2048:	5,6
2032:	48,2	2049:	4,1
2033:	45,5	2050:	2,8
2034:	42,9		

Whole building energy intensity pathway

Year	$kWh/m^2/yr$	Year	$kWh/m^2/yr$
2018:	216,8	2035:	95,1
2019:	206,5	2036:	88,8
2020:	196,6	2037:	82,4
2021:	187,3	2038:	75,9
2022:	178,5	2039:	69,6
2023:	170,4	2040:	63,3
2024:	162,8	2041:	57,1
2025:	155,8	2042:	51,1
2026:	149,1	2043:	45,4
2027:	142,8	2044:	40,0
2028:	136,8	2045:	34,8
2029:	130,9	2046:	29,9
2030:	125,1	2047:	25,3
2031:	119,2	2048:	20,9
2032:	113,4	2049:	16,7
2033:	107,4	2050:	12,9
2034:	101,3		

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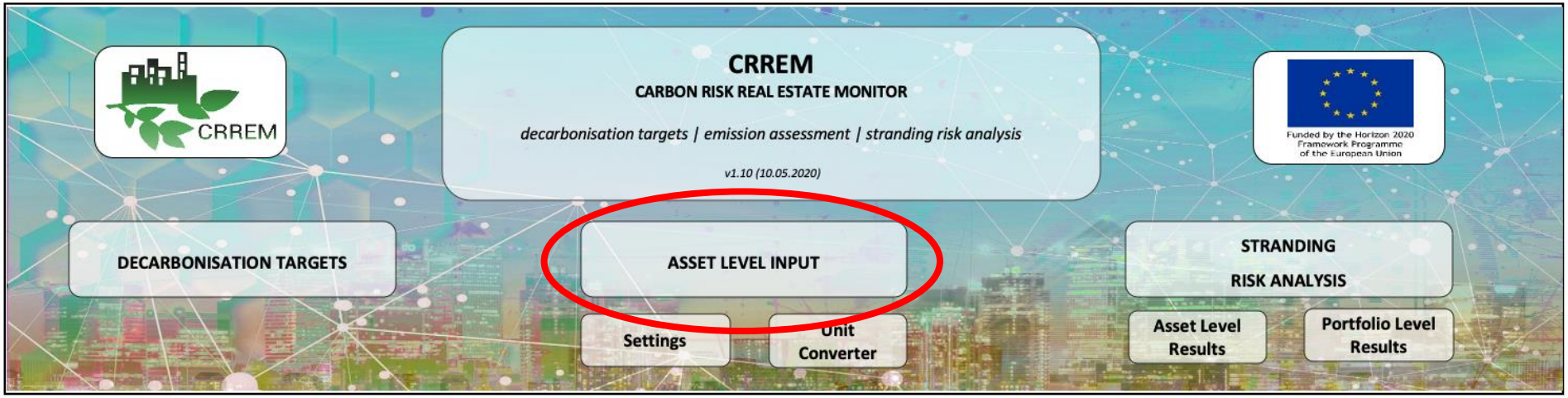

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C D E F G H I J K L M N AM BP EE FX FY GJ GW GX GY

CRREM

ASSET LEVEL INPUT

Funded by the Horizon 2020 Framework Programme of the European Union

The asset level input sheet serves as main section for entering data on individual assets that is necessary to conduct the CRREM stranding risk analysis.

Users may employ the plus- and minus-signs above column headers to collapse and expand data groups.

		General information						General information	Building characteristics	Energy consumption	Fugitive emissions	Renewable energy	Retrofit actions		
Asset ID	Inclusion	Asset Name	Reporting year	Gross Asset Value (GAV)	Reporting period		Entity							Click on 'User-defined settings' to change CRREM default assumptions for a specific asset	Click on 'results' to see results of CRREM stranding risk analysis on asset level. (you will have to manually select the desired asset (ID) in the asset results sheet)
					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	Include	Steinbach Tower	2018	2.000.000	January	10								User-defined settings	Results
2	Include	Linden Paleis	2018	6.000.000	January	12	Fund 2							User-defined settings	Results
3	Include	Smalle Kanaal	2018	4.750.000	January	12	Fund 2							User-defined settings	Results
4	Include	Maison Eiffel	2018	4.750.000	January	12	Fund 2							User-defined settings	Results
5	Include	Example Name 2	2018	1.000.000	February	10								User-defined settings	Results

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Case Study

		General information	Building characteristics																				
Asset ID	Inclusion		Location				Property type	Floor area share of different property types in mixed use buildings										Air conditioning	Asset size	
			Country	City	Zip Code	Address		Office	Retail, High Street	Retail, Shopping Center	Retail, Warehouse	Industrial, Distribution Warehouse	Hotel	Healthcare	Lodging, Leisure & Recreation	Data Centers	Check if floor area shares sum up to 100%		Total gross internal area (IMPS 2)	Average annual vacant area
Pre-filled	Dropdown		Mandatory	Optional (only to be displayed in results)	Optional (for improved accuracy)	Optional (only to be displayed in results)	Mandatory	Mandatory if Property type = Mixed Use	Mandatory if Property type = Mixed Use	Mandatory if Property type = Mixed Use	Mandatory if Property type = Mixed Use	Mandatory if Property type = Mixed Use	Mandatory if Property type = Mixed Use	Mandatory if Property type = Mixed Use	Mandatory if Property type = Mixed Use	Mandatory if Property type = Mixed Use		Optional	Mandatory	Mandatory
ID	*INC*		Drop-down *COUN*	Text *CITY*	Text/Numbers *ZIP*	Text *Address*	Type of use *AS.TY*	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	MX.100	Drop-down AC.YN	[m²] TO.FL	[m²] BSR_OC.AN
1	Include		Austria	Wörgl	6300	Josef-Steinbacher-Straße 1	Office												6.000	300
2	Include		Austria	Kufstein	6330	Andreas-Hofer-Straße 9	Mixed Use	10%	12%	70%	0%	0%	0%	0%	0%	8%	Sum=100%		1.000	-
3	Include		Netherlands	Amsterdam	2514		Office												1.500	-
4	Include		France	Paris	75000		Office												1.000	-
5	Include		Austria	Wörgl	6300		Retail, High Street												300	-

Case Study

Asset ID	Inclusion	General information	Building characteristics	Energy consumption																											
				Whole building energy consumption Combined energy consumption of Common Areas + Tenant Space 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.																												
				Grid Electricity			Natural gas			Fuel oil			District heating [steam]				District cooling [chilled water]				Other energy consumption type 1				Other energy consumption type 2					
Pre-filled				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	Data Coverage Mandatory if usage ≠ 0	Maximum Coverage Mandatory if usage ≠ 0	Usage	Set user-defined emission factor	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				
ID	Dropdown INC			[kWh] EL.GRID	[m²] EL.DC	[m²] EL.MC	[kWh] NG.CON	[m²] NG.DC	[m²] NG.MC	[kWh] OL.CON	[m²] OL.DC	[m²] OL.MC	[kWh] DH.CON	Hyperlink	[m²] DH.DC	[m²] DH.MC	[kWh] DC.CON	Hyperlink	[m²] DC.DC	[m²] DC.MC	Drop-down OT1.TY	[kWh] OT1.CON	[m²] OT1.DC	[m²] OT1.MC	Drop-down OT2.TY	[kWh] OT2.CON	[m²] OT2.DC	[m²] OT2.MC				
1	Include			150.000	6.000	6.000	340.000	5.500	6.000				10.000	Settings	5.500	6.000	2.000	Settings	5.000	5.000	Biogas	20.000	5.000	5.000	Biogas	1.000	5.000	5.000				
2	Include			30.000	10.764	10.764	70.000	10.764	10.764				10.000	Settings	10.764	10.764	0	Settings														
3	Include			120.000	1.000	1.000	55.000	700	900				10.000	Settings	75	100	0	Settings			Wood pellets	1.000	700	900								
4	Include			10.000	1.000	1.000	80.000	700	900				-	Settings	75	100	0	Settings				-										
5	Include			20.000	300	300	20.000	300	300					Settings				Settings														

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Asset ID	Inclusion	General information	Building characteristics	Energy consumption	Fugitive emissions			
					Refrigerant losses / Fugitive emissions Whole building (Can only be reported at whole building) Same reporting period as energy consumption data			
					Gas 1		Gas 2	
					Type of gas Mandatory if amount of leakage ≠ 0	Amount of leakage	Type of gas Mandatory if amount of leakage ≠ 0	Amount of leakage
Pre-filled	Dropdown				Drop-down	[kg]	Drop-down	[kg]
ID	*INC*				GHG.Leak1.Type	GHG.Leak1.Amount	GHG.Leak2.Type	GHG.Leak2.Amount
1	Include				Carbon dioxide (CO2)	10	Methane (CH4)	10
2	Include				Carbon dioxide (CO2)	20	Methane (CH4)	20
3	Include				Carbon dioxide (CO2)	30	Methane (CH4)	30
4	Include							
5	Include							

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Asset ID	Inclusion	General information	Building characteristics	Energy consumption	Fugitive emissions	Renewable energy						
						On-site renewable electricity (PV, wind)		Off-site renewable electricity Generated off-site and consumed on-site			Other on-site renewable energy source (heatpump, solar thermal)	
						Generated and consumed on-site	Generated on-site and exported	Generally, 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 under strict conditions.			Generated and consumed on-site	Generated on-site and exported
Pre-filled						Amount	Amount	Amount	Reporting method	Emission factor if market-based	Amount	Amount
ID	Dropdown INC					[kWh]	[kWh]	[kWh]	Drop-down	[kgCO$_2$e/kWh]	[kWh]	[kWh]
1	Include					-	-		Location-based approach		-	-
2	Include					-	100		Location-based approach			
3	Include					100	-	0	Location-based approach			
4	Include					100	-		Location-based approach			
5	Include					-	-		Location-based approach			

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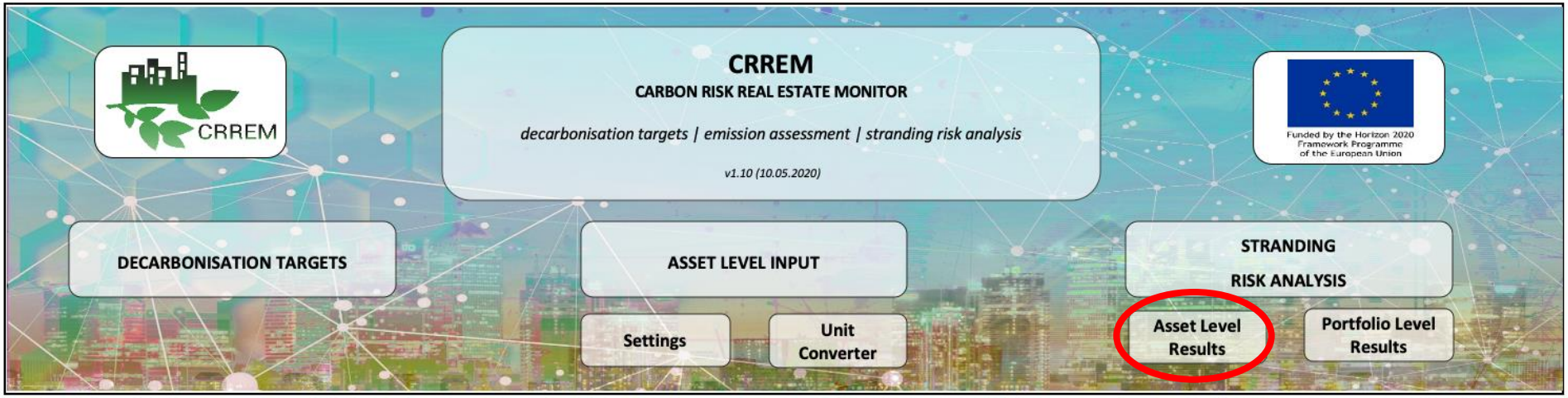
Case Study

Asset ID	Inclusion	General information	Building characteristics	Energy consumption	Fugitive emissions	Renewable energy	Retrofit actions												
							Retrofit action				Retrofit action 2				Retrofit action 3				
Pre-filled	Dropdown						Year	Investment	Achieved reduction of energy consumption [%] - Leave blank to apply default values	Embodied carbon related to retrofit action	Year	Investment	Achieved reduction of energy consumption [%] - Leave blank to apply default values	Embodied carbon related to retrofit action	Year	Investment	Achieved reduction of energy consumption [%] - Leave blank to apply default values	Embodied carbon related to retrofit action	
ID	*INC*						[yyyy] RF1.YR	[€] RF1.EUR	[%] RF1.PC	[kg] RF1.EC	[yyyy] RF2.YR	[€] RF2.EUR	[%] RF2.PC	[kg] RF2.EC	[yyyy] RF3.YR	[€] RF3.EUR	[%] RF3.PC	[kg] RF3.EC	DatCent
1	Include						2024	350.000 €	50%	400.000									
2	Include																		Not available for data centers and mixed use
3	Include																		
4	Include																		
5	Include																		



Click the desired functionality. **Stranding risk analysis** requires **input data on asset level**.
Decarbonisation targets for different property types and each EU member state can be viewed without entering specific asset data.
Click the **CRREM logo** on any sheet to return to this summary.

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IRE|BS International Real Estate Business School Universität Regensburg

STRANDING RISK ANALYSIS ASSET LEVEL RESULTS

Funded by the Horizon 2020 programme of the European Union

This sheet shows the results of the CRREM stranding risk analysis for each property entered in the asset input sheet.

Click here to see results on a portfolio level

Upper part: Diagrams and specific carbon risk analysis results for selected individual properties. Lower part: Tabular information on all assets

Select an asset (ID) to see results: 1

Global warming target (or user-defined): 2°C

Click here to define own targets ('Settings' sheet)

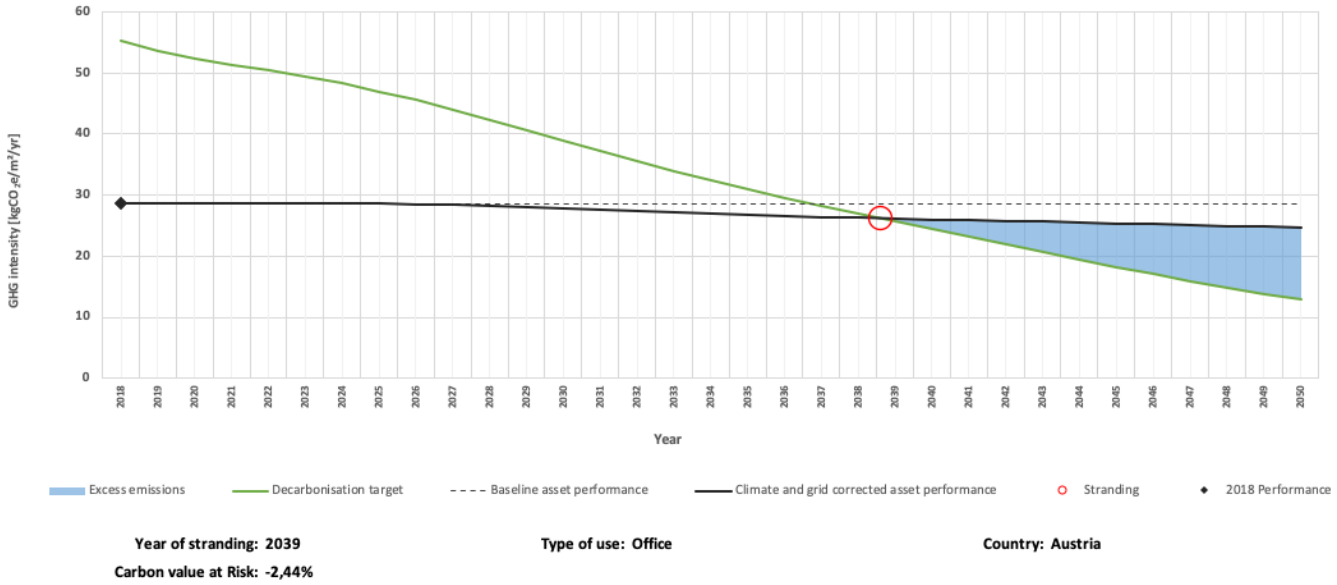
Click to see further tabular results for the selected asset

Click here to see calculation parameters (default or user-defined for selected asset

STRANDING DIAGRAM (Asset #1 - Steinbach Tower)

Based on global warming target: 2°C

Display excess emissions: Yes



Year of stranding: 2039

Type of use: Office

Country: Austria

Carbon value at Risk: -2,44%

2018 Baseline GHG Intensity: 29 kgCO₂e/m²

Whole building GHG intensity targets 2°C-target

Year	kgCO₂e/m²/yr	Year	kgCO₂e/m²/yr
2018:	55,3	2035:	30,9
2019:	53,6	2036:	29,5
2020:	52,3	2037:	28,2
2021:	51,3	2038:	26,9
2022:	50,4	2039:	25,7
2023:	49,4	2040:	24,5
2024:	48,3	2041:	23,3
2025:	47,0	2042:	22,0
2026:	45,6	2043:	20,8
2027:	44,0	2044:	19,5
2028:	42,4	2045:	18,3
2029:	40,6	2046:	17,1
2030:	38,9	2047:	15,9
2031:	37,2	2048:	14,7
2032:	35,5	2049:	13,8
2033:	33,9	2050:	13,0
2034:	32,4		

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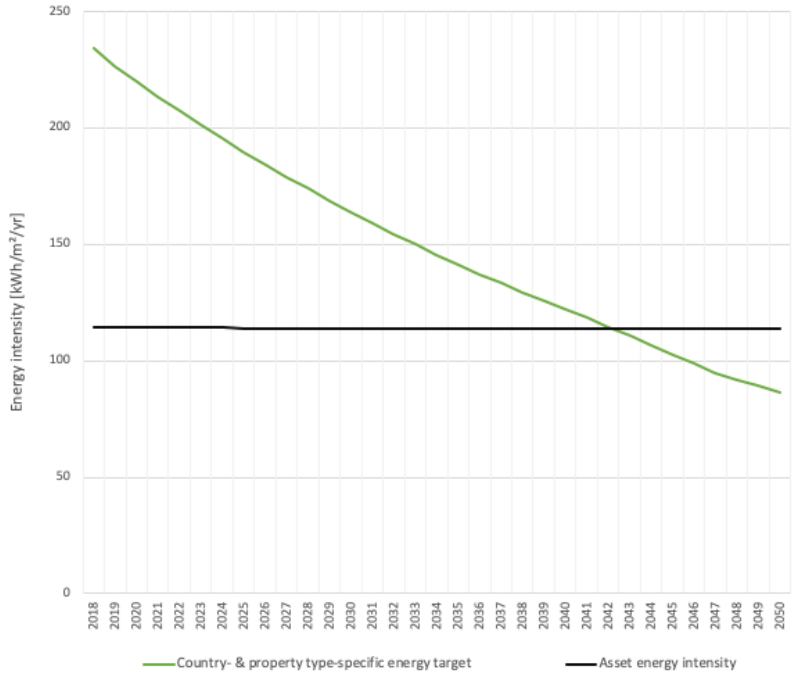
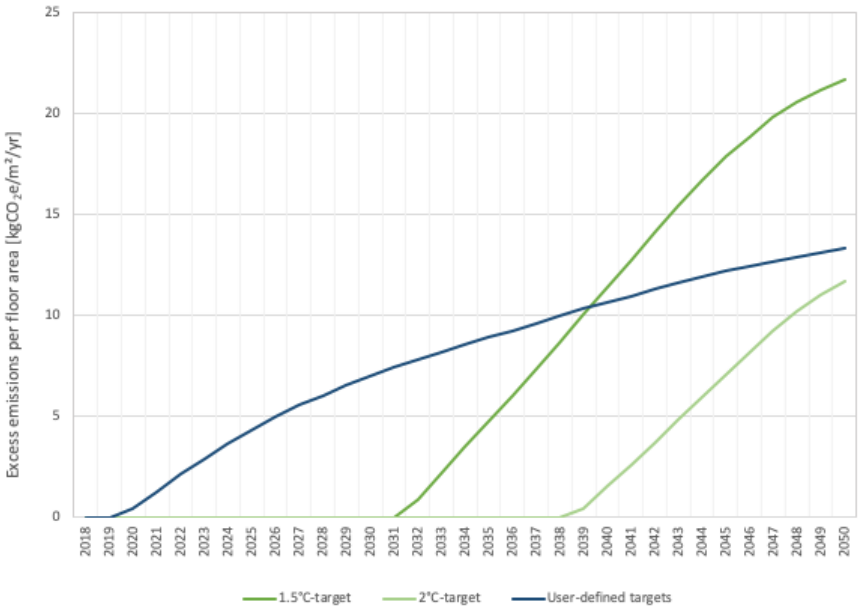
ENERGY REDUTION PATHWAY (Asset #1 - Steinbach Tower)

Based on net energy = procured energy - exported energy = consumed energy - on-site generated energy



EXCESS EMISSIONS PER FLOOR AREA (Asset #1 - Steinbach Tower)



Cumulative excess emissions until 2050 [$kgCO_2e$]:	1.5°C-target	2°C-target	User-defined
	1.404.151	458.980	1.549.372

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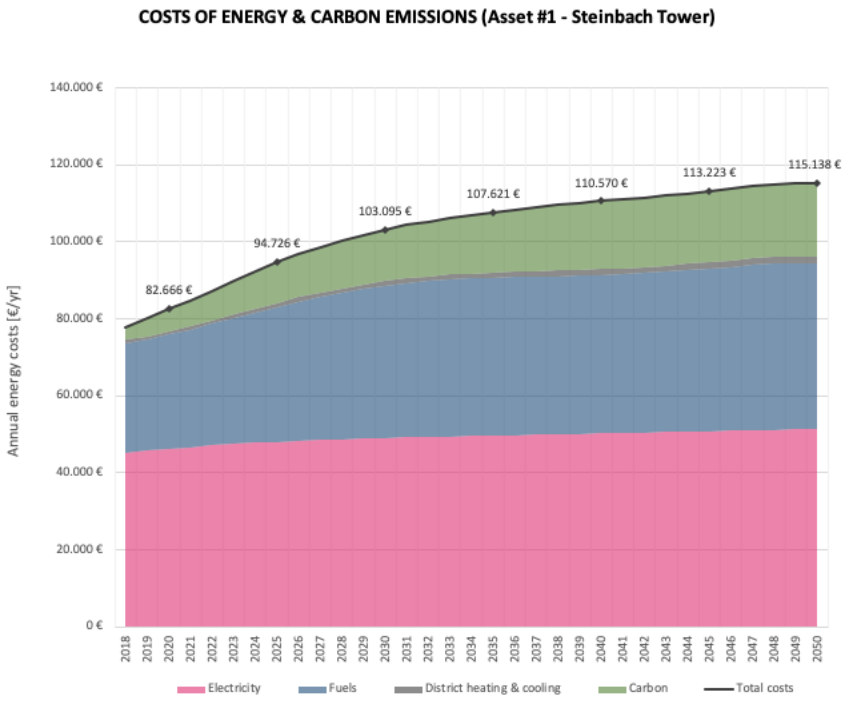

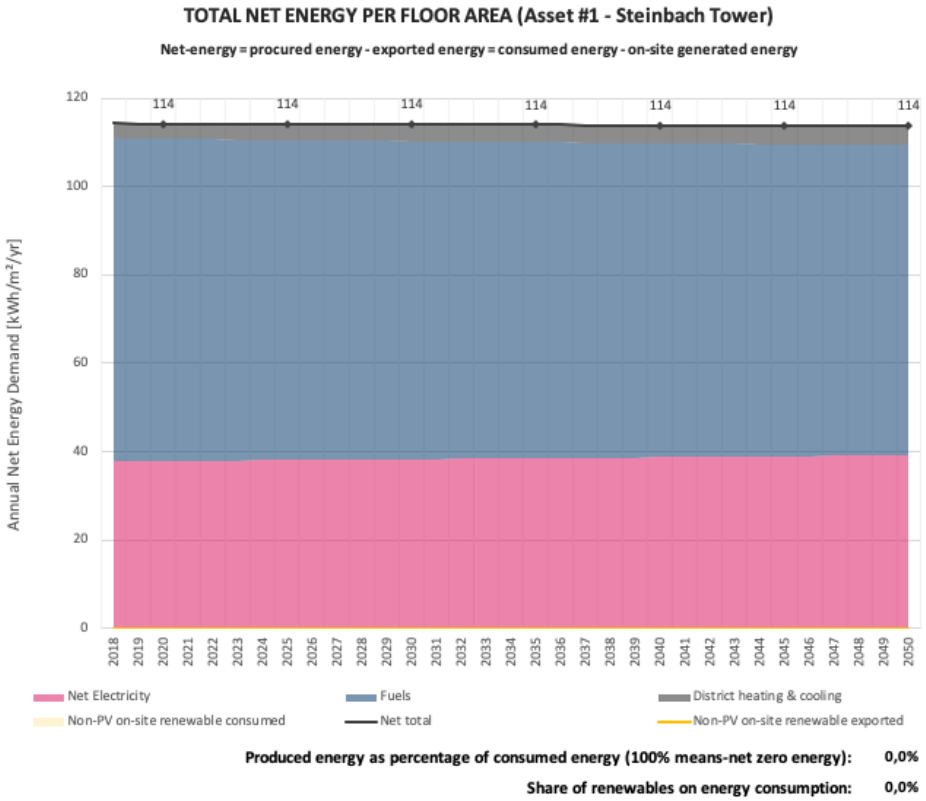

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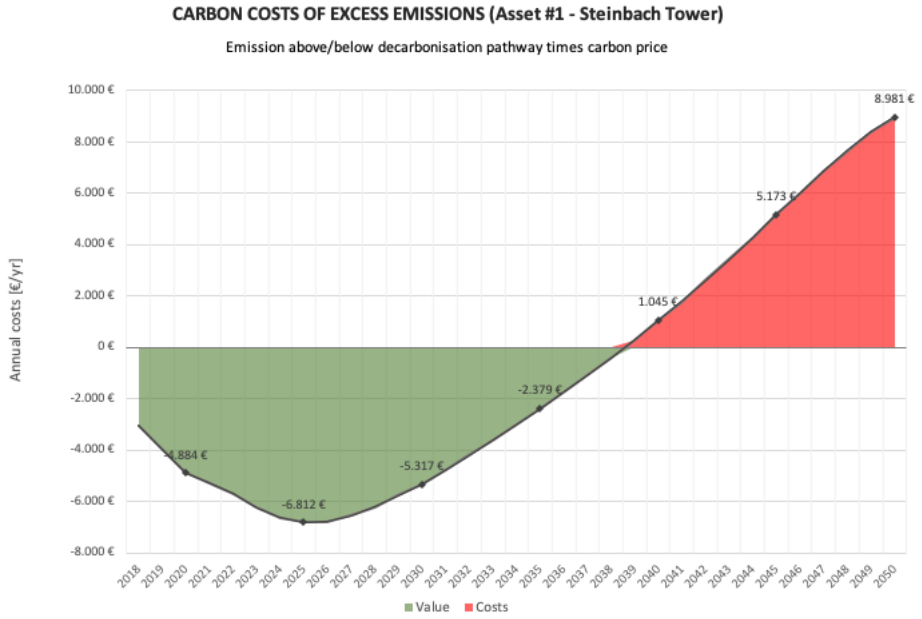

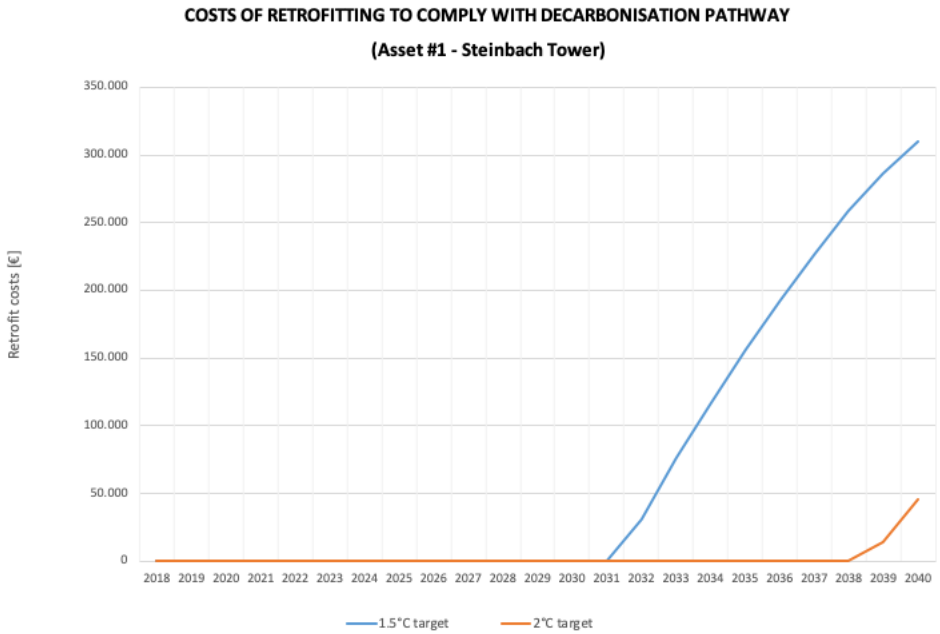

Set discount rate:	2%
Global Warming Target	2°C
Discounted costs of excess emissions:	- 32.844 €
Discounted value of emissions below target:	81.725 €
Carbon Value at Risk	-2,44%

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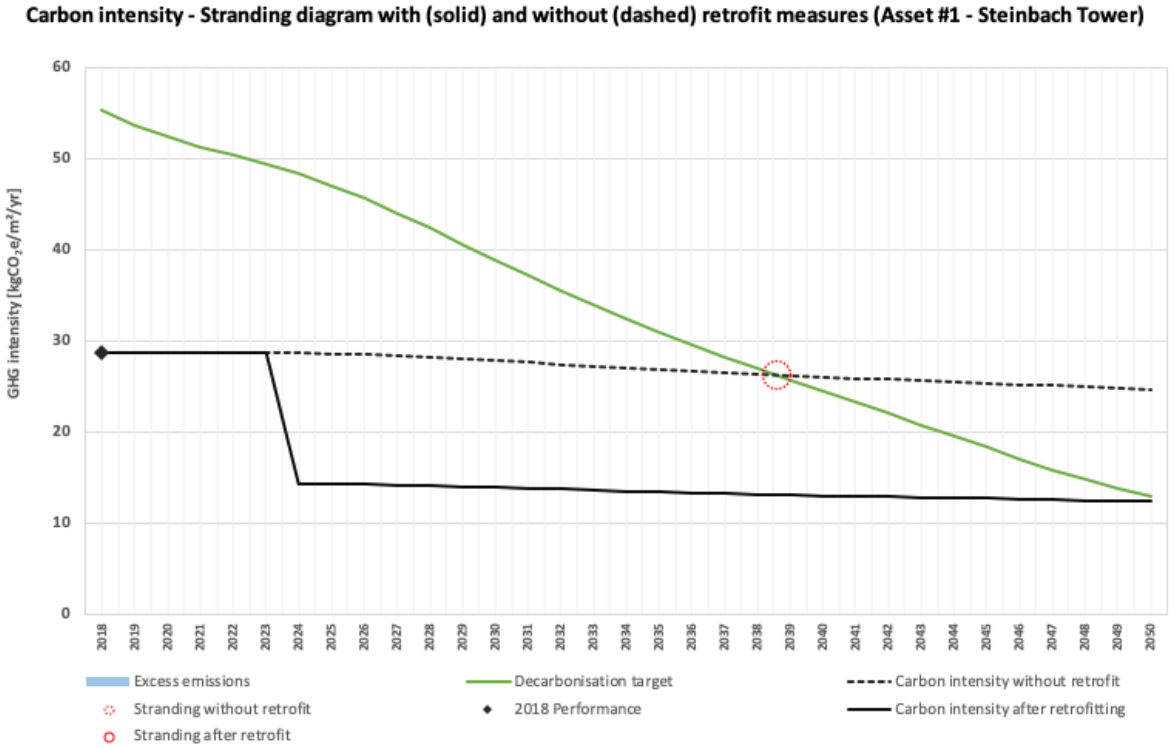

	Without retrofit	After retrofit
Stranding year	2039	2°C-ready
Present (negative) value of excess emissions	- 32.844 €	- €
Present value of emissions below target	81.725 €	195.117 €
Sum	48.880 €	195.117 €

Present value of energy savings (-2050)	1.016.770 €
Net present investment costs	- 317.006 €
Sum	699.764 €

	Without retrofit	With retrofit
Carbon Value at Risk	-2,44%	-9,76%

Set discount rate: 2%

Potential value premium assuming a 70% capitalisation of cost savings: 711.739 € (36% of GAV)

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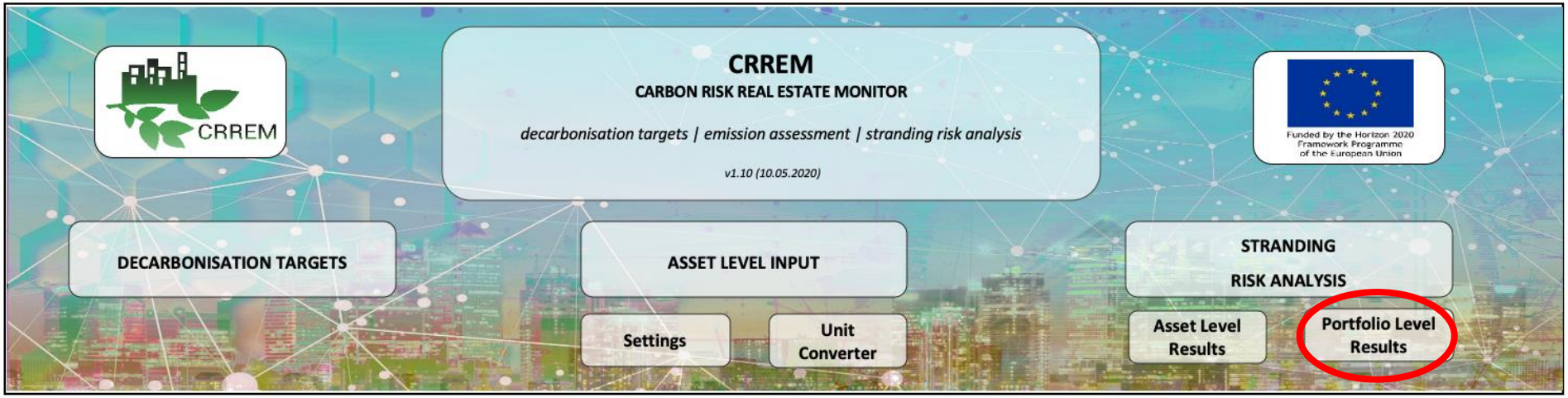

Click the desired functionality. **Stranding risk analysis** requires **input data on asset level**.
Decarbonisation targets for different property types and each EU member state can be viewed without entering specific asset data.
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International Real Estate Business School
Universität Regensburg

STRANDING RISK ANALYSIS
PORTFOLIO LEVEL RESULTS

Funded by the Horizon 2020 programme of the European Union

This sheet shows the aggregated results of the CRREM stranding risk analysis for all properties entered in the Asset input sheet. 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 .

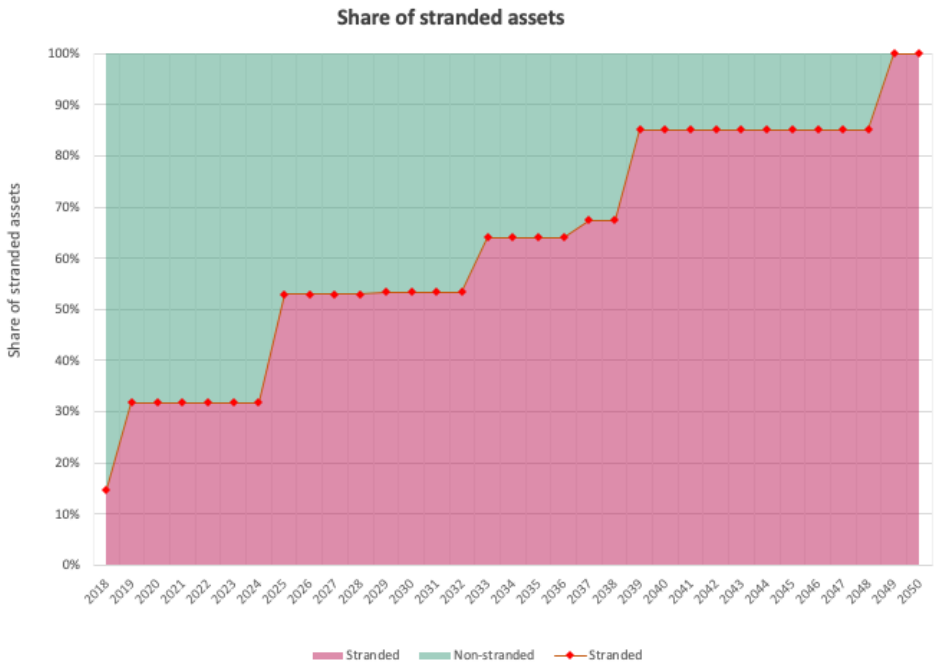
Click here to see results on asset level

Set filter: Country: All | Property type: All | Entity/Fund: All | Assessment year: all

EVOLUTION OF STRANDING WITHIN PORTFOLIO

Diagrams on the right display the evolution of stranding within your portfolio. Upper graph: Relative share of stranded assets. Lower graph: Absolute figures. Choose whether to display data based on the number of buildings, gross floor area (GFA) or gross asset value (GAV). Choose whether to exclude individual assets or exclude them from a certain year on.

Asset ID	Include	Sell in year
1	Yes	Don't sell
2	Yes	Don't sell
3	Yes	Don't sell
4	Yes	Don't sell
5	Yes	Don't sell
6	Yes	Don't sell
7	Yes	Don't sell
8	Yes	Don't sell
9	Yes	Don't sell
10	Yes	Don't sell
11	Yes	Don't sell
12	Yes	Don't sell



Show shares based on: Gross asset value

Climate target: 2°C

Note: If the share of stranded assets is chosen to be based on Gross asset values (GAV), the diagramm considers only those assets for which the GAV was entered by the user. Assets with no GAV provided are grayed out in the list of assets.

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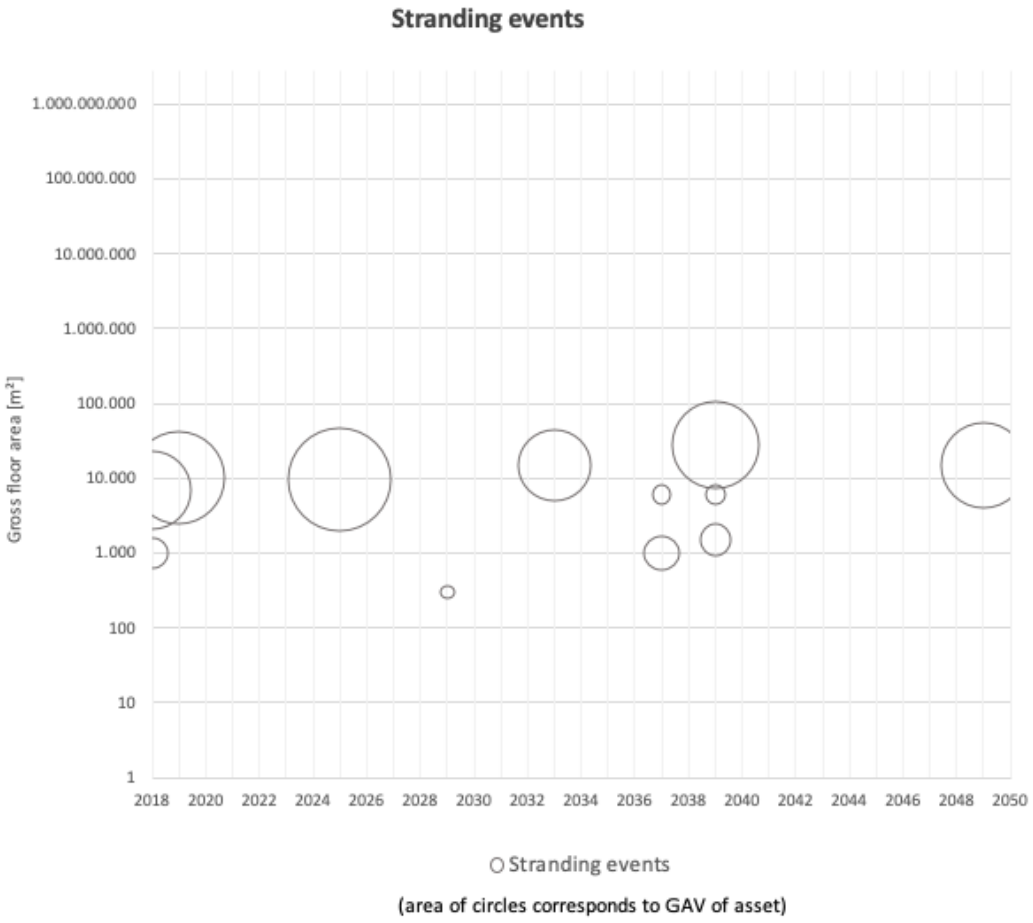
STRANDING EVENTS: NEED FOR ACTION?

The graph on the right provides a summary of stranding events in the course of time. Each circle corresponds to one asset not complying with its decarbonisation pathways for the first time. Circle size (GAV) and y-axis (Floor area) indicate the importance of an asset within the portfolio.

The area of the circles corresponds to the GAV of the stranded asset.
Choose below which global warming target to apply. The numbers next to the circles depict the asset ID.

Climate target: 2°C



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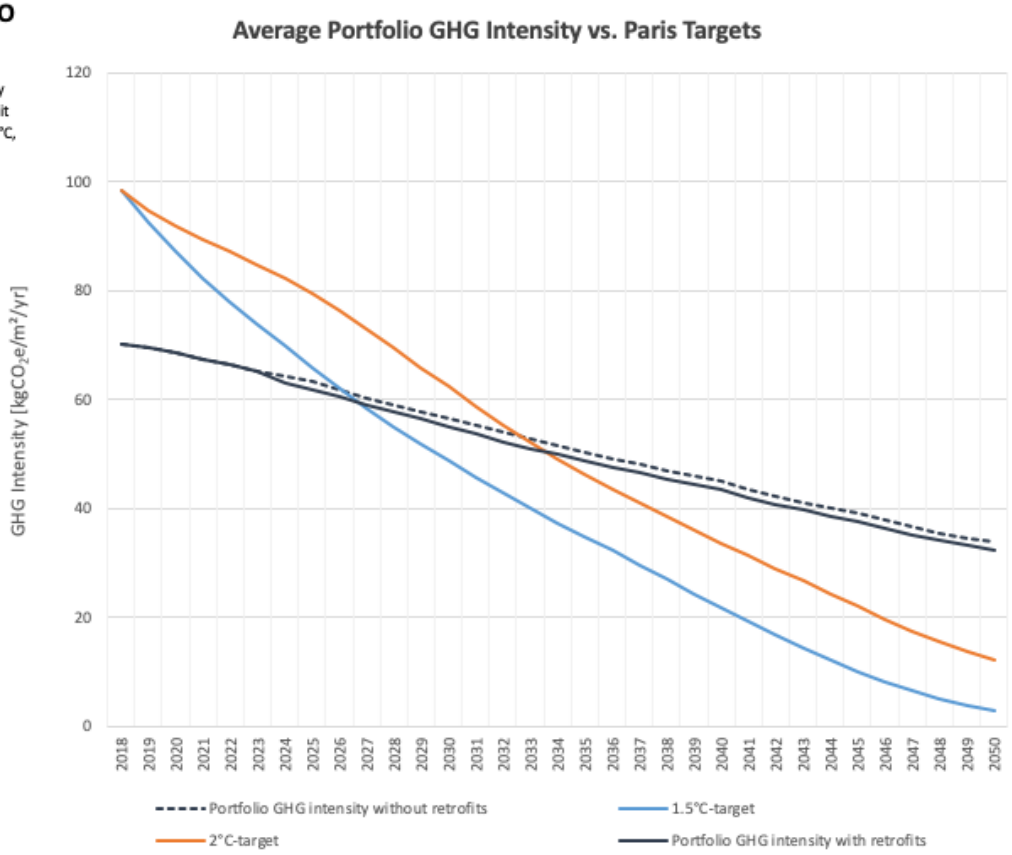
GHG & ENERGY INTENSITY OF PORTFOLIO vs. 1.5°C- & 2°C-TARGETS

The graphs on the right present the GHG intensity (above) and energy intensity (bellow) of the selected portfolio (black line), benchmarking it against the floor-area-weighted decarbonisation pathway (orange: 2°C, blue: 1.5°C).
Exclude individual assets by means of the table below.

Asset ID	Include
1	Yes
2	Yes
3	Yes
4	Yes
5	Yes
6	Yes
7	Yes
8	Yes
9	Yes
10	Yes
11	Yes
12	Yes



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Tasks:

You are working for an investor with two assets under management. Due to the ongoing discussion about climate change, you want to control your company's portfolio emissions and assess, if the properties are future proof (2/1.5degree ready). All given values are displayed in the table below:

	Asset 1			Asset 2		
Country	Netherlands			Austria		
Building Type	Office			Retail - Shopping Center		
Emissions	Amount	Emissions factor [kgCO2/Unit]	Emissions [$kgCO_2e$]	Unit	Emissions factor [kgCO2/Unit]	Emissions [$kgCO_2e$]
Total Electricity Consumption [kWh]	500.000	0,468		2.000.000	0,314	
Gas [kWh]	-	0,18396		2.000.000	0,18396	
Refrigerant losses [kg]	10 kg CCl3F	4660		0		
18 Photovoltaics On-site Generation [kWh]	50.000	- 0,468		-	- 0,314	-
Total Emissions			-			-
Gross Floor Area			9.500			25.000
2019 baseline GHG intensity						

You decided to use the CRREM risk assessment toolkit, accessible via www.crrem.eu, which includes up-to-date emission targets (see later on).

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Task 1: Calculating of the buildings' baseline emissions & GHG intensity:

1. Step: Calculating the (sum of) current emissions:

	Asset 1		
Country	Netherlands		
Building Type	Office		
Emissions	Amount	Emissions factor [kgCO2/Unit]	Emissions [$kgCO_2e$]
Total Electricity Consumption [kWh]	500.000	0,468	
Gas [kWh]	-	0,18396	
Refrigerant losses [kg]	10 kg CCl3F	4660	
18 Photovoltaics On-site Generation [kWh]	50.000	- 0,468	
Total Emissions			-
Gross Floor Area			9.500
2019 baseline GHG intensity			

500.000 kWh *0,486 $kgCO_2e$/kWh =	**234.241 $kgCO_2e$**
10 kg CCl3F*4660 $kgCO_2e$ =	**+ 46.600 $kgCO_2e$**
50.000 kWh*0,486 $kgCO_2e$/kWh=	**- 23.424 $kgCO_2e$**
Total emissions	**257.417 $kgCO_2e$**

	Asset 2		
Country	Austria		
Building Type	Retail - Shopping Center		
Emissions	Unit	Emissions factor [kgCO2/Unit]	Emissions [$kgCO_2e$]
Total Electricity Consumption [kWh]	2.000.000	0,314	
Gas [kWh]	2.000.000	0,18396	
Refrigerant losses [kg]	0		
18 Photovoltaics On-site Generation [kWh]	-	- 0,314	-
Total Emissions			-
Gross Floor Area			25.000
2019 baseline GHG intensity			

2.000.000 kWh*0,31 $kgCO_2e$/kWh=	**627.314 $kgCO_2e$**
2.000.000 kWh*0,18396 $kgCO_2e$/kWh =	**+367.920 $kgCO_2e$**
Total emissions	**995.234 $kgCO_2e$**

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Task 1: Calculating of the buildings' baseline emissions & GHG intensity:

2. Step: Calculating the baseline GHG intensity by dividing the total amount of emissions by the given gross floor area (GFA):

	Asset 1		
Country	Netherlands		
Building Type	Office		
Emissions	Amount	Emissions factor [kgCO2/Unit]	Emissions [$kgCO_2e$]
Total Electricity Consumption [kWh]	500.000	0,468	
Gas [kWh]	-	0,18396	
Refrigerant losses [kg]	10 kg CCl3F	4660	
18 Photovoltaics On-site Generation [kWh]	50.000	- 0,468	
Total Emissions			-
Gross Floor Area			9.500
2019 baseline GHG intensity			

	Asset 2		
Country	Austria		
Building Type	Retail - Shopping Center		
Emissions	Unit	Emissions factor [kgCO2/Unit]	Emissions [$kgCO_2e$]
Total Electricity Consumption [kWh]	2.000.000	0,314	
Gas [kWh]	2.000.000	0,18396	
Refrigerant losses [kg]	0		
18 Photovoltaics On-site Generation [kWh]	-	- 0,314	-
Total Emissions			-
Gross Floor Area			25.000
2019 baseline GHG intensity			

2019 baseline GHG intensity:

Asset 1:

257.417 $kgCO_2e$ / 9.500 m² = 27,1 $kgCO_2e/m²$

Asset 2:

955.234 $kgCO_2e$ / 25.000 m² = 39,8 $kgCO_2e/m²$

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

Task 1: Results

	Asset 1			Asset 2		
Country	Netherlands			Austria		
Building Type	Office			Retail - Shopping Center		
Emissions	Amount	Emissions factor [kgCO2/Unit]	Emissions [$kgCO_2e$]	Amount	Emissions factor [kgCO2/Unit]	Emissions [$kgCO_2e$]
Total Electricity Consumption [kWh]	500.000	0,468	234.241	2.000.000	0,314	627.314
Gas [kWh]	-	0,18396	-	2.000.000	0,18396	367.920
Refrigerant losses [kg]	10 kg CCI3F	4660	46600	0		0
18 Photovoltaics On-site Generation [kWh]	50.000	- 0,468	- 23.424	-	- 0,314	-
Total Emissions			**257.417**			**995.234**
Gross Floor Area			9.500			25.000
2019 baseline GHG intensity		27,1			39,8	

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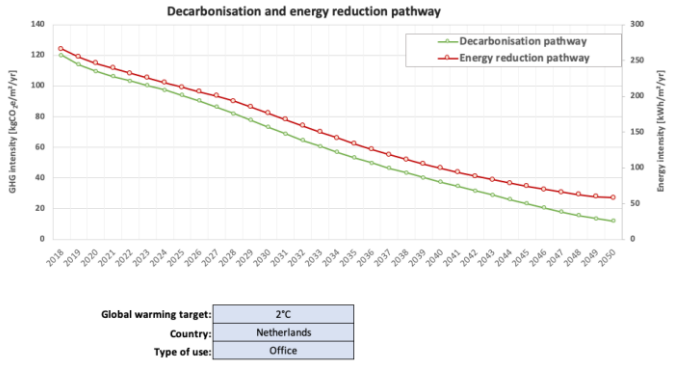
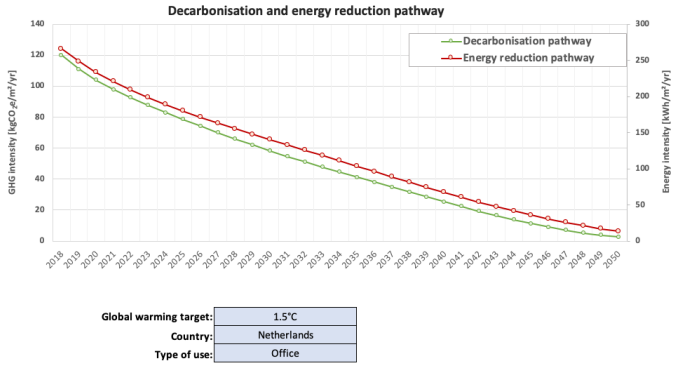
Task 2: Assessing the year of stranding:

According to the CRREM tool, you already know your emission targets for the given property locations and usage types:

Office building, Netherlands:





2 ˚C targets

Whole building GHG intensity pathway:

Year $kgCO_2e/m^2/yr$	Year $kgCO_2e/m^2/yr$
2018: 120,0	2035: 53,1
2019: 114,0	2036: 49,7
2020: 109,6	2037: 46,5
2021: 106,2	2038: 43,3
2022: 103,3	2039: 40,4
2023: 100,4	2040: 37,4
2024: 97,3	2041: 34,6
2025: 94,0	2042: 31,7
2026: 90,3	2043: 28,8
2027: 86,3	2044: 26,0
2028: 82,0	2045: 23,2
2029: 77,6	2046: 20,5
2030: 73,2	2047: 17,9
2031: 68,9	2048: 15,5
2032: 64,6	2049: 13,5
2033: 60,6	2050: 11,8
2034: 56,8	

1.5 ˚C targets

Whole building GHG intensity pathway:

Year $kgCO_2e/m^2/yr$	Year $kgCO_2e/m^2/yr$
2018: 120,0	2035: 41,2
2019: 111,1	2036: 38,0
2020: 103,9	2037: 34,8
2021: 97,9	2038: 31,7
2022: 92,6	2039: 28,5
2023: 87,7	2040: 25,4
2024: 83,0	2041: 22,3
2025: 78,5	2042: 19,3
2026: 74,2	2043: 16,4
2027: 70,0	2044: 13,7
2028: 65,9	2045: 11,2
2029: 62,0	2046: 8,9
2030: 58,3	2047: 6,9
2031: 54,6	2048: 5,2
2032: 51,2	2049: 3,8
2033: 47,8	2050: 2,7
2034: 44,5	

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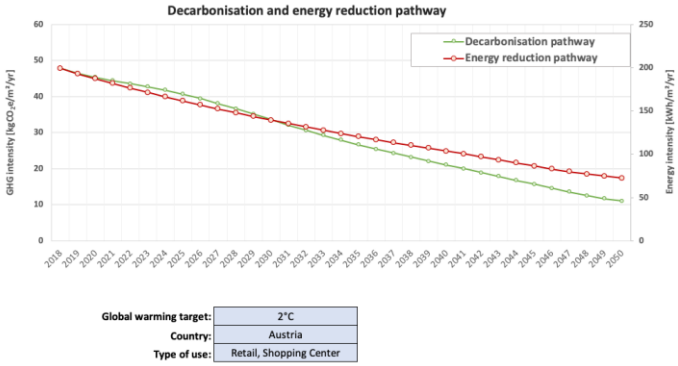
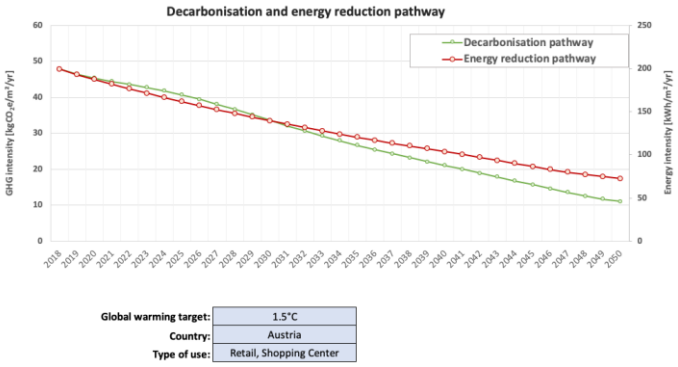
Task 2: Assessing the year of stranding:

According to the CRREM tool, you already know your emission targets for the given property locations and usage types:

Retail - Shopping Center, Austria:





2 ˚C targets

Whole building GHG intensity pathway:

Year	$kgCO_2e/m^2/yr$	Year	$kgCO_2e/m^2/yr$
2018:	47,9	2035:	26,6
2019:	46,4	2036:	25,4
2020:	45,3	2037:	24,3
2021:	44,4	2038:	23,2
2022:	43,6	2039:	22,1
2023:	42,7	2040:	21,1
2024:	41,8	2041:	20,0
2025:	40,7	2042:	18,9
2026:	39,4	2043:	17,9
2027:	38,1	2044:	16,8
2028:	36,6	2045:	15,7
2029:	35,1	2046:	14,6
2030:	33,6	2047:	13,6
2031:	32,1	2048:	12,6
2032:	30,7	2049:	11,7
2033:	29,3	2050:	11,1
2034:	27,9		

1.5 ˚C targets

Whole building GHG intensity pathway:

Year	$kgCO_2e/m^2/yr$	Year	$kgCO_2e/m^2/yr$
2018:	47,9	2035:	19,1
2019:	45,1	2036:	17,8
2020:	42,8	2037:	16,5
2021:	40,7	2038:	15,2
2022:	38,8	2039:	13,9
2023:	36,9	2040:	12,6
2024:	35,2	2041:	11,3
2025:	33,4	2042:	10,0
2026:	31,8	2043:	8,8
2027:	30,1	2044:	7,6
2028:	28,6	2045:	6,5
2029:	27,1	2046:	5,4
2030:	25,7	2047:	4,5
2031:	24,3	2048:	3,7
2032:	22,9	2049:	3,1
2033:	21,6	2050:	2,5
2034:	20,3		

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Task 2: Assessing the year of stranding:

Find the year in which the asset will face stranding:

(Without accounting for grid decarb. and change in HDD/CDD)

Office building, Netherlands:

Current GHG intensity (see task 1):

27,1 $kgCO_2e/m^2$

Stranding 2 ˚C : 2044

Stranding 1.5 ˚C : 2040

2 ˚C targets

Whole building GHG intensity pathway:

Year $kgCO_2e/m^2/yr$	Year $kgCO_2e/m^2/yr$
2018: 120,0	2035: 53,1
2019: 114,0	2036: 49,7
2020: 109,6	2037: 46,5
2021: 106,2	2038: 43,3
2022: 103,3	2039: 40,4
2023: 100,4	2040: 37,4
2024: 97,3	2041: 34,6
2025: 94,0	2042: 31,7
2026: 90,3	2043: 28,8
2027: 86,3	2044: 26,0
2028: 82,0	2045: 23,2
2029: 77,6	2046: 20,5
2030: 73,2	2047: 17,9
2031: 68,9	2048: 15,5
2032: 64,6	2049: 13,5
2033: 60,6	2050: 11,8
2034: 56,8	

1.5 ˚C targets

Whole building GHG intensity pathway:

Year $kgCO_2e/m^2/yr$	Year $kgCO_2e/m^2/yr$
2018: 120,0	2035: 41,2
2019: 111,1	2036: 38,0
2020: 103,9	2037: 34,8
2021: 97,9	2038: 31,7
2022: 92,6	2039: 28,5
2023: 87,7	2040: 25,4
2024: 83,0	2041: 22,3
2025: 78,5	2042: 19,3
2026: 74,2	2043: 16,4
2027: 70,0	2044: 13,7
2028: 65,9	2045: 11,2
2029: 62,0	2046: 8,9
2030: 58,3	2047: 6,9
2031: 54,6	2048: 5,2
2032: 51,2	2049: 3,8
2033: 47,8	2050: 2,7
2034: 44,5	

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Task 2: Assessing the year of stranding:

Find the year in which the asset will face stranding:

(Without accounting for grid decarb. and change in HDD/CDD)

Retail - Shopping Center, Austria:

Current GHG intensity (see task 1):

39,8 $kgCO_2e/m^2$

Stranding 2 ˚C : 2026

Stranding 1.5 ˚C : 2022

2 ˚C targets

Whole building GHG intensity pathway:

Year	$kgCO_2e/m^2/yr$	Year	$kgCO_2e/m^2/yr$
2018:	47,9	2035:	26,6
2019:	46,4	2036:	25,4
2020:	45,3	2037:	24,3
2021:	44,4	2038:	23,2
2022:	43,6	2039:	22,1
2023:	42,7	2040:	21,1
2024:	41,8	2041:	20,0
2025:	40,7	2042:	18,9
2026:	39,4	2043:	17,9
2027:	38,1	2044:	16,8
2028:	36,6	2045:	15,7
2029:	35,1	2046:	14,6
2030:	33,6	2047:	13,6
2031:	32,1	2048:	12,6
2032:	30,7	2049:	11,7
2033:	29,3	2050:	11,1
2034:	27,9		

1.5 ˚C targets

Whole building GHG intensity pathway:

Year	$kgCO_2e/m^2/yr$	Year	$kgCO_2e/m^2/yr$
2018:	47,9	2035:	19,1
2019:	45,1	2036:	17,8
2020:	42,8	2037:	16,5
2021:	40,7	2038:	15,2
2022:	38,8	2039:	13,9
2023:	36,9	2040:	12,6
2024:	35,2	2041:	11,3
2025:	33,4	2042:	10,0
2026:	31,8	2043:	8,8
2027:	30,1	2044:	7,6
2028:	28,6	2045:	6,5
2029:	27,1	2046:	5,4
2030:	25,7	2047:	4,5
2031:	24,3	2048:	3,7
2032:	22,9	2049:	3,1
2033:	21,6	2050:	2,5
2034:	20,3		

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Task 3: Calculating the excess emissions after stranding:

T3.1: You are interested in the amount of emissions, that exceed the relevant decarbonisation targets.

Excess emissions = $\sum_t^n (Baseline\ Emissions\ -\ Emission\ target_t)$; t= year of stranding

<u>Excess emissions Asset 1:</u>

1.5 ˚C (2040-2050):

(27,1 $kgCO_2e/m^2$ - 25,4 $kgCO_2e/m^2$) + (27,1 $kgCO_2e/m^2$ - 22,3 $kgCO_2e/m^2$) + (27,1 $kgCO_2e/m^2$ - 19,3 $kgCO_2e/m^2$) + (27,1 $kgCO_2e/m^2$ - 16,4 $kgCO_2e/m^2$) + (27,1 $kgCO_2e/m^2$ - 13,7 $kgCO_2e/m^2$) + (27,1 kgCO2e/m² - 11,2 kgCO2e/m²) + (27,1 kgCO2e/m² - 8,9 kgCO2e/m²) + (27,1 kgCO2e/m² - 6,9 kgCO2e/m²) + (27,1 kgCO2e/m² - 5,2 kgCO2e/m²) + (27,1 kgCO2e/m² - 3,8 kgCO2e/m²) + (27,1 kgCO2e/m² - 2,7 kgCO2e/m²) =

162,3 $kgCO_2e/m^2$

2 ˚C (2044-2050):

(27,1 kgCO2e/m² - 26,0 kgCO2e/m²) + (27,1 kgCO2e/m² - 23,2 kgCO2e/m²) + (27,1 kgCO2e/m² - 20,5 kgCO2e/m²) + (27,1 kgCO2e/m² - 17,9 kgCO2e/m²) + (27,1 kgCO2e/m² - 15,5 kgCO2e/m²) + (27,1 kgCO2e/m² - 13,5 kgCO2e/m²) + (27,1 kgCO2e/m² - 11,8 kgCO2e/m²) =

61,3 $kgCO_2e/m^2$

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Task 3: Calculating the excess emissions after stranding:

T3.1: You are interested in the amount of emissions, that exceed the relevant decarbonsiation targets.

Excess emissions = $\sum_t^n (Baseline\ Emissions\ -\ Emission\ target_t)$; t= year of stranding

<u>Excess emissions Asset 2:</u>

1.5 ˚C (2022-2050):

(39,8 $kgCO_2e/m^2$ - 38,8 $kgCO_2e/m^2$) + … + (39,8 $kgCO_2e/m^2$ - 2,5 $kgCO_2e/m^2$) =

619,0 kgCO2e/m²

2 ˚C (2026-2050):

(39,8 $kgCO_2e/m^2$ - 39,4 $kgCO_2e/m^2$) + … + (39,8 $kgCO_2e/m^2$ - 11,1 $kgCO_2e/m^2$) =

396,6 $kgCO_2e/m^2$

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Task 4: Calculating the carbon costs in the year of stranding:

T4.1: You are interested in the (direct) potential financial threats of stranding. Based on the current ETS price, you assume a (constant) carbon price of 29,- €/tCO_2. Define the Net-Present-Value (NPV) of the carbon costs in the year of stranding. Interest rate: 2,0 %.

Asset 1:

	1.5°C	2°C
year of stranding	2040; in 20 years	2044; in 24 years
excess emission in year of stranding	27,1 – 25,4 = 1,7 kgCO_2/m²	27,1 – 26,0 = 1,1 kgCO_2/m²
carbon costs per m²:	(29,00 €/t / 1.000) *1,7 kgCO2/m² = 0,0493 €/m²	(29,00 €/t / 1.000) *1,1 kgCO2/m² = 0,0319 €/m²
Total carbon costs: (9.500 m²)	0,0493 €/m² * 9.500 m² = **468,35 €**	0,0319 €/m² * 9.500 m² = **303,05 €**
NPV:	468,35 € * 1/(1+0,02)^20 = **315,17 €**	303,05 € * 1/(1+0,02)^24 = **188,41 €**

Remarks:

Pay attention to the unit conversion between kg and tons of CO_2

Pay attention to the gross floor area of the building!

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Task 4: Calculating the carbon costs in the year of stranding:

T4.1: You are interested in the (direct) potential financial threats of stranding. Based on the current ETS price, you assume a (constant) carbon price of 29,- €/tCO_2. Define the Net-Present-Value (NPV) of the carbon costs in the year of stranding. Interest rate: 2,0 %.

Asset 2:

	1.5°C	2°C
year of stranding	2022; in 2 years	2026; in 6 years
excess emission in year of. stranding	39,8 – 38,8 = 1,0 kgCO_2/m²	39,8 – 39,4 = 0,4 kgCO_2/m²
carbon costs per m²:	(29,00 €/t / 1.000) * 1,0 kgCO2/m² = 0,029 €/m²	(29,00 €/t / 1.000) * 0,4 kgCO2/m² = 0,0116 €/m²
Total carbon costs: (25.000 m²)	0,029 €/m² * 25.000 m² = **725,00 €**	0,0116 €/m² * 25.000 m² = **290,00 €**
NPV:	725,00 € * 1/(1+0,02)^2 = **696,85 €**	290,00 € * 1/(1+0,02)^6 = **257,51 €**

Remarks:

Pay attention to the unit conversion between kg and tons of CO_2

Pay attention to the gross floor area of the building!

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Task 4: Calculating the carbon costs in the year of stranding:

T4.2: What costs would occur, if the carbon price increases

by +3 %, +5 % or +7 % p.a.?

Relevant carbon prices for Asset 1:

€/tCO_2	+ 3 % p.a.	+ 5 % p.a.	+ 7 % p.a.
2040	52,38	76,95	112,22
2044	58,95	93,53	147,10

Relevant carbon prices for Asset 2:

€/tCO_2	+ 3 % p.a.	+ 5 % p.a.	+ 7 % p.a.
2022	30,77	31,97	33,20
2026	34,63	38,86	43,52

	+3% p.a.	+5% p.a.	+7% p.a.
2020	29,00	29,00	29,00
2021	29,87	30,45	31,03
2022	30,77	31,97	33,20
2023	31,69	33,57	35,53
2024	32,64	35,25	38,01
2025	33,62	37,01	40,67
2026	34,63	38,86	43,52
2027	35,67	40,81	46,57
2028	36,74	42,85	49,83
2029	37,84	44,99	53,32
2030	38,97	47,24	57,05
2031	40,14	49,60	61,04
2032	41,35	52,08	65,31
2033	42,59	54,68	69,89
2034	43,87	57,42	74,78
2035	45,18	60,29	80,01
2036	46,54	63,30	85,61
2037	47,93	66,47	91,61
2038	49,37	69,79	98,02
2039	50,85	73,28	104,88
2040	52,38	76,95	112,22
2041	53,95	80,79	120,08
2042	55,57	84,83	128,48
2043	57,23	89,07	137,48
2044	58,95	93,53	147,10
2045	60,72	98,20	157,40
2046	62,54	103,11	168,41
2047	64,42	108,27	180,20
2048	66,35	113,68	192,82
2049	68,34	119,37	206,31
2050	70,39	125,34	220,76

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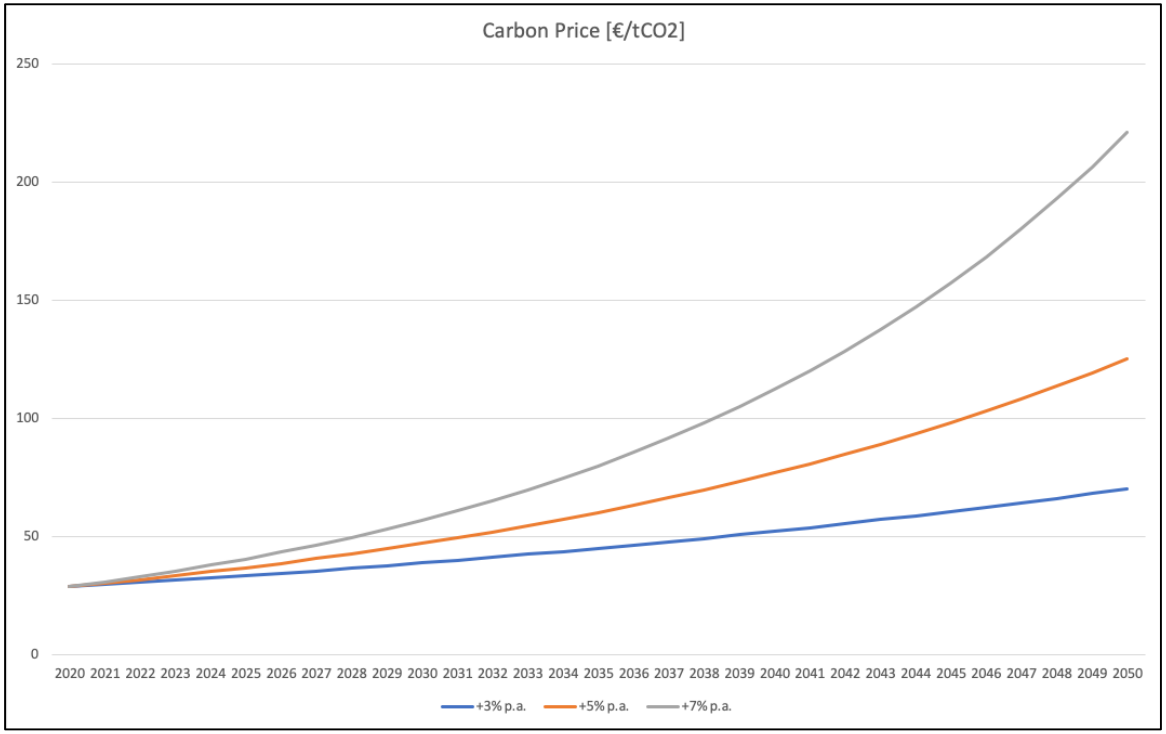
The effects of carbon pricing:

- Based on the excess emissions, the tool is able to calculate the expenditures for a given carbon price:

Carbon Price
2020 baseline: Current ETS-price of 29€/tCO2
low, mid and high level scenario: +3/5/7% p.a.

	+3% p.a.	+5% p.a.	+7% p.a.
2020	29,00	29,00	29,00
2021	29,87	30,45	31,03
2022	30,77	31,97	33,20
2023	31,69	33,57	35,53
2024	32,64	35,25	38,01
2025	33,62	37,01	40,67
2026	34,63	38,86	43,52
2027	35,67	40,81	46,57
2028	36,74	42,85	49,83
2029	37,84	44,99	53,32
2030	38,97	47,24	57,05
2031	40,14	49,60	61,04
2032	41,35	52,08	65,31
2033	42,59	54,68	69,89
2034	43,87	57,42	74,78
2035	45,18	60,29	80,01
2036	46,54	63,30	85,61
2037	47,93	66,47	91,61
2038	49,37	69,79	98,02
2039	50,85	73,28	104,88
2040	52,38	76,95	112,22
2041	53,95	80,79	120,08
2042	55,57	84,83	128,48
2043	57,23	89,07	137,48
2044	58,95	93,53	147,10
2045	60,72	98,20	157,40
2046	62,54	103,11	168,41
2047	64,42	108,27	180,20
2048	66,35	113,68	192,82
2049	68,34	119,37	206,31
2050	70,39	125,34	220,76



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Task 4: Calculating the carbon costs in the year of stranding:

T4.2: What costs would occur, if the carbon price increases by +3 %, +5 % or +7 % p.a.?

Asset 1:

	1.5°C	2°C
year of stranding	2040; in 20 years	2044; in 24 years
excess emission in year of. stranding	27,1 – 25,4 = 1,7 $kgCO_2/m^2$	27,1 – 26,0 = 1,0 $kgCO_2/m^2$
carbon costs per m²:	(52,38 €/t / 1.000) *1,7 kgCO2/m² = 0,0890 €/m² *(+3 % p.a.)* 0,1308 €/m² *(+5 % p.a.)* 0,1908 €/m² *(+7 % p.a.)*	(58,95 €/t / 1.000) *1,0 kgCO2/m² = 0,0590 €/m² *(+3 % p.a.)* 0,0935 €/m² *(+5 % p.a.)* 0,1471 €/m² *(+7 % p.a.)*
Total carbon costs: (9.500 m²)	0,0890 €/m² * 9.500 m² = **845,50 €** 0,1308 €/m² * 9.500 m² = **1.242,60 €** 0,1908 €/m² * 9.500 m² = **1.812,35 €**	0,0590 €/m² * 9.500 m² = **560,50 €** 0,0935 €/m² * 9.500 m² = **888,25 €** 0,1471 €/m² * 9.500 m² = **1.397,45 €**
NPV:	845,50 € * 1/(1+0,02)^20 = **569,00 €** 1.242,60 € * 1/(1+0,02)^20 = **836,23 €** 1.812,35 € * 1/(1+0,02)^20 = **1.219,66 €**	560,50 € * 1/(1+0,02)^24 = **348,47 €** 888,25 € * 1/(1+0,02)^24 = **552,24 €** 1.397,45 € * 1/(1+0,02)^24 = **868,82 €**
Delta to Task 4.1	**Up to 522,81 €**	**Up to 680,41 €**

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Task 4: Calculating the carbon costs in the year of stranding:

T4.2: What costs would occur, if the carbon price increases by +3 %, +5 % or +7 % p.a.?

Asset 2:

	1.5°C	2°C
year of stranding	2022; in 2 years	2026; in 6 years
excess emission in year of. stranding	39,8 – 38,8 = 1,0 $kgCO_2/m^2$	39,8 – 39,4 = 0,4 $kgCO_2/m^2$
carbon costs per m^2:	(30,77 €/t / 1.000) * 1,0 $kgCO_2/m^2$ = 0,03077 €/m^2 *(+3 % p.a.)* 0,03197 €/m^2 *(+5 % p.a.)* 0,03320 €/m^2 *(+7 % p.a.)*	(34,63 €/t / 1.000) * 0,4 $kgCO_2/m^2$ = 0,01385 €/m^2 *(+3 % p.a.)* 0,01554 €/m^2 *(+5 % p.a.)* 0,01741 €/m^2 *(+7 % p.a.)*
Total carbon costs: (25.000 m^2)	0,03077 €/m^2 * 25.000 m^2 = **769,25 €** 0,03197 €/m^2 * 25.000 m^2 = **799,25 €** 0,03320 €/m^2 * 25.000 m^2 = **830,00 €**	0,01385 €/m^2 * 25.000 m^2 = **462,50 €** 0,01554 €/m^2 * 25.000 m^2 = **388,50 €** 0,01741 €/m^2 * 25.000 m^2 = **435,25 €**
NPV:	769,25 € * 1/(1+0,02)^2 = **739,38 €** 799,25 € * 1/(1+0,02)^2 = **768,21 €** 830,00 € * 1/(1+0,02)^2 = **797,77 €**	462,50 € * 1/(1+0,02)^6 = **410,69 €** 388,50 € * 1/(1+0,02)^6 = **344,98 €** 435,25 € * 1/(1+0,02)^6 = **386,49 €**
Delta to Task 4.1	**Up to 100,92 €**	**Up to 128,98 €**

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Calculating emissions and stranding with the CRREM tool:

(Same assets as in Task 1 but including the effects of grid decarbonisation and change in HDD/CDD)

	Asset 1			Asset 2		
Country	Netherlands			Austria		
Building Type	Office			Retail - Shopping Center		
Emissions	Amount	Emissions factor [kgCO2/Unit]	Emissions [$kgCO_2e$]	Amount	Emissions factor [kgCO2/Unit]	Emissions [$kgCO_2e$]
Total Electricity Consumption [kWh]	500.000	0,468	234.241	2.000.000	0,314	627.314
Gas [kWh]	-	0,18396	-	2.000.000	0,18396	367.920
Refrigerant losses [kg]	10 kg CCl3F	4660	46600	0		0
18 Photovoltaics On-site Generation [kWh]	50.000	- 0,468	- 23.424	-	- 0,314	-
Total Emissions			**257.417**			**995.234**
Gross Floor Area			9.500			25.000
2019 baseline GHG intensity		27,1			39,8	

→ Instead of static baseline emissions (as calculated in task 1), the tool accounts for the effects of grid decarbonisation and the change in HDD/CDD

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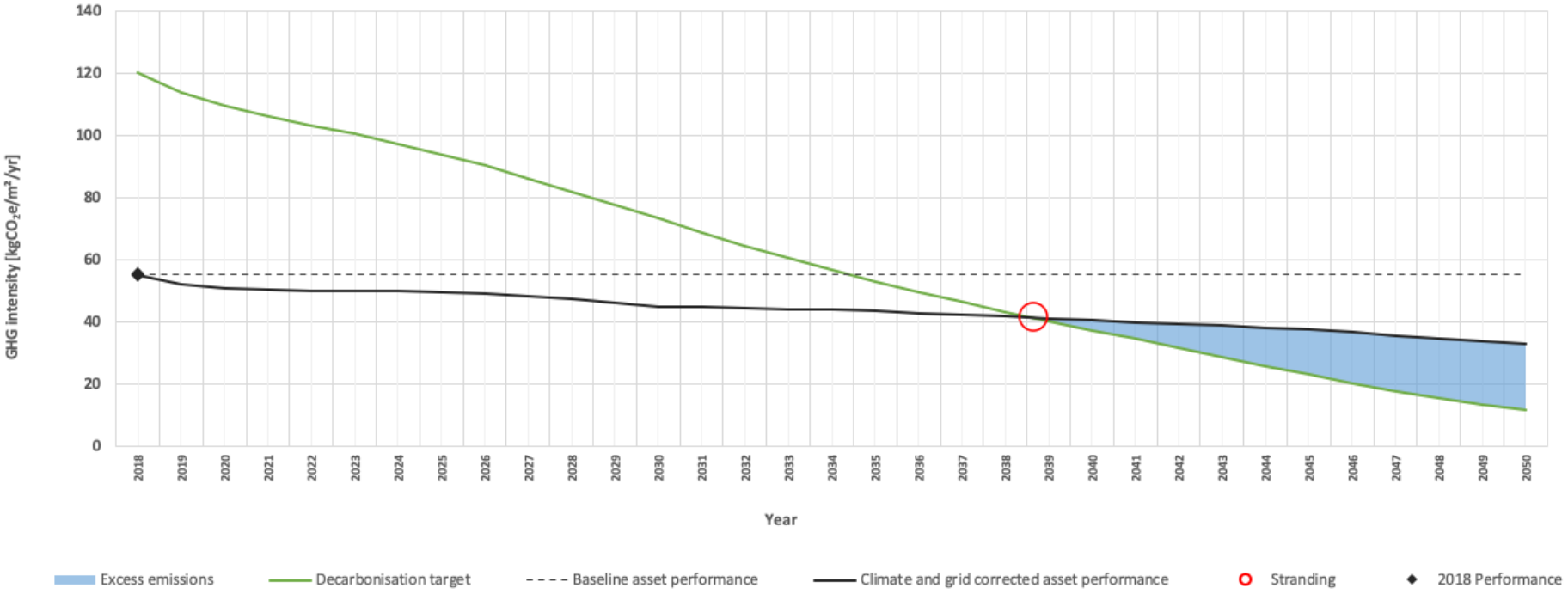
Calculating emissions and stranding with the CRREM tool:



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Calculating emissions and stranding with the CRREM tool – Asset 1:

							Excess emissions	
	Emissions	GHG Intensity	1.5°C-target	2°C-target	1.5°C-stranding	2°C-stranding	1.5°C-target	2°C-target
2018	257.417	27,1	133,4	132,3	No	No	- 1.009.547	- 999.603
2019	243.489	25,6	128,5	126,6	No	No	- 977.690	- 958.866
2020	230.481	24,3	123,9	121,1	No	No	- 946.874	- 920.145
2021	231.824	24,4	118,4	116,9	No	No	- 892.932	- 878.840
2022	233.176	24,5	112,9	112,4	No	No	- 839.762	- 834.182
2023	234.538	24,7	107,6	108,3	No	No	- 787.349	- 794.069
2024	235.910	24,8	102,3	103,8	No	No	- 735.688	- 750.665
2025	237.292	25,0	97,1	99,9	No	No	- 684.773	- 711.748
2026	231.502	24,4	91,9	95,2	No	No	- 641.768	- 672.957
2027	225.889	23,8	86,9	91,0	No	No	- 599.315	- 638.466
2028	220.446	23,2	81,9	86,4	No	No	- 557.408	- 600.661
2029	215.168	22,6	77,0	81,9	No	No	- 516.030	- 563.346
2030	210.050	22,1	72,1	77,9	No	No	- 475.179	- 530.215
2031	208.665	22,0	69,3	75,0	No	No	- 449.883	- 503.415
2032	207.291	21,8	66,1	71,2	No	No	- 420.849	- 469.525
2033	205.929	21,7	62,9	67,9	No	No	- 391.741	- 439.307
2034	204.579	21,5	59,7	64,6	No	No	- 362.565	- 409.027
2035	203.240	21,4	56,5	60,9	No	No	- 333.309	- 374.930
2036	200.415	21,1	53,3	57,9	No	No	- 305.475	- 349.768
2037	197.642	20,8	50,0	55,4	No	No	- 277.516	- 328.272
2038	194.919	20,5	46,8	52,4	No	No	- 249.435	- 302.915
2039	192.245	20,2	43,5	49,4	No	No	- 221.222	- 277.453
2040	189.619	20,0	40,3	46,9	No	No	- 192.881	- 255.665
2041	186.785	19,7	37,4	44,1	No	No	- 168.957	- 232.422
2042	184.006	19,4	34,4	41,6	No	No	- 142.912	- 211.264
2043	181.283	19,1	31,4	39,1	No	No	- 116.614	- 189.900
2044	178.614	18,8	28,3	36,1	No	No	- 90.059	- 164.465
2045	175.998	18,5	25,2	33,5	No	No	- 63.240	- 142.673
2046	171.626	18,1	22,1	31,4	No	No	- 37.968	- 126.372
2047	167.402	17,6	18,9	29,2	No	No	- 12.331	- 109.793
2048	163.321	**17,2**	**15,8**	27,0	Yes	No	13.674	- 92.938
2049	159.377	16,8	13,0	24,8	Yes	No	35.547	- 75.808
2050	155.567	16,4	10,3	22,5	Yes	No	57.273	- 58.406

→ Stranding occurs later; the tool offers the possibility to calculate the excess emissions

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Calculating emissions and stranding with the CRREM tool – Asset 2:

						Excess emissions	
Emissions	GHG Intensity	1.5°C-target	2°C-target	1.5°C-strand	2°C-strandir	1.5°C-target	2°C-target
995.234	39,8	52,7	52,4	No	No	-322.816,12	-314.773,96
1.004.087	40,2	52,5	51,8	No	No	-307.666,13	-291.728,40
1.013.080	40,5	52,2	51,3	No	No	-292.575,87	-268.875,35
1.012.567	40,5	50,5	50,3	No	No	-250.444,36	-245.100,23
1.012.053	40,5	48,8	49,2	No	No	-208.334,24	-218.386,46
1.011.539	40,5	47,1	48,2	No	No	-166.239,05	-194.646,47
1.011.025	40,4	45,4	47,2	No	No	-124.163,78	-167.979,62
1.010.512	40,4	43,7	46,2	No	No	- 82.111,72	-144.301,18
1.000.491	40,0	42,0	45,0	No	No	- 49.580,47	-124.249,32
990.610	39,6	40,3	43,9	No	No	- 16.920,88	-107.041,50
980.867	**39,2**	**38,6**	42,7	Yes	No	15.867,72	- 86.758,75
971.260	38,9	36,9	41,5	Yes	No	48.796,66	- 66.352,92
961.786	38,5	35,2	40,4	Yes	No	81.863,88	- 48.781,99
941.556	37,7	34,1	39,6	Yes	No	88.167,67	- 47.258,44
921.974	36,9	33,0	38,5	Yes	No	95.838,92	- 41.517,84
903.018	36,1	31,9	37,6	Yes	No	104.669,77	- 37.723,26
884.669	35,4	30,8	36,7	Yes	No	114.643,17	- 32.897,57
866.905	34,7	29,6	35,6	Yes	No	125.756,37	- 23.948,94
856.805	34,3	28,5	34,8	Yes	No	145.091,10	- 13.104,24
846.885	33,9	27,3	34,1	Yes	No	165.183,55	- 4.850,63
837.144	**33,5**	26,0	**33,2**	Yes	Yes	186.035,70	7.113,40
827.576	33,1	24,8	32,3	Yes	Yes	207.663,76	19.660,10
818.180	32,7	23,5	31,5	Yes	Yes	230.070,32	29.540,18
808.042	32,3	22,4	30,7	Yes	Yes	249.229,63	41.487,16
798.104	31,9	21,1	29,9	Yes	Yes	269.506,33	50.947,74
788.363	31,5	19,9	29,1	Yes	Yes	290.699,57	61.054,96
778.815	31,2	18,6	28,1	Yes	Yes	312.824,72	75.224,52
769.455	30,8	17,3	27,3	Yes	Yes	335.897,90	86.679,23
759.270	30,4	16,0	26,6	Yes	Yes	358.915,37	94.295,50
749.310	30,0	14,7	25,9	Yes	Yes	382.948,39	102.542,98
739.570	29,6	13,3	25,1	Yes	Yes	408.013,70	111.425,12
730.045	29,2	12,1	24,4	Yes	Yes	428.764,73	120.945,93
720.730	28,8	10,8	23,6	Yes	Yes	449.873,40	131.109,52

→ Stranding occurs later; the tool offers the possibility to calculate the excess emissions

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1. Introducing the CRREM project
2. Specific Issues regarding Carbon Risk (Q&A)
3. Case Study: Calculating carbon emissions & stranding risks
4. What's new?

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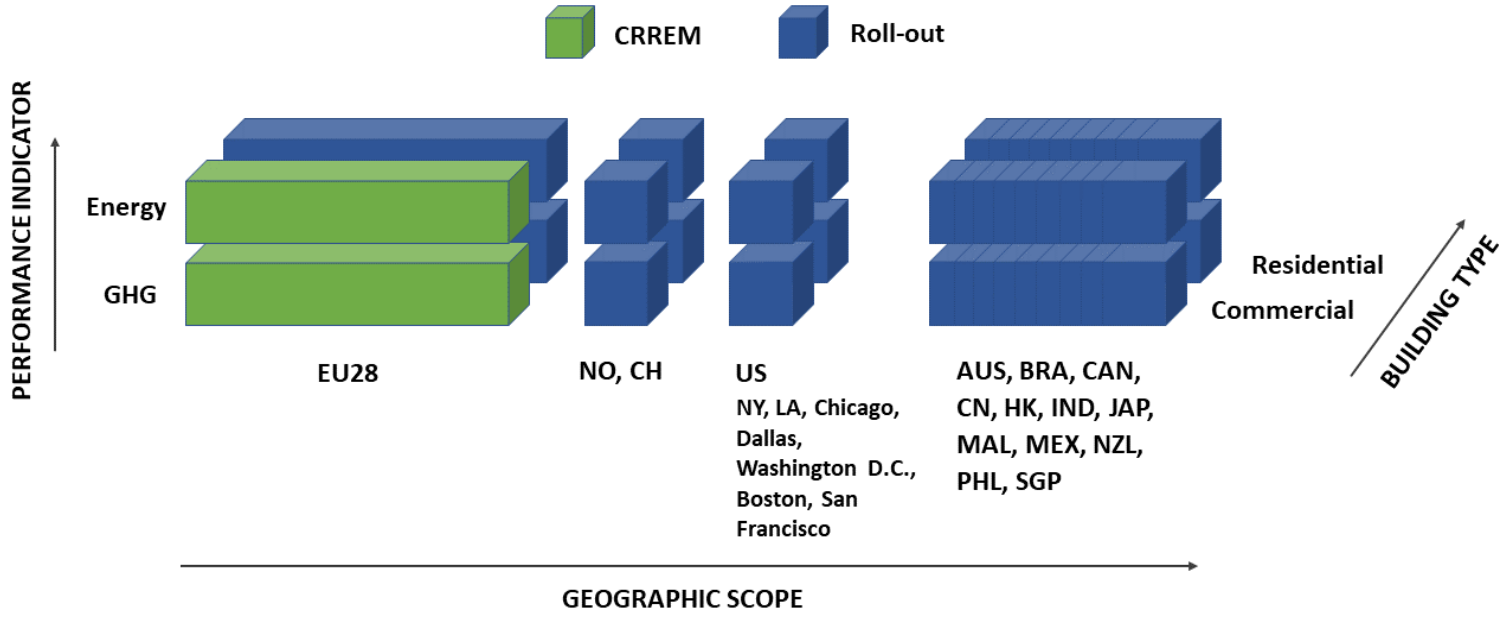
CRREM GLOBAL

- Extension of the CRREM pathways: www.CRREM.org
- Including residential buildings and key global real estate markets



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Corporate communication of CO2 targets: "2-degree readiness"

- Corporate communication of CO2 targets: "2-degree readiness"
- Reporting templates to produce 2-degree-ready reports for their assets, enabling transparent reporting of targets and performance.
- Standardisation by comparison with other reporting initiatives and formats, especially

TCFD TASK FORCE ON CLIMATE-RELATED FINANCIAL DISCLOSURES

ADVANCING NET ZERO
Accelerating Uptake of Net Zero Carbon Buildings

FSB FINANCIAL STABILITY BOARD

G20

WORLD GREEN BUILDING COUNCIL

European Commission

- (Automatic) link between CRREM Tool and Reporting Templates for parts of the template

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Thanks for your attention!

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