Carbon Risk Real Estate Monitor

STRANDING RISK & CARBON

Science-based decarbonising of the
EU commercial real estate sector

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HOW TO READ THIS REPORT

The content of this document is comprehensive, but designed to be feasible and accessible to a multidisciplinary readership. The structure permit readers to approach the report as a full document, or alternatively the individual chapters serve as standalone outputs with specific thematic focus.

EXECUTIVE SUMMARY

The document starts with a brief section listing the key outcomes of the research. This section is not intended as a summary of the whole report, but as a structured **selection of the most important areas of discussion** that the authors would like to highlight to *CRREM* stakeholders. The executive summary dedicates one page to each of this report's four main sections.

MAIN SECTIONS

Sections A provides an introduction to the *CRREM* project and background information on 'stranding risk'. Section B describes global and *EU* policies on climate change mitigation as well as international standards on the assessment of greenhouse gases. Section C explains how property specific targets according to necessary greenhouse gas reductions can be derived from global climate targets and international commitments. Finally, Section D focusses on greenhouse gases in the built environment, their assessment and strategies to manage and reduce resulting risks on a property and corporate level.

The following overview is a summary of each section's content. Further details can be found in the executive summary and the key facts and findings available at the beginning of each section.

SECTION A CRREM – REDUCING CARBON RISK IN THE REAL ESTATE SECTOR

This section defines the concept of 'stranding risk' as well as *CRREM's* main output: a toolkit to assess the risk of assets becoming 'stranded'. The toolkit will be able to model the future evolution of the carbon and economic performance of portfolios following global warming scenarios. It will also help users to assess their assets, plan the improvement actions required to mitigate their impact towards climate change and adapt them to future climatic conditions.

SECTION B GLOBAL AND EU POLICY. CARBON REPORTING

Conceived as a reference section, the content of this section ensures that all readers are familiar with current carbon policies and accounting protocols. Detailed descriptions of past and current policies on climate change is included, focusing on EU policy and its implications for the Real Estate sector. Section B also incorporates a detailed description of the *Greenhouse Gas Protocol*, used by *CRREM* to account carbon emissions.

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SECTION C DOWNSCALING CARBON BUDGETS AND SETTING SCIENCE-BASED DECARBONISATION TARGETS

This section calculates the carbon budget that the real estate sector can emit up to 2050 to comply with *EU's* international commitments. Details on the downscaling process – distribution of carbon reduction responsibilities – per county and sector are also provided, including decarbonisation pathways and carbon reduction targets.

SECTION D CORPORATE MANAGEMENT OF STRANDING RISK

Section D identifies all carbon emission sources within the non-domestic building stock and describes the available methods to classify them depending on different reporting perspectives. It also defines the current baseline of the real estate sector, both on corporate awareness of stranding risk and the characteristics of the EU non-domestic building stock, and the available measures to reduce carbon emissions and risk.

CROSS-REFERENCES

The document structure is completed with multiple cross references between sections to guide readers to other areas of the text and find further background information or details on a specific topic. Each section's summary of key facts and findings includes the paragraph '**Related topics',** which provides basic references to other parts of the document for further complementary reading.

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EXECUTIVE SUMMARY

SECTION A: CRREM - REDUCING 'STRANDING RISK' FOR REAL ESTATE

The *EU*[1] commercial real estate sector is 14 years behind schedule: At the current rate of emissions the carbon budget available for 2050 will be consumed in 2036.

What is stranding risk?

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.

How do buildings become stranded?

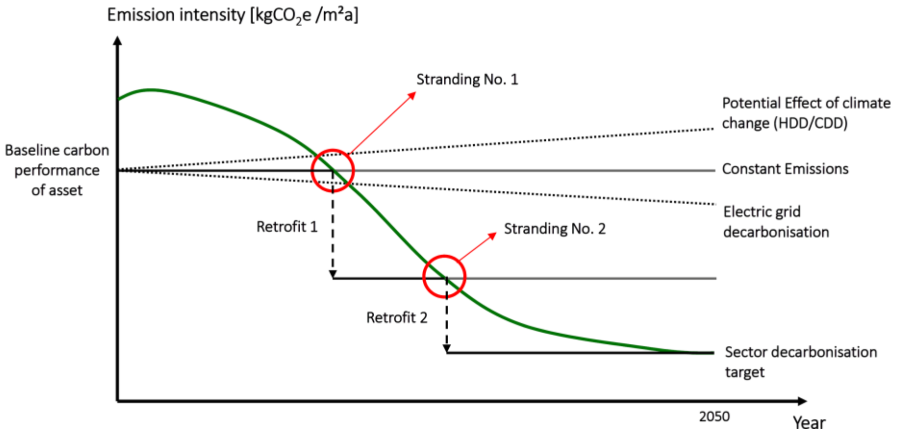
Stranded assets are properties that will be increasingly exposed to the risk of early economic obsolescence due to climate change because they will not meet future regulatory efficiency standards or market expectations. These buildings will become less marketable and may require costly refurbishment measures.

How much carbon can the EU commercial real estate sector still emit?

In 2015 the *EU* adopted the legally binding *Paris Agreement*, which aims to limit global warming to well below 2°C and pursuing efforts to limit it to 1.5°C. To comply with this commitment, the maximum amount of carbon that the *EU* commercial real estate sector can emit from 2019 until 2050 is 24 $GtCO_2e$ for a 2°C warming scenario. At the current rate of emissions, this 'carbon budget' would only last until 2039. In a 1.5°C warming scenario, the budget will be depleted by 2036.

How does a framework that helps investors to address stranding risks look like?

***CRREM* defines decarbonisation targets and pathways, broken down per country and building use, which are consistent with the *EU* commitment to limit global warming to 1.5°C or 2°C.** These pathways and targets provide **benchmarking** roadmaps for individual properties, in particular the **existing building stock,** which has to radically reduce its carbon footprint within the next decades. The figure below provides a summary of this approach: The green curve presents the decarbonisation target pathway for a specific building. The future emissions of that building are affected by climate change, the decarbonisation of electricity generation and, last but not least, energetic retrofit measures. Stranding occurs, if the building will no longer meet the requirements in terms of emission targets.



[1] If not stated otherwise, the term *EU* refers to the *EU-28*.

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SECTION B: POLICY EFFORTS TO REDUCE GLOBAL WARMING

Current *EU* climate pledges are not enough and lead to an above 2°C global warming.

What efforts is the *EU* currently undertaking to reduce climate change?

By entering the *Paris Agreement* at *COP21,* the *EU* committed to limit global warming to well below 2°C as well as to take further actions targeting towards a 1.5°C limit. The *EU* intends to reduce its GHG emissions by 80-95% below 1990 levels and has adopted a **variety of interim targets and instruments** aiming to reduce energy consumption and carbon emissions. The best-known instrument is the ***EU Emission Trading System (EU-ETS)***, though not targeting direct emissions from the building sector.

In 2018, the ***Effort Sharing Decision (ESD)*** was adopted, covering also emissions from buildings. **The property industry will have to drastically increase its current efforts in emissions reductions.** The *ESD* sets binding annual greenhouse gas emission targets for each member state for the periods 2013-2020 and 2021–2030. Targets consider different economic growth expectations and investment capacities across *EU* member states, ranging from 0% to -40% reduction by 2030 compared to 2005 levels.

The ***Energy Performance of Buildings Directive (EPBD)*** is the main framework to reduce carbon emissions in the built environment. Building regulations in all *EU* member states need to comply with the *EPBD*. Its 2018 recast reflects the low refurbishment rate in the existing building stock, taking up the *ESD* targets not only for new buildings, but also for existing ones. This report provides answers to remaining questions regarding the GHG reporting on property level from an investor or tenant perspective, considering issues like embodied carbon, green energy and the avoidance of double counting.

Are *EU* policies enough to meet international commitments?

According to scientific evidence, the *EU's* current carbon reduction pledges will lead to an **above 2°C global warming scenario**, unmistakably failing to meet *COP21* climate targets. Future policy is expected to strengthen regulations to meet the commitments.

What other efforts must the EU undertake?

- **MORE DATA:** Future data collection will have to look beyond **emissions that can be controlled during the design stage of new buildings or large retrofit projects,** addressing all emissions related to the built environment. This includes plugged-in equipment as well as embodied carbon of new buildings and major retrofit works. Embodied carbon comprises all emissions related to building related upstream and downstream activities (new construction and refurbishment), including procurement, construction, maintenance and disposal. **The embodied carbon from newly constructed buildings from today until 2050 equals their cumulative operational greenhouse gas (GHG) emissions in the same period.**[2] A **net positive environmental benefit of retrofit measures** can only be ensured if embodied carbon, as well as savings at operational level, are accounted for.
- **BETTER DATA: Improved data collection** of *EU* carbon emissions is crucial to attain existing targets. Efficient policy making and scientific research require reliable data on building stock characteristics including **minimum performance indicators on energy and carbon performance**. Comparable data requires a **harmonisation of member states' assessment and reporting methodologies**, sufficient funding and infrastructure for regular data collection and monitoring. The current *EPBD* building classification system should be extended by further subcategories reflecting the existing **variety of energy consumption profiles across different types of use.**

[2] Bionova Ltd., 2018.

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SECTION C: SETTING TARGETS FOR THE REAL ESTATE SECTOR

Buildings will need to reduce their carbon emissions by more than 80% until 2050.

How much does the real estate sector need to reduce carbon emissions?

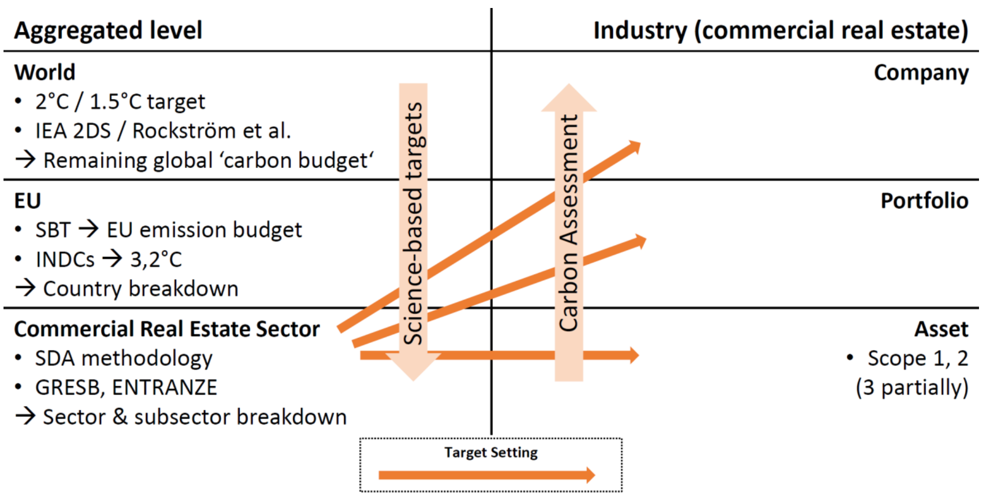
Following the *Paris Agreement, CRREM* considered three possible scenarios to calculate **carbon intensity reduction pathways and targets (kgCO_2e / m^2)** for the commercial building stock:

SCENARIO	REQUIRED AVERAGE REDUCTION as of 2019	RATIONALE
1.5°C	**91%** (by 2050)	Paris Agreement aspirational
2.0°C	**78%** (by 2050)	Paris Agreement binding
NDC	**29%** (by 2030)	EU-ESD to meet determined contributions

How have targets been calculated from global to individual property level?

The process to allocate carbon reduction requirements (downscaling) involves three stages:

1. **FROM GLOBAL TO EU CARBON BUDGET:** The global carbon budget is the amount of carbon that can be emitted without exceeding the 1.5 or 2°C warming threshold. *CRREM* uses data from the *International Energy Agency (IEA)* and applies recognised climate models (e.g. *Rockström et al., 2017)* to calculate the decarbonisation efforts required from the *EU* economy.
2. **FROM TOTAL EU BUDGET TO EU AND COUNTRY SPECIFIC COMMERCIAL REAL ESTATE TARGETS:** *CRREM* uses data from various *EU* databases and the *EU Reference Scenario 2016* to calculate the portion of the *EU* carbon budget that can be emitted by the commercial real estate sector and distribute responsibilities to each member state. This downscaling step is based on the *Sectoral Decarbonisation Approach (SDA),* a methodology recognised by the *Science Based Targets* initiative *(SBTi)*.
3. **FROM COUNTRY SPECIFIC TO BUILDING TYPE SPECIFIC CARBON REDUCTION TARGETS:** *CRREM* further downscales each country's carbon budget and carbon intensity pathway to different commercial real estate subsectors, like office or retail. This downscaling process considers the commercial building stock size, expected growth and current carbon emission intensity in each country and subsector.



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SECTION D: CARBON COUNTING AND RISK MITIGATION STRATEGIES

> **Negative long-term climate change impacts on annual returns in the real estate sector *(Mercer)*. Strategic reactions to mitigate risk still lag behind**

Risk assessment: How is stranding risk from real estate currently being reported?

The **assessment of stranding risks** in the built environment is a distinctly more complex challenge than measuring energy and carbon. It involves the assessment of multiple energy fuels and a variety of greenhouse gases with different global warming potential, the difficulty to assess indirect emissions (e.g. embodied carbon and unregulated carbon emissions) and the uncertainty to estimate the impact of climate change on future energy demand.

There are solid **carbon accounting and reporting standards** available (*GHG Protocol*, *GRI*, *EPRA*, etc.), which often define emission boundaries from the reporting organisations' perspective. However, emissions from buildings are usually shared amongst different reporting stakeholders who must collaborate towards a common reduction target. ***CRREM* fairly and completely allocates the total carbon emissions of buildings amongst all involved stakeholders.**

Risk management: How aware is the real estate sector of the increasing carbon risk?

CRREM survey of commercial real estate investors/owners representing EUR 260 billion assets under management concludes:

1. **Market readiness**: The commercial real estate industry is generally seeking to reduce carbon emissions and risk. However, a clearly defined roadmap presently does not exist.
2. **Imbalanced penetration**: Only larger institutional investors and prime commercial real estate owners have already embraced energy efficiency and carbon risk assessment. The remaining investor profiles lag behind.
3. **Perceived impact on value**: There is evidence inferring that investment in green buildings can result in higher rental and occupancy rates, lower operating expenses and higher asset values.
4. **Identified risks**: Requiring a risk-premium for properties with a poor carbon footprint is no longer exceptional as they will face rising energy prices, increasing regulation, higher construction costs, etc.
5. **Opportunity:** The commercial real estate sector sees the regulatory change as an opportunity for value creation and innovation, seeking guidance on the most effective means of driving change.
6. **Barriers to appropriate adaptation:** Stakeholders lack sufficient information on their assets' actual carbon performance regarding property-specific and science-based decarbonisation targets.

Studies of the *International Energy Agency IEA* or the *Urban Land Institute ULI* confirm these findings, stating a high-level of climate related risk to the real estate industry and a low level of strategic response.

Risk mitigation: How will *CRREM* estimate carbon risk reduction in real estate assets?

The *CRREM* tool will assess the carbon risk of real estate assets and portfolios, which involve the quantification and assessment of all carbon emissions released from buildings. *CRREM* will also help to fairly and completely distribute the responsibility to mitigate the carbon risk amongst all carbon emitting stakeholders within the building, usually tenants (units) and landlords (common parts). Building owners will need to liaise with tenants the interpretation of their own reporting boundaries to avoid gaps or double counting.

CRREM outputs will also quantify the carbon and economic costs and savings that result from carbon risk mitigating measures, including retrofit works to ensure compliance, evolution of the electricity grid decarbonisation and embodied carbon assessments. The results can be used to build Marginal Abatement Cost curves that will inform users on the most cost-effective possibilities available to set priorities and plan their carbon reduction strategies.

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CRREM

Reducing carbon risk in the real estate sector

A

SECTION A CRREM – REDUCING CARBON RISK IN THE REAL ESTATE SECTOR

Climate change is causing major challenges for the real estate industry. Climate-related risks are increasingly affecting assets' capital as well as rental values, some properties will even face early economic obsolescence. Section A defines the concepts of 'Stranded Asset' and 'Stranding Risk' and clarifies how *CRREM* project's outputs offer solutions to mitigate these risks.

KEY FACTS AND FINDINGS

A.1 NEED FOR ACTION: AVOIDING 'STRANDING RISK' IN REAL ESTATE

'Stranded (real estate) assets' are properties which will not meet future efficiency standards and market expectations regarding their carbon performance and might be increasingly exposed to the risk of early economic obsolescence and write-downs. These buildings will ultimately become less marketable and may require costly refurbishment activities.

Assuming a higher than 2°C warming scenario the real estate sector is likely to face negative impacts on property returns over the next 35 years. Since real estate is a location-bound and a long-term investment, it is highly exposed to climate risks. Stranded assets can expect write-downs due to:

1. **Demand shifts towards sustainable properties**, putting pressure on 'non-green' assets
2. **Higher exposure to natural risk** (storms, flooding, wild fires, etc.)
3. **Poor carbon performance** of buildings and increasing energy and carbon prices (carbon taxation or higher prices for carbon certificates)

About 29% of all greenhouse gas (GHG) emissions – the main source for global warming – can be attributed to the property industry. If GHG emissions ought to peak not later than 2020 urgent action is required. Therefore, the real estate sector is and will remain in the spotlight and will **be the focus of increased political pressure for further mitigation** efforts to contribute to the transition to a 'low-carbon economy' by 2050. According to latest research **the industry is 'not-on-track'** regarding the building sector's technological progress. Increasing awareness considering these potential threats poses a stronger **liability** on CEO's and an increasing fiduciary responsibility on fund managers regarding the **transparent disclosure** and management of climate risks.

A.2 CRREM PROJECT: CARBON RISK REAL ESTATE MONITOR

CRREM makes these risks transparent for asset managers and investors. The project will provide the real estate industry with tools and guidelines that define appropriate carbon reduction pathways and targets. Also, strategic options for investors to prepare their portfolios to the likely impact of climate change will be presented. All results will be aligned with international initiatives like *GRI*, *CDP*, *GRESB* and coordinated with other *EU* initiatives. Besides science-based carbon reduction targets that are aligned with the *United Nations Framework Convention on Climate Change* and the *Paris Agreement*, *CRREM* also presents targets according to the *EU*'s *National Determined Contribution*.

CRREM's main output is a toolkit to assess the risk of individual real estate assets and portfolios becoming 'stranded'. The toolkit will include predefined **Decarbonisation Pathways** (see 1.1 to 1.3 in the figure below and see SECTION C) for most commercial real estate subsectors in all *EU* member states. We are focussing especially on 'carbon intensity' (see Section B.2) as key indicator and 2050 as the generally accepted target year of a substantial

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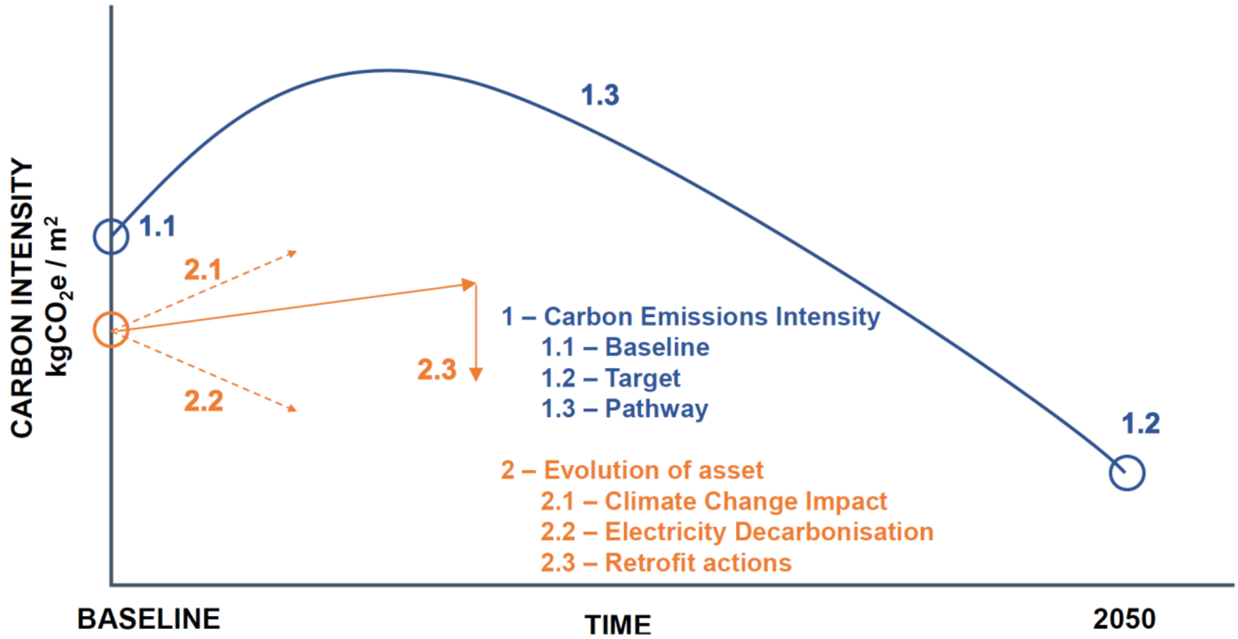
decarbonisation of the economy. The analysis will further incorporate a prediction on the **Future Evolution** (see 2.1 to 2.3 in the figure below and SECTION D and SECTION C) of the carbon and economic performance of assets or whole portfolios, also accounting for external factors like potential policy changes, fluctuations of refurbishment and energy costs, carbon pricing and climate change. Besides that, the *CRREM* toolkit will also provide a broad range of guidance documents that support strategic decision making.



The carbon intensity of a company's portfolio against a peer-group benchmark will clearly become a more dominant competitive factor. Real estate owners must develop a profound response to deal with climate risks. Options include 'mitigation', 'transfer', 'accept', or 'control' of these risks. The analysis and simulation of potential retrofit measures and their effects regarding energy savings, GHG reduction and costs in the context of global carbon reduction targets will enable investors to quantify and manage the stranding risk within their portfolios.

RELATED TOPICS

CALCULATION OF CARBON REDUCTION PATHWAYS AND TARGETS	SECTION C
CORPORATE STRATEGIES ON CARBON RISK MANAGEMENT	SECTION D.1
CARBON RISK ASSESSMENT IN THE BUILT ENVIRONMENT	SECTION D.2

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A.1 NEED FOR ACTION: AVOIDING 'STRANDING RISK' IN REAL ESTATE

Latest research on Earth's future climate has given rise to fear that even a global warming of 2°C until the end of the 21st Century might be enough to cross a threshold beyond which self-reinforcing feedback mechanisms might result in a state that the study's authors refer to as **'Hothouse Earth' with a global average temperature higher than in the past 1.2 million years**[3]. Also, the recent *Intergovernmental Panel on Climate Change (IPCC)* Special Report 'Global Warming of 1.5°C' clearly stated that the 2°C target will not be ambitious enough to avoid dramatic ecological, economic and social impacts[4].

Climate change is already happening and will accelerate in the future. The period from 2014-2018 inclusive witnessed the years with the five highest August global land and surface temperatures since the start of worldwide records beginning in 1880[5]. The **earth's atmosphere is warming faster than ever in the last 1,000 years**[6] and the growing research field of event attribution science was able to identify a number of single **extreme weather events** and event categories whose intensity or frequency was significantly affected by climate change[7,8]. According to the world's leading reinsurance company *Munich RE*, damage caused by **natural catastrophes reached its highest ever value of EUR 115 billion in 2017**.[9] Overall losses amounted to ca. EUR 280 billion in 2017, which was the second-highest figure ever recorded, only exceeded in 2013 due to the non-climate related earthquake catastrophe in Japan. The global increase of exposed assets (either insured or not) is one driver of the continuously increasing weather-related losses, but there is also a clear tendency towards an increased number and frequency of natural disasters themselves[10]. It is a myth, that this development does not affect property owners as long as they have insurance protection. With increasing costs due to extreme weather events, insurance companies will raise premiums or might even declare some locations uninsurable, e.g. after repeated flooding[11]. Besides extreme weather events, it is water scarcity, increased temperatures and sea-level rise, that are substantially **threatening ecosystems as well as economic assets including property values** (see Annex 3). Besides these direct impacts of climate change, the increasing regulation of greenhouse gas emissions (GHG) exerts more and more pressure on companies to shift away from fossil fuels.

Steadily growing global energy consumption and anthropogenic emissions have resulted in an increase of CO_2 concentration in Earth's atmosphere exceeding 408 parts per million (ppm) in comparison to 280 ppm in the pre-industrial era[12] (see Figure A-1). Recent findings confirm the consensus among climate scientists, that man-made GHG emissions are the main source for global warming **inevitably resulting in a further temperature increase in the decades ahead**[13]. In order to limit global warming to below 2C° above the pre-industrial level, GHG emissions ought to peak not later than 2020[14]. In contrast to many analysts' predictions and environmentalists' hopes, global oil production seems to be far away from its awaited peak, but will, distinctly increase over the next five years due to rising demand especially for flight and road transportation.

3 Steffen et al., 2018.
4 IPCC, 2018.
5 NOAA, 2018a.
6 Smith et al., 2015.
7 ECIU, 2017.
8 National Academies of Sciences, Engineering, and Medicine, 2016.
9 Munich RE, 2018.
10 Hirsch/Braun/Bienert, 2015.
11 Bienert, 2014.
12 NOAA, 2018b.
13 Goodwin, 2018.
14 Rockström et al., 2017.

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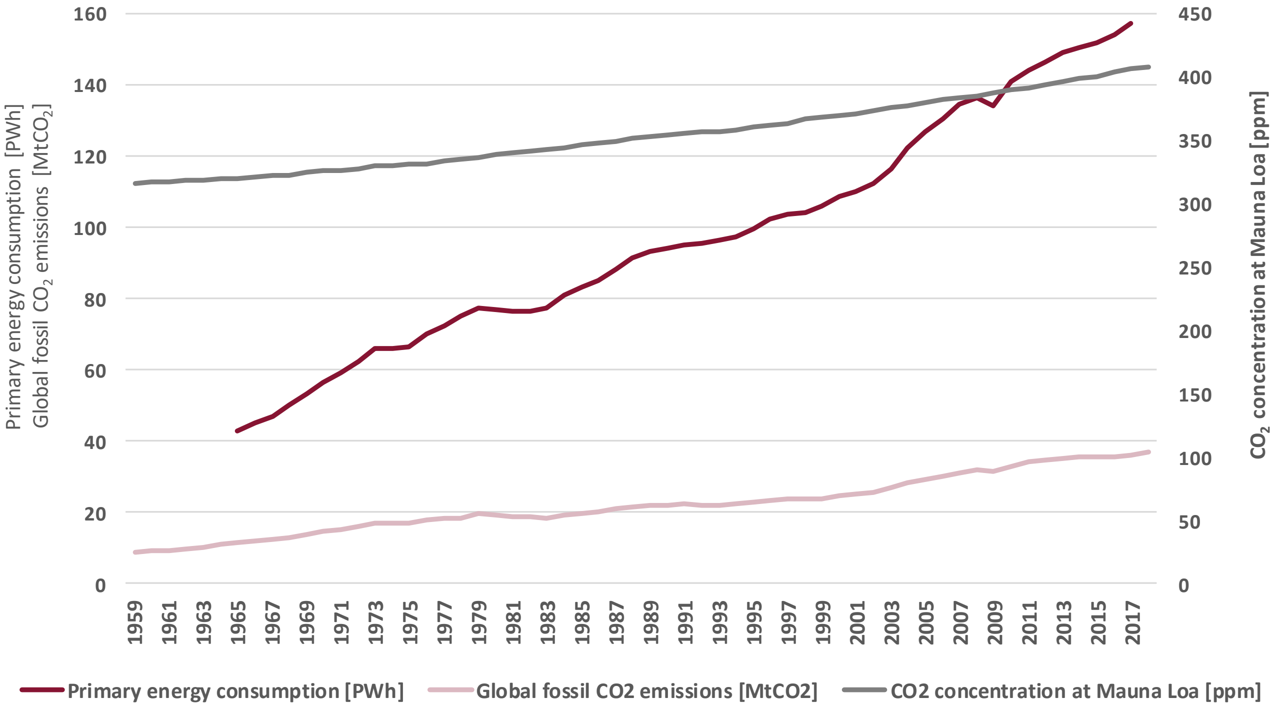
Figure A-1: Annual global CO_2 emissions from fossil fuels and industry (1959-2018) [$MtCO_2$], primary energy consumption (1965-2017) [PWh] and CO_2 concentration at Mauna Loa (1959-2018) [ppm]



Source: Energy consumption: BP, 2018. CO_2 emissions: Global Carbon Project, 2018. CO_2 concentration: NOAA, 2018b.

The status quo and outlook of climate change and its negative impact on the economy and human civilisation as a whole, underlines the **urgent need to limit climate change**. The current state of political initiatives and commitments targeting the necessary turnaround in energy consumption and GHG emissions is described in SECTION B.

Generally, **climate change is more and more regarded as a material financial issue driving risks.** This perception goes far beyond the mere physical impact of extreme weather events or sea-level rise, it includes consumer shift, changes in taxation, legally binding retrofits etc. As a result, company leaders can no longer categorise climate change and mitigation measures only as an ethical or environmental issue (of goodwill).[15] The term **'low-carbon economy'** is already in place and well known, but still the lion's share of today's global economic processes, structures and assets remain dependant on fossil fuels. Inevitably, the transition to a low-carbon economy, which has started just to become a material trend, will result in a **devaluation of infrastructure, knowledge and assets whose value is to some degree based on burning fossil fuels and emitting greenhouse gases.** This fundamental transition is generally referred to as **'decarbonisation'** and affects physical assets as well as financial assets and portfolios (see Annex 5).[16] The market capitalisation of many fossil fuel-related companies has seen a dramatic decline in the past few years but it is still unclear whether future risks are already adequately priced into current asset values[17]. The standard term for those negative effects of climate change on the value of assets is 'stranding'. While, for example, the *International Energy Agency* (*IEA*, 2013) defines 'stranded assets' as investments which will no more earn any economic return prior to the end of their economic life, the *CRREM* project follows the wider definition of *Caldecott et al.* (2013): **'Stranded assets are assets that have suffered from unanticipated or premature write-downs, devaluations, or conversion to liabilities'.**

[15] Barker et al., 2018.

[16] Thomä/Chenet, 2018.

[17] Thomä/Chenet, 2018.

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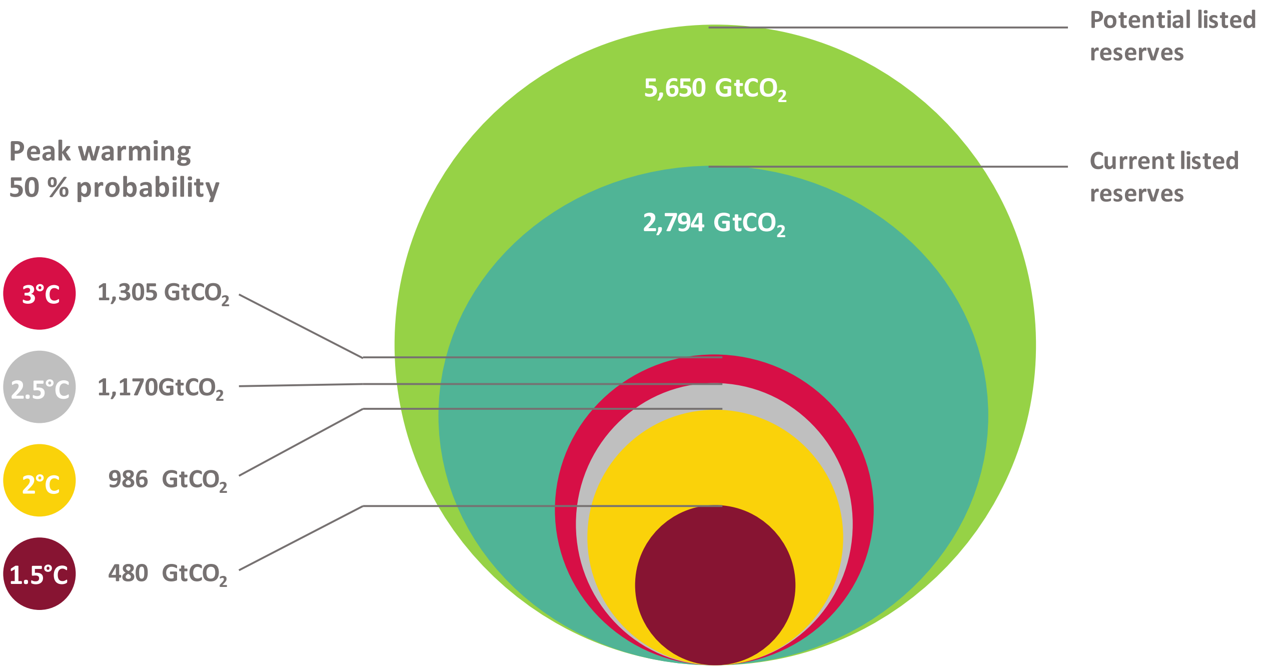
Figure A-2: Comparison of listed coal, oil and gas reserves to 50% probability pro-rata 2°C-conform carbon budget



Source: Carbon Tracker & Grantham Research institute on Climate Change and the Environment at LSE, 2013, own presentation.

The term **'stranding risk'** was originally applied in the context of companies from the coal or oil industry, expressing that some aspects that are currently considered in the company value unexpectedly have to be reappraised, ultimately resulting in write-downs:

1. This revaluation can be caused **by reduced turnovers if demand and prices for those resources decline** contrary to expectations or if producers have to bear a special (e.g. carbon) tax[18] in order to compensate for negative external effects caused by the product. For example, there is a shift of consumer demand towards electric cars.
2. Another key factor that can lead to revaluations and therefore 'stranded assets', e.g. in the context of the fossil fuel industry, are power plants or oil fields that might face premature retirement. According to research from *Carbon Tracker* and the *Grantham Research Institute on Climate Change and the Environment*, 'between 60-80% of coal, oil and gas reserves of publicly listed companies are **'unburnable'** if the *Paris climate targets* (see Section B.1) shall be reached and global warming shall not exceed 2°C' (see Figure A-2).
3. **Increased prices for CO_2 emissions certificates** can reduce the relative competitiveness of carbon-intensive technologies, which is currently accelerating the switch from coal to gas regarding power generation and questioning the rationale for keeping old coal and lignite power plants running beyond 2021[19].+
4. Another trigger of economic obsolescence is the clear shift in investors' portfolio allocation strategies, which afford greater prominence to sustainability and climate sensitivity. Thus, the **global trend towards a high awareness of sustainability issues creates additional challenges** for companies with a heavy dependence on fossil fuels compared to their peers. This process of **divestment** already started to accelerate: For example, in May 2018, the world's largest insurance company *Allianz* announced it would no longer insure coal-fired power

[18] Caldecott, 2018a; Caldecott, 2018b.
[19] Euractiv, 2018b.

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plants and coal mines. Until 2040, *Allianz* further intends a stepwise retreat of insuring companies compromising the achievement of the 2°C.[20] In other words, *Allianz* will only insure companies that can prove to be **'2°C ready'**. Besides private companies like *Allianz* or *Standard Chartered*[21], **sovereign wealth funds** have also increasingly structured their investments towards ethical principles. For example, the Norwegian sovereign wealth fund in 2014 divested from more than 50 companies doing business in coal mining and coal-fired power generation.

The term 'stranding risk' can be applied to any kind of economic, societal or technological transition that poses risk to certain assets' value. Most commonly, the term 'stranding risk' is used in the context of climate change and GHG emissions. Consequently, it is very common to use 'stranding risk' and **'carbon risk'** synonymously and this report sticks to this common practice.

Whether and to what extent certain assets will get stranded in the future will depend on (1) the rate of technological innovations and their diffusion, (2) societal developments effecting the demand for low- and high-carbon products and services, (3) the speed and characteristics of climate change and finally (4) political decisions on the regulation of energy efficiency, carbon emissions and instruments like emission trading systems or other methods of carbon pricing. *MSCI* emphasises that it is not only companies with high GHG emissions that are facing stranding risks, but also corporates in 'carbon-dependent industries' like manufacturers of heavy electrical equipment whose revenues depend to a high degree on companies with carbon intensive operations or products.[22]

The growing awareness and knowledge about these transitional climate risks as well as write-downs of certain assets or whole sectors will inevitably lead to a **growing liability of company leaders and an increasing fiduciary responsibility of fund managers** to adequately address and manage those risks. An investment strategy that is, for example, based on a biased selection of energy and fuel-mix projections might thwart the obligations to act in the best interest of beneficiaries.[23] By contrast, personal liability of fund managers will be restricted if actions are based on informed evidence based and rational decisions reflecting all aspects of climate change impacts and transferring them to sound cost-benefit-analysis underpinning the respective strategic decisions. Against the background of climate risks becoming more and more common-place among key market stakeholders, an inactive and passive approach towards the risks of climate change can hardly be regarded as informed and rational. Such liability risks are among the key reasons for the **growing importance of an objective disclosure of climate risks**. Moreover, in a recent study on the disclosure of climate-related financial risks, two-thirds of respondents expected a first mover advantage from an early adoption of disclosing in line with the recommendations of the ***Task Force on Climate-related Financial Disclosures (TCFD)*** [24].

In 2015, the *Financial Stability Board* launched the *TCFD* which aims at developing 'voluntary, consistent climate-related financial risk disclosures for use by companies in providing information to stakeholders'[25]. The *TCFD* comprehensively analysed the financial impact of **climate-related risks and opportunities**. Figure A-3 demonstrates **the complex mechanisms of (transition and physical) risks and opportunities inducing potential financial impacts stakeholders are facing in the context of climate change**. In Section A.2 of this report, we explain how the *CRREM* project covers risks and opportunities related to carbon emissions in the real estate sector. Section C.2 provides decarbonisation targets that can be applied as valid benchmarks when disclosing climate-related risks, ideally, demonstrating the '2°C readiness' at portfolio level. In-depth information on the assessment, management and strategic mitigation of carbon risk is given in SECTION D.

[20] NZZ, 2018.

[21] Standard Chartered. 2018.

[22] MSCI, 2018.

[23] Barker et al., 2018, p. 99.

[24] South Pole, 2017.

[25] TCFD, 2018.

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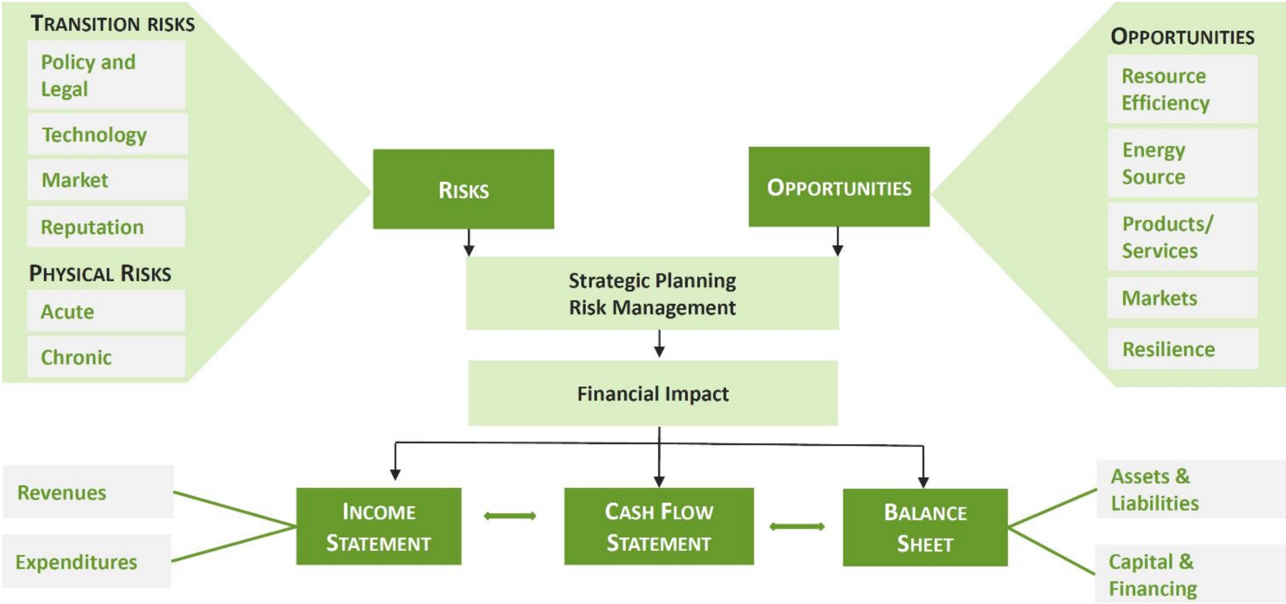
Figure A-3: Concept of climate-related financial risks and opportunities for assets and companies



Source: TCFD, 2018.

Recent analysis by *Investment & Pensions Europe (IPE)* details that a reduction of carbon emissions in line with the *Paris Agreement* could come along with a decline 'of at least 5% of the value of listed energy and utility companies […] [and that a] more abrupt transition away from fossil fuel could increase these losses up to 25%'[26]. This infers that **assets from various sectors valued at trillions of dollars are at risk of becoming 'stranded'** if the global economy proceeds investing in new fossil fuel ventures[27]. Climate change, and adaptation measures intending to limit its impact, will substantially affect the intrinsic value and performance of individual assets and whole sectors. **In particular, location-bound and long-term investments like real estate and infrastructure will be affected.**

Assuming a 2°C-consistent 'transformation scenario', the international consulting company *Mercer* estimates a slightly positive impact of climate change on 10- and 35-year median annual returns for the real estate sector. However, when assuming a 4°C high-impact scenario, the impact over 35 years on median annual return will be negative in the real estate industry.[28]

The carbon intensity of a company's portfolio against a peer-group benchmark will clearly become a more dominant competitive advantage in the future. Consumers exhibit more and more environmentally conscious behaviour and demand sustainable products, whilst governments pass increasingly tighter regulatory requirements on the energy efficiency of existing, retrofitted and especially newly constructed buildings.

The **relationship between the real estate sector and climate change** is two-fold. On the one hand, the built environment is contributing to climate change. **About 29% of all *EU* GHG emissions can be directly or indirectly attributed to the property industry.**[29] Consequently, **real estate is therefore a prominent feature in political mitigation efforts** since there is a broad consent amongst stakeholders that (1) the absolute potential savings in the sector are huge due to its overall share of emissions and (2) the cost-benefit relationship or so-called abatement costs (see Section D.3) for carbon reduction is more favourable compared to other sectors. On the other hand, the physical impacts of progressing climate

[26] IPE, 2018.

[27] Mercure et al., 2018. Exact figures range from USD 1-4 trillion, depending on future climate policies and level of oil production

[28] Mercer, 2015.

[29] EPRA/INREV, 2016.

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change include an increase of extreme weather events, sea-level rise and changes to the energy demand of buildings. Global warming is reducing heating and increasing cooling demand, which is in turn affecting the future GHG emissions of buildings (see 'Future impact of climate change on real estate GHG emissions' within section D.2).

The interrelation between climate change and buildings can be described in the **framework of the two terms 'mitigation' and 'adaptation'. Mitigation** includes the measures intended to **reduce the impact of buildings on climate change** by reducing GHG emissions (see Section B.1 outlining current *EU* policy). **Adaptation** includes measures aiming to **reduce the (physical or financial) impact of climate change on buildings** (see SECTION D for cost-benefit-analysis and strategic options to reduce carbon risks). The negative impacts of climate change on buildings comprise physical damage from natural disasters as well as potential write-downs due to increased regulation of carbon emissions. Consequently, the reduction of carbon emissions can be regarded as a measure of adaptation as well as of mitigation in the context of stranding risks.

The **building sector's technological progress towards a below 2°C climate target** is tracked by the *IEA* by benchmarking current technological standards to those outlined in *IEA*'s 2°C consistent *Sustainable Development Scenario (SDS)*. In 2017, the **building sector was deemed to be 'Not on track'.** A breakdown of different building technologies reveals, that especially investments with higher upfront costs and longer pay-back-periods are lagging behind (see Table A-1).

Further studies[30] also emphasise the **high risks emerging from climate change to the real estate industry** and that **to date strategic reactions have been insufficient**. This lagging can be partially explained by a lack of data and figures on necessary reduction targets and related cost-benefit considerations.

In 2015 the *EU* adopted the legally binding ***Paris Agreement***, which aims to limit global warming to well below 2°C and pursuing efforts to limit it to 1.5°C (see Section B.1). To comply with this commitment, the maximum amount of GHG that the ***EU* commercial real estate sector** can emit from 2019 until 2050 is 24 $GtCO_2e$ for a 2°C warming scenario. At the current rate of emissions, this 'carbon budget' would only last until 2039. In a 1.5°C warming scenario, the budget will be depleted by 2036. Further information on the concept of 'carbon budgets' and the setting of emission reduction targets on property level can be found in SECTION C.

Table A-1: IEA building sector Sustainable Development Scenario technology tracker 2017

TECHNOLOGY	STATUS
Building envelopes	Not on track
Heating	Not on track
Cooling	More efforts needed
Lighting	On track
Appliances and equipment	More efforts needed
Data centres and networks	On track

Source: IEA, 2017a.

[30] See Bienert, 2016.

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Applying the general concept of stranding risks to the real estate sector determines that there are a combination of external and industry specific factors that might pose additional threats to the overall investment value and increase the likelihood of an asset (or portfolio) becoming stranded. Sources of stranding risk within the real estate industry can be summarised as follows:

1. Write-downs due to demand shifts towards more sustainable properties (putting pressure on 'non-green'-assets compared to peers),
2. Write-downs due to a higher exposure to natural risks in combination with insufficient adaptation to these hazards (e.g. storms, flooding, wild fires etc.),
3. Write-downs caused by poor carbon-/GHG-performance of buildings compared to peers in combination with high adaptation-costs for energetic retrofitting and/or devaluation due to increasing energy/carbon-prices (e.g. due to carbon taxation or higher prices for emissions certificates).

DEFINITION: Stranded assets are properties which will not meet future efficiency standards and market expectations regarding their carbon performance and will be increasingly exposed to the risk of early economic obsolescence and write-downs. These buildings will become less marketable and may require costly refurbishment measures.

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A.2 CRREM PROJECT: CARBON RISK REAL ESTATE MONITOR

OVERALL OBJECTIVES OF CRREM

The poor energy efficiency of the European commercial real estate sector allied with low refurbishments rates are among the key obstacles to achieve the **ambitious decarbonisation targets** determined in the *Paris Climate Agreement* (see Section B.1).

The *Carbon Risk Real Estate Monitor (CRREM)* project will accelerate decarbonisation and climate change resilience of the *EU* commercial real estate sector by **clearly communicating the downside financial risks associated with poor energy and carbon performance and quantifying the financial implications of climate change on the building stock.**

KEY OBJECTIVES OF THE *CRREM* TOOL INCLUDE:

- Identify and assess the **risk of economic obsolescence** of single properties,
- Enable investors to account for different future GHG emission **reduction pathways** (including 1.5°C and 2C° scenarios and *NDC*) and the possibility to integrate own individual targets,
- **Undertake aggregated analysis** of portfolios,
- **Benchmark** properties and portfolios against competitors,
- Evaluate the **progress** of investors' carbon performance,
- Quantify **risks** premised on cost estimations of necessary refurbishment measures to fulfil targets,
- Analyse the **impact of retrofit** on the total carbon performance of buildings and a company,
- **Visualize** the energy performance of single properties, portfolios and companies, create so called '1.5°C and 2°C-readiness reports' summarizing present and future risks of stranded assets, which will help build retrofit action plans to efficiently adapt assets to global warming and policy changes.

The project is funded by the *European Commission* under the *Horizons 2020* programme. The methodological process and functional specifications of *CRREM* is regularly scrutinised by the ***European Investor Committee (EIC)*** members. The *EIC* has been set up to guide the project development, enhance alignment with investors' requirements and ensure that *CRREM*´s outcome is fit-for-purpose.

BENEFITS FOR INVESTORS

CRREM will **provide the industry with appropriate science-based carbon reduction pathways at building, portfolio and company level** in tandem with financial risk assessment software to cost-effectively **develop and manage carbon mitigation strategies.** The project aims at optimising industry's investments in energy efficient retrofits by **making carbon risks more transparent** and by **unveiling opportunities for property owners and investors**.

CRREM enables investors to **assess the risk of assets becoming 'stranded' due to insufficient carbon performance**. The software will apply science-based GHG-reduction pathways consistent with limiting global warming to 1.5°C and 2°C, and will be complemented by reporting templates, contributing to an **accelerated decarbonisation of the *EU* building stock**.

The project aims at establishing a **standardised methodology for the assessment of GHG emissions** and a transparent basis for decision making by reducing uncertainty and increasing transparency. The *CRREM* tool will **enable investors to simulate different 'virtual' retrofit, selling and buying decisions and assess their impact on corporate energy and**

carbon performance. The integration of carbon efficiency and retrofit requirements into investment decisions is supported by demonstrating the cost-benefit ratio of retrofit measures, the risk of a do-nothing scenario and the importance of timely investments.

IMPLICATIONS FOR POLICY MAKERS

A major challenge for the *EU* is the low rate of deep energetic retrofit in the existing building stock that would reduce energy consumption and carbon emissions. *CRREM* supports the *European Union´s* efforts to **quantify the share of carbon savings that the built environment will need to achieve to comply with the *Nationally Determined Contributions (NDC)*** committed in the *Paris Agreement*. *CRREM* provides policy makers with transparent decarbonisation pathways applicable to different types of commercial buildings, like office or retail, and specific for each *EU* member state (see SECTION C).

MAIN OUTCOME OF CRREM: CARBON RISK TOOLKIT AND GUIDANCE

The underlying assumption of carbon risk for real estate is that properties with low energy efficiency and high GHG emissions will face decreased marketability due to changing legislative environment and market expectations. Many investors and asset managers already assess the GHG emissions of their properties, but only building-specific targets demonstrate what the assessed figures actually mean and what emission reduction measures will be necessary. These targets and pathways will be the guidelines to quantify the carbon reduction efforts that buildings and portfolios need to undertake and will also contribute to define the risk of assets to become stranded.

An estimation of future stranding risks must consider the following three aspects:

(1) Present and future building performance regarding GHG emissions are contrasted with respective **(2) target figures** derived from science-based carbon emissions budgets, *NDC*s or user defined reduction targets. **(3) Necessary investments to meet these targets** indicate the stranding risk of a certain property, portfolio or company.

The *CRREM* tool estimates these figures based on information provided by the user regarding property characteristics, energy consumption, GHG emissions and general assumptions (regarding energy prices, carbon prices, inflation etc. – see Figure A-5). Analysis can be carried out for single properties, portfolios or a company as a whole. In a first step, users are provided a **graphical summary of a building's present and future GHG performance and a target pathway**.

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Figure A-4: CRREM approach: Graphic output

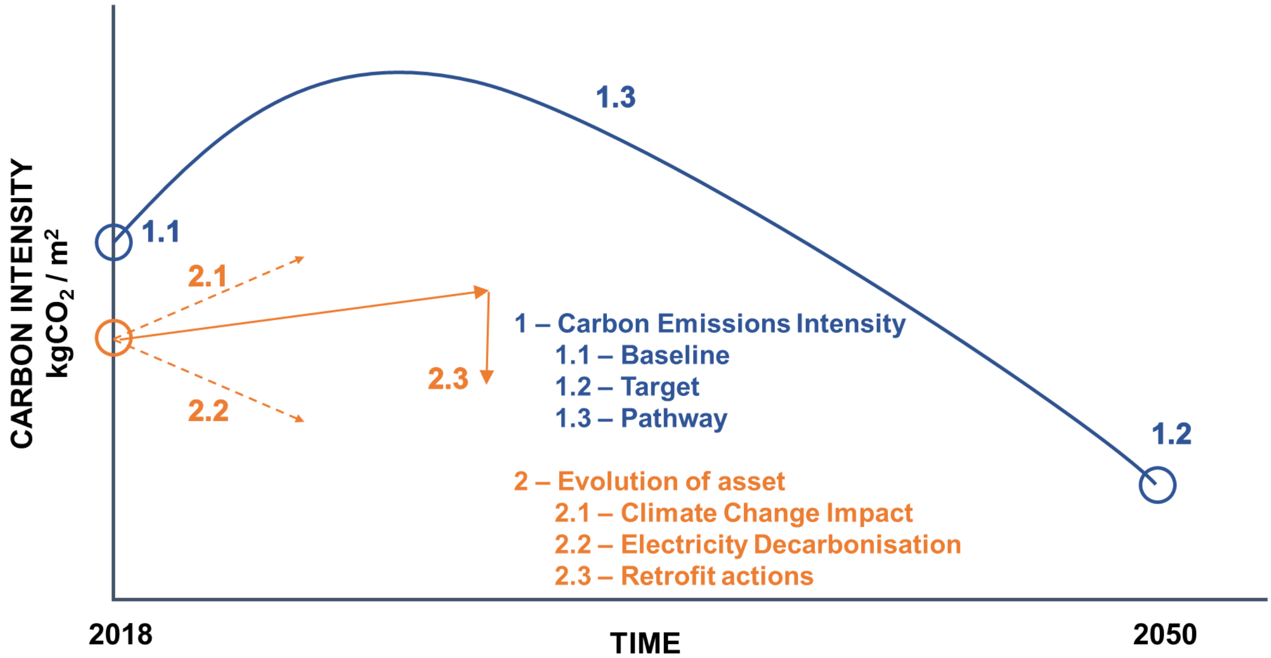

Figure A-4 describes how information on future decarbonisation targets as well as the likely impacts of climate change, the decarbonisation of the electrical grid and retrofit measures on the carbon performance on their assets. The figure demonstrates how retrofit measures will contribute to a low risk of buildings and portfolios becoming stranded.

1 – Carbon emissions intensity target

The decarbonisation pathways (1.3) define the GHG requirements buildings and portfolios will need to comply with *EU* climate targets or science-based emission budgets consistent with a global warming of 1.5°C or 2°C. Pathways are calculated for certain typologies of assets and for specific countries. Pathways define a current baseline (1.1) and the 2050 target (1.2) that complies with the respective climate targets.

See SECTION C for further details on setting decarbonisation targets on property level.

2 – Evolution of asset

It is necessary to perform a baseline evaluation on a specific asset or portfolio level first. From the reported building's or portfolio's current performance, one must calculate the asset's likely future carbon emissions. Emissions will vary due to changes in energy demand following climate change (2.1) and the efforts of policy makers in reducing the carbon impact of energy sources, particularly the carbon footprint of the electricity grid (2.2). It is required to provide stakeholders with the possibility of **simulating one or more retrofit measures for certain properties and evaluating its effects** (2.3). Based on this, one must calculate the carbon and financial impact of these actions and help users define a climate resilience program for their buildings and portfolios to meet their target.

See Section D.2 for further details on how climate change and grid decarbonisation effects the carbon performance of buildings and how to manage the resulting stranding risks.

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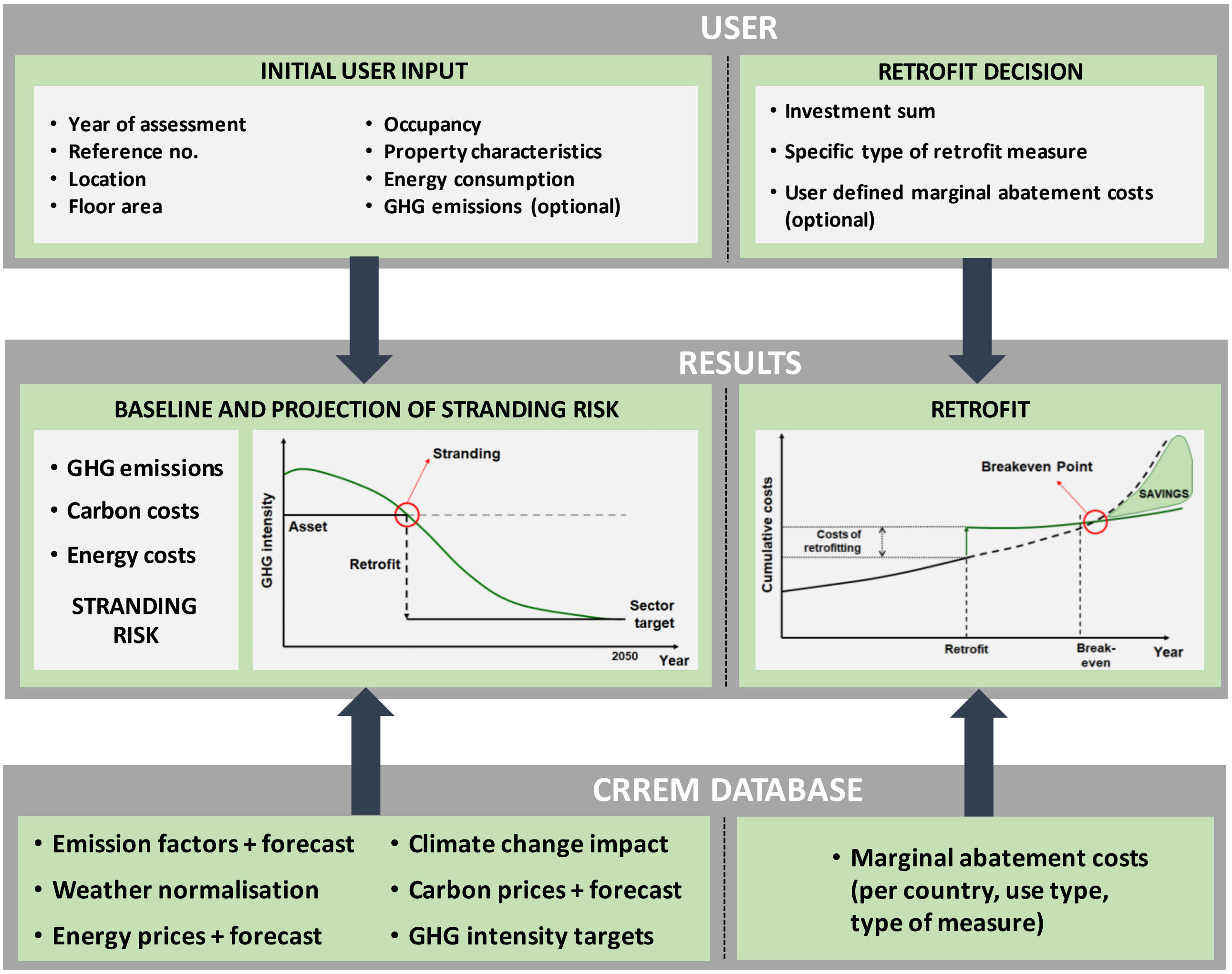
Figure A-5: User input and information from CRREM database used to determine stranding risks and effects of energetic retrofitting



Source: CRREM.

The *CRREM* tool provides the user with relevant information regarding a building's GHG performance and science-based requirements: (1) country-specific emission target pathways for different types of use, (2) the point in time when the expected future GHG performance will not meet the requirements (3) information on the remaining carbon budget for each property, (4) the year in which this budget will be consumed if emissions remain on the current levels and (5) the absolute amount of emissions that will be emitted beyond the target allowances.

The benchmarking of portfolios and companies is based on target values reflecting the analysed portfolio's composition of assets from different commercial real estate subsectors and their specific average carbon intensity (weighted for building area). Benchmarking of portfolios and companies will be possible against national and *EU*-wide targets.

For each retrofit measure, the *CRREM* tool, calculates **potential energy and GHG savings, necessary retrofit costs and the amount of embodied carbon related to the provision and installation of new materials as well as the disposal of previous installations**. The respective figures are combined in order to calculate an **economic as well as an ecological breakeven point for each retrofit measure** (see Figure A-7). Costs and benefits are evaluated over the whole life cycle of a certain property or retrofit measure respectively. In the course of time, retrofit costs, the emissions factor of electricity (due to grid decarbonisation), energy prices and embodied carbon figures change. *CRREM* reflect these

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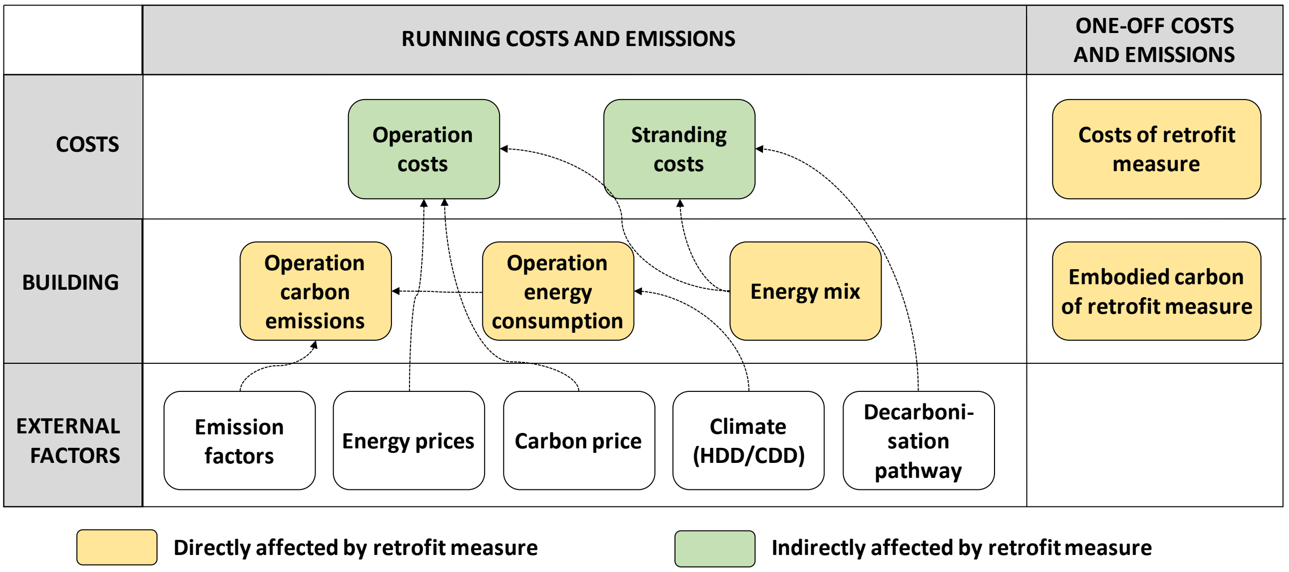
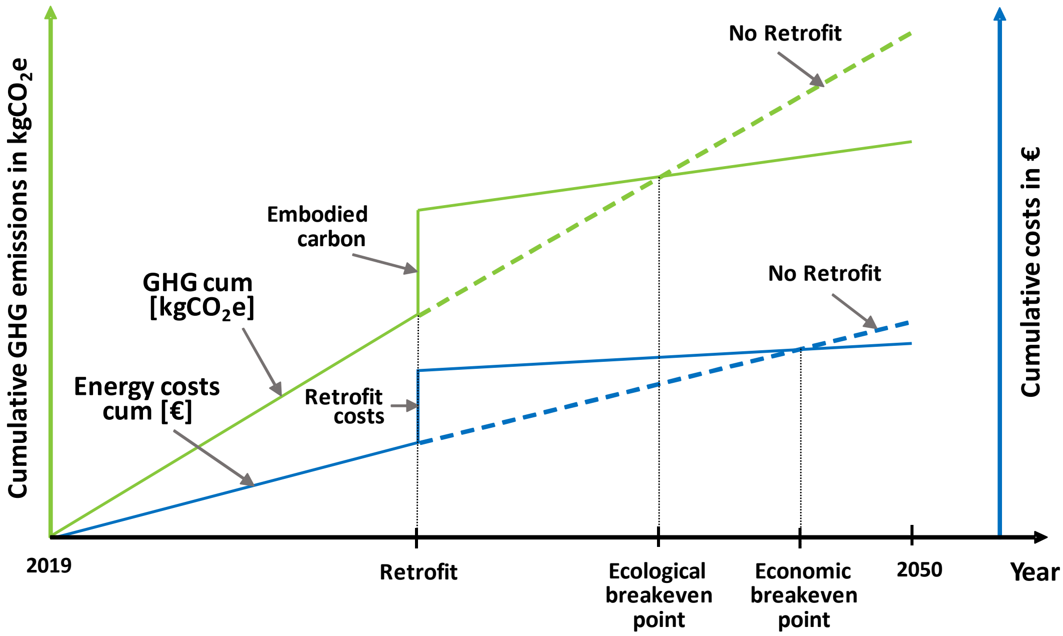
changes by relying on estimations of numerous studies of the *IEA, IPCC, EU* etc. but enables the user also to enter their own assumptions. Figure A-6 summarises the relations between external factors, building characteristics, conventional running costs as well as one-off monetary costs and emissions.

Figure A-6: Relation between costs, building characteristics and external factors in the context of retrofit measures



Source: CRREM.

Figure A-7: Cumulative GHG emissions, energy costs and breakeven points of retrofit measures including embodied carbon and retrofit costs (in $kgCO_2e$ and €)



Source: CRREM.

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CRREM

Global and EU policy. Carbon reporting standards

B

SECTION B GLOBAL AND EU POLICY. CARBON REPORTING STANDARDS

The *CRREM* project is framed within *EU's* climate change mitigation policies and common carbon accounting practices as well as aligned with leading industry standards like *Global Reporting Initiative (GRI), European Public Real Estate Association (EPRA),* and *Global Real Estate Sustainability Benchmark (GRESB)*. Section B is compiled to ensure that all readers are familiar with the main policies related to carbon and decarbonisation, alongside the most relevant directives, commitments and accounting protocols. It includes detailed descriptions of the past and current policy framework on climate change, focusing on *EU* policy and its implications for the real estate sector. Section B also covers a detailed description of the *GHG Protocol*.

KEY FACTS AND FINDINGS

B.1 POLICY EFFORTS TOWARDS CLIMATE CHANGE MITIGATION

INTERNATIONAL EFFORTS: 196 countries committed in Paris to limit global warming to at least 2°C compared to the pre-industrial level and to take actions to further reduce warming to 1.5°C. The signatories, including the *EU*, defined and submitted to the *United Nations Framework Convention on Climate Change* (*UNFCCC*) their *Nationally Determined Contributions* (*NDCs*) for carbon reduction. However, scientific research demonstrated that current global pledges are not enough to meet the 2°C target. As a result, reduction efforts are expected to become tighter, requiring long-term planning and budgeting of retrofit actions and adaptation measures to protect and maintain real estate assets' value.

EU EFFORTS: Following other carbon reduction schemes, the *EU* recently adopted the *Effort Sharing Decision* (*ESD*), aiming to complement the existing *EU Emission Trading System (ETS)*. *ESD* defines targets for 2020 and 2030 for those emissions that have not been covered by the *ETS* including the real estate sector. These targets are different for each member state. Current regulations within the *EPBD* framework aim to reduce part of the energy consumption and emissions released during the life of new buildings. Investors need to consider these forthcoming policies within their strategic management of carbon risk.

B.2 CARBON ACCOUNTING AND THE GREEN HOUSE GAS PROTOCOL

Most real estate companies and funds monitor and report their carbon emissions. There are several methodologies to collect data and measure carbon responsibilities like *EPRA, GRI* and *GRESB.* All common methodologies promote the use of intensity indicators ($kgCO_2e/m^2$) and they are aligned to the basic recommendations as outlined in the *Green House Gas Protocol*, which is briefly described for readers who may not be familiar with this methodology.

RELATED TOPICS

IMPACT OF POLICY ON DECARBONISATION PATHWAYS	SECTION C.3
CARBON ACCOUNTING IN THE REAL ESTATE INDUSTRY	SECTION D.2

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B.1 POLICY EFFORTS TOWARDS CLIMATE CHANGE MITIGATION

INTERNATIONAL ACTION - COP21: PARIS AGREEMENT

At the 21st *Conference of the Parties of the UNFCCC*[31] in Paris (***COP21* / *'Paris Conference'***) representatives of 196 countries in 2015 developed the so-called *Paris Agreement*. The agreement defines a common framework regarding GHG emissions, adaptation and finance starting in 2020. The necessary rate of approval of at least 55 countries that are responsive for at least 55% of global carbon emissions was obtained with the ratification of the European Union in November 2016. As of September 2018, the agreement has been signed by 195 *UNFCCC* member countries and 180 countries have become an official party (the *EU* is counted as one 'country' in these figures). The main target of the agreement is to **limit global warming to at least 2°C** compared to the pre-industrial level. The parties further agreed to take actions to limit global warming to even 1.5°C. At ***COP23* in Bonn**, participating countries worked out the necessary implementation guidelines for the *Paris Agreement*, developing distinct measures that shall be taken to attain the defined targets. In 2019, these actions were concretised at ***COP24* in Katowice**, including a biennial reporting obligation of countries regarding the actions they take to reduce carbon emissions. *COP24* decisions are not binding under international law, but a so-called 'naming and shaming' shall exert necessary pressure to enforce the adopted measures.

According to a study published by *Rockström et al. (2017),* there is a **remaining budget of anthropogenic (human-caused) carbon emission** from 2017 until the end of the century of 700 $GtCO_2$ (about 1.000 $GtCO_2e$[32]) resulting in a 66% probability of limiting global warming to 2°C maximum if emissions stay within the stated budget. Therefore, anthropogenic CO_2 emissions have to reach almost zero around 2050, necessitating robust transformation pathways for the participating countries and all economic sectors (see Figure B-1 and section C.2 'Downscaling to country level' for further details). **Considering the current rate of CO_2 emission, this budget of 700 $GtCO_2$ will be consumed by 2036.** These projections depend on numerous assumptions, such as the development and application of carbon capture and storage technologies or the exact impact of GHG emissions on global warming. The more into the future models are projected, the more uncertain their results are. Nevertheless, science-based emission reduction targets and budgets are crucial for any political interventions and should serve as the basis for strategic investment decisions in the real estate industry (see SECTION D).

[31] UNFCCC United Nations Framework Convention on Climate Change, 2015.

[32] Umweltbundesamt, 2018. CO_2e stands for so-called CO_2-equivalents, including the effect of non-CO_2 greenhouse gases on global warming. See Annex 2 for further details.

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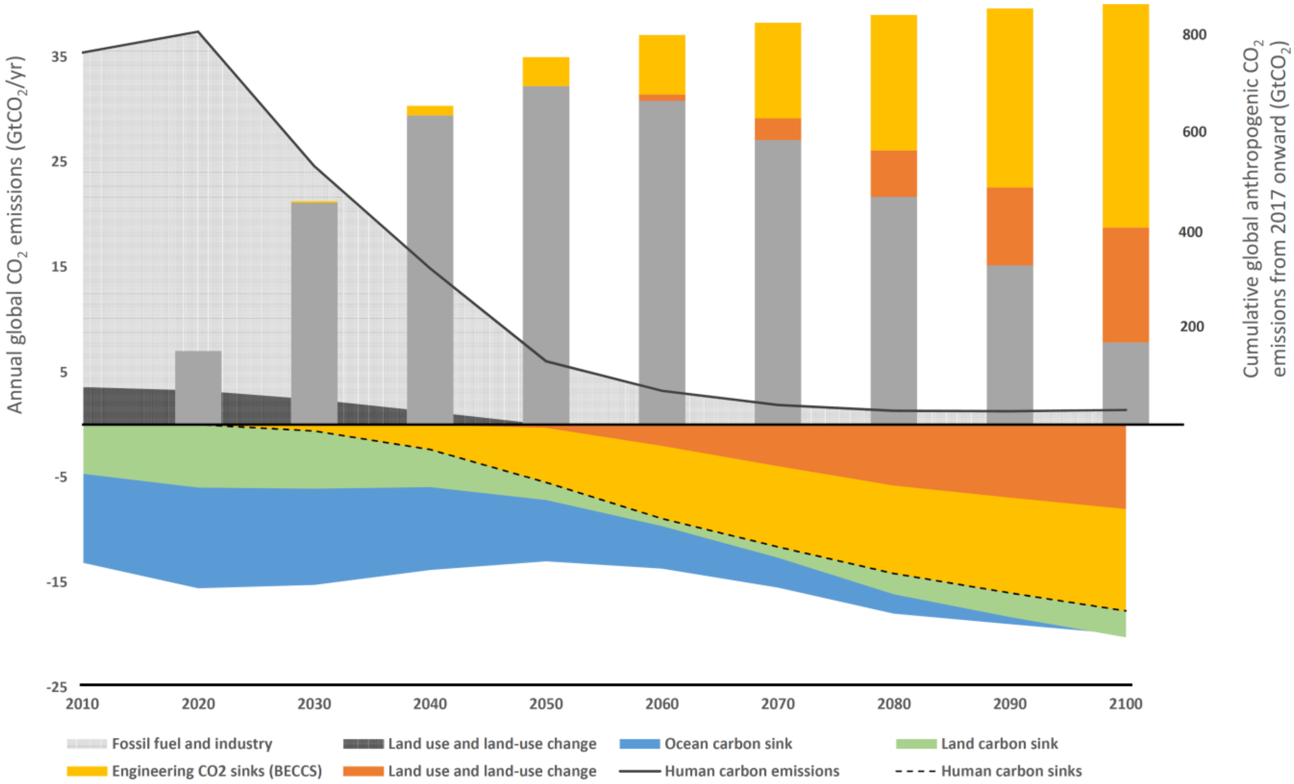
Figure B-1: 1.5°C target-consistent decarbonisation pathway according to Rockström et al. 2017



Source: Rockström et al., 2017, own presentation.

All participating countries of the *Paris Agreement* committed themselves to set up and fulfil national climate action plans which are referred to as ***Intended Nationally Determined Contributions INDCs***. With the entry into force of the *Paris Agreement* in 2020 these *INDCs* will become so-called ***Nationally Determined Contributions NDCs*** for each country having ratified the agreement. Currently 169 countries (including the *EU,* representing its 28 member states, therefore actually 196 countries) have submitted an *NDC* covering more than 95% of global carbon emissions.[33]

The **Paris Agreement does not contain any explicit penalties** for countries not fulfilling the *NDCs* they submitted to the *UNFCCC*. The question whether the *Paris Agreement* offers any possibility to file legal actions against countries not complying with their obligations is still highly debated among legal professionals.[34]

A recent evaluation demonstrated that **current global *NDC* pledges will not suffice to meet the 2°C target** but will rather lead to a warming of 2.7-3.0°C[35]. Such predictions are exposed to significant uncertainty, not least because *NDC* pledges predominantly only cover the period until 2030. Since even the 2°C target is probably not ambitious enough to prevent severe impacts on the environment and the economy[36], much more ambitious policies and measures will have to be implemented as soon as possible to prevent the damage. *COP21* participants pointed out that the building sector has to make a significant contribution to mitigation measures. The *Paris Agreement* itself contains no specific reduction targets for the real estate industry, but it is obvious that overall targets will not be achievable without mainstreaming

[33] World Resources Institute, 2018.

[34] Ekardt et al., 2018.

[35] Climate Action Tracker, 2018.

[36] IPCC, 2018.

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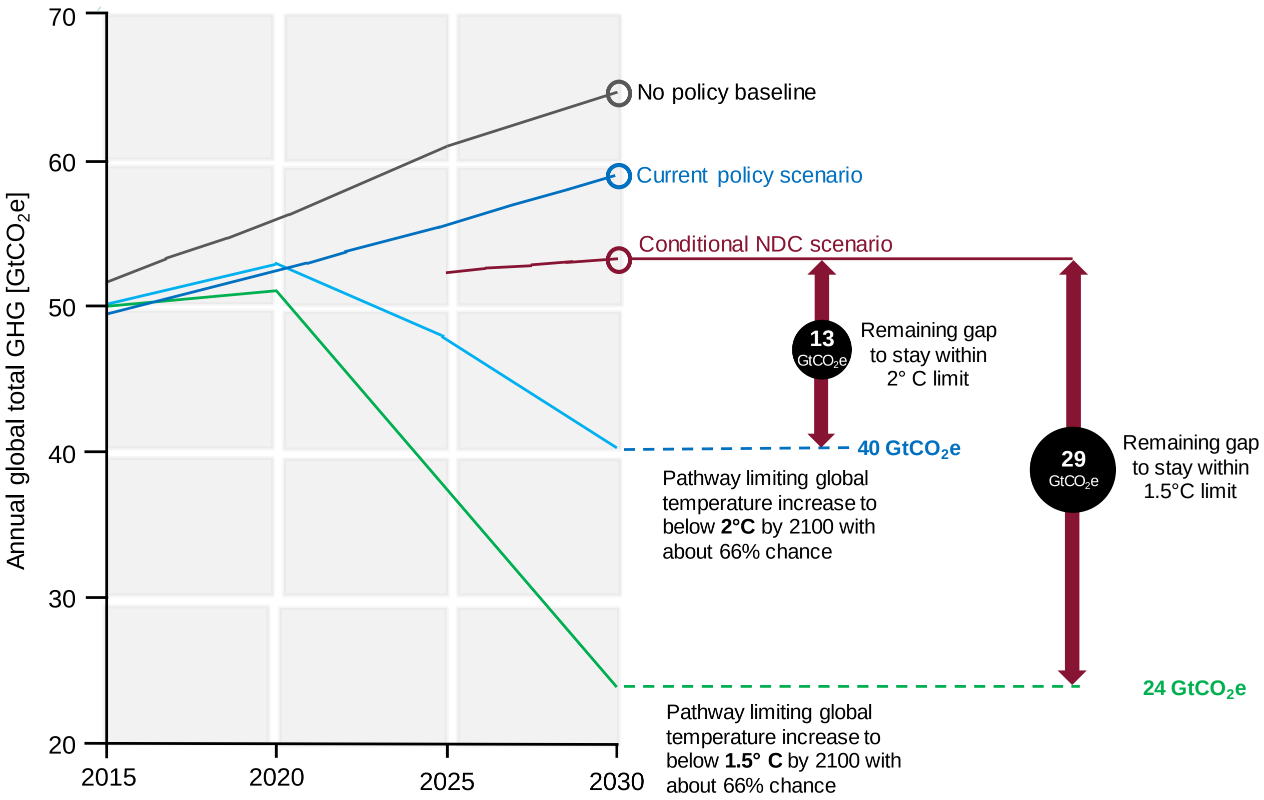
low-emission in respect of new asset construction in tandem with stimulating a marked uptake in deep renovation within the existing stock.

The ***UN Emissions Gap Report 2017***[37] provides a comprehensive summary of current policy pledges, necessary efforts to achieve the Paris targets and a so-called baseline or business-as-usual scenario (see Figure B-2).

Figure B-2: Global greenhouse gas emissions under different scenarios and the emissions gap in 2030 (median estimate)



Source: UNEP, 2017.

[37] UNEP, 2017.

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EU-TARGETS TO COMPLY WITH THE PARIS AGREEMENT

The *EU* has established stepwise climate protection targets for 2020, 2030 and 2050. Unless otherwise stated, all targets in this section refer to reductions compared to 1990 levels.

EU 2020 Targets

In 2009 a set of binding legislation, '**the 2020 package'**[38,39,40]**,** was adopted to ensure the *EU* meets its climate and energy targets through to 2020. The package sets three key targets: (1) **20% cut in greenhouse gas emissions (from 1990 levels)**; (2) 20% of *EU* energy consumption from renewable sources and (3) 20% improvement in energy efficiency[41,42]. The *2020 package* relied on the *EU Emission Trading System* (*EU-ETS*) system together with other areas of action like national emission reduction targets, national targets for renewable energy and the *Energy Efficiency Plan* and directives, which included the 2010 recast of the *EPBD* for buildings[43]. Since the adoption of the *2020 package,* the *EU* has set more detailed reduction targets for 2030 materialised on the *Effort Sharing Decisions* (*ESD*), setting country-specific targets including emissions from buildings.

EU 2030 Targets

In preparation of *COP21* the *European Council* passed the ***2030 Framework for Climate and Energy***[44]. This framework already included the 40% GHG reduction target as well as a binding target of at least 27% of renewable energy consumption in 2030 and a non-binding target of increasing energy efficiency by at least 27% until 2030.

On 6th of March 2015 – three months after *COP21* – the ***EU* submitted the *INDC*s** for its member states, committing to a **binding target of at least 40% domestic reduction in GHG emissions by 2030**. This reduction is the commitment of the *EU* to comply with the *Paris agreement* to ensure that global warming is kept well below 2°C.

The process of downscaling global emission to single countries or regions like the *EU* is described in SECTION C of this report. Accordingly, a **40% reduction of GHG emissions is not enough to be consistent with a 2°C scenario,** which deems a reduction of at least 48% necessary. ***CIT 2050 Roadmap*** scenarios (see section C.2) reaching net-zero emissions in the *EU* in 2050 estimate GHG emissions reductions of 55% to 65% until 2030.[45] In June 2018, the *EU* revised the targets for the share of renewable energy and energy efficiency to 32% and 32.5%. Even though the full implementation of these targets would result in a 45% reduction of GHG emissions, the *EU* has not adapted its *NDC*-target. At the end of September 2018, *EU* Commissioner for Energy and Climate Action Miguel Arias Cañete surprisingly announced that he had **stopped his plans to make the new 45%-target legally binding**.[46] A leaked internal memo of Europe's biggest employer association *BusinessEurope* demonstrates the existence of obstacles and resistors against an effective emission reduction. The document contains possible lines of argumentation for delaying any actual obligation and recommends pretending a positive attitude towards the *EU*'s climate policy 'as long as it remains a political statement with no implications'.[47]

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[38] European Commission, 2009a.
[39] European Commission, 2009b.
[40] European Commission, 2009c.
[41] European Commission, 2009b.
[42] European Commission, 2009a.
[43] European Commission, 2010.
[44] European Commission, 2014.
[45] CLIMACT, 2018.
[46] Süddeutsche Zeitung, 2018.
[47] Cited according to Euractiv, 2018a.

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

EU 2050 Targets

According to its ***Energy Roadmap 2050***[48], the *EU* aims to **reduce carbon emissions by 80-95%** until 2050.[49] Even though detailed policy has not been outlined yet, this ambitious target will put particular pressure on energy systems, which will need to decarbonise while maintaining supply security and competitive prices. If the *EU* achieves the target of a 40% reduction in GHG emissions by 2030, the greatest efforts are still ahead. In order to achieve the targets for 2050, annual reduction rates have to reach 5.3% (80% reduction) or even 11.7% (95% reduction).

The *European Commission* has considered several decarbonisation scenarios, which revolve around four critical areas to reach this target:

- **High energy efficiency:** Reduction of energy demand up to 41% by 2050 as compared to the peaks in 2005-06.
- **High renewable energy sources:** Leading to 75% renewable in gross final energy and 97% in electricity consumption.
- **Nuclear energy:** Scenarios consider different levels of acceptance of nuclear generation, from a low – or no – nuclear scenario to a higher public acceptance level.
- **Carbon capture and storage:** Depending on the technical development and commercial viability, if nuclear energy generation is constrained, carbon capture and storage will need to be implemented to prevent the emissions caused by burning fossil fuel from reaching the atmosphere.

The scenarios show that the decarbonisation of the energy system is possible and that costs will not differ substantially from the current policy initiatives.[50] Higher expenditure will be initially required for new systems to be implemented: mainly power plants and grid improvement, but also cooling and heating systems, smart meters, insulation material, more efficient and low-carbon vehicles. **Electricity will play an increasing role**, almost doubling its share in final energy demand. However, this proportional increase needs to be compatible with the expected reduction in the energy demand (which requires much higher energy efficiency of end uses), which also needs to be decoupled from an annual 1.7% expected economic growth rate. The higher rate of renewable energy generation will lead to a more decentralised energy system: larger generation plants will need to be coordinated with domestic generation. Finally, carbon capture and storage and nuclear power generation will play pivotal roles: the storage of carbon from fossil fuel burning will need to compensate the energy production of states that do not pursue nuclear generation of electricity.

The built environment will face substantial challenges against the background of this transformation of the *EU* energy system. Buildings have already started to turn from sheer places of consumption to actual producers of (clean) energy. An effective system where **individual buildings may act as producers and consumers** requires smart systems to measure the related energy flows and a distinct reduction of current transaction costs. The blockchain technology needed to tackle this challenge continues to evolve and be refined. In the future, the decentralisation of energy production and the increasing importance of renewables will require an intensive coupling of different economic sectors and the application of technologies like Power-to-X. **The real estate industry will potentially play a role as an energy buffer, storing energy during times of high production and low demand.**

[48] European Commission, 2011.

[49] European Commission, 2012.

[50] European Commission, n.y.

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

EU-INSTRUMENTS TO ACHIEVE CARBON REDUCTION TARGETS

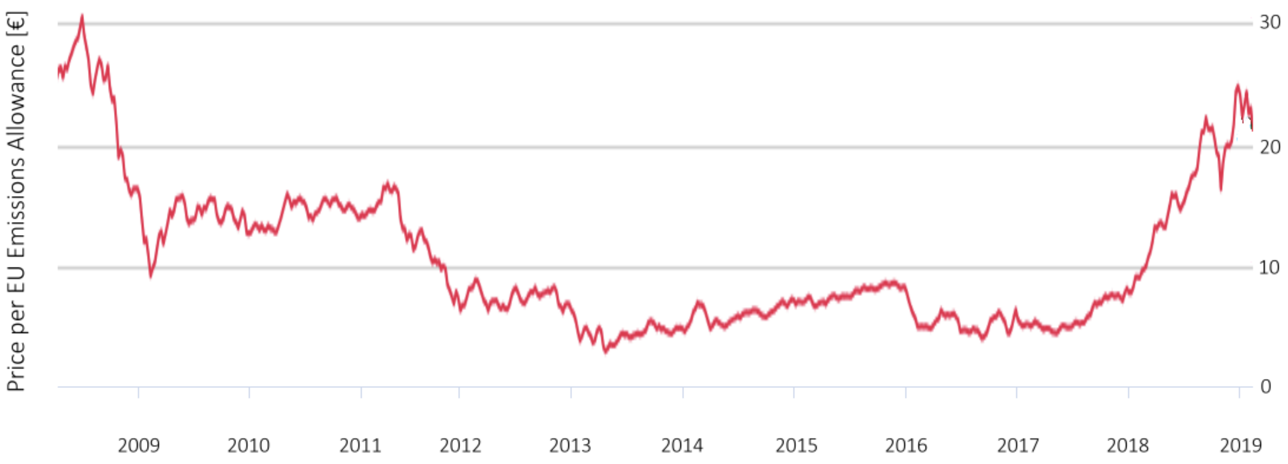
Since the *Kyoto Protocol* was agreed in 1997, the *EU* has developed a number of steering instruments and control mechanisms aimed at supporting GHG emission reductions. Over time, these instruments began to cover an ever-greater share of overall emissions and managed to account for the different conditions in individual countries and sectors.

EU Emissions Trading System

In 2003, the *European Commission* launched the ***EU Emission Trading System (EU-ETS)***[51], which promotes GHG emissions reductions by **putting a price on CO_2 emissions** and establishing a **pan-European trading scheme for emission allowances (*EU Emissions Allowance EUA*)**. According to ***Directive (EU) 2018/410***[52] ***ETS* emissions shall be reduced by 43% compared to 2005.** However, not all *EU* GHG emissions are included in the system, which is (until now) limited to combustions plants, oil refineries, coke ovens, iron and steel plants, factories producing cement, glass, lime, brick, ceramics, pulp and paper, aviation and further process emissions.[53]

The *EU-ETS system* was criticised for lacking efficiency due to the high number of available emission allowances which resulted in low emission prices respectively (Figure B-3). In 2017 the EU reformed the *EU-ETS* by introducing the so-called ***Market Stability Reserve (MSR)*** which will reduce the existing oversupply by taking excess permits from the market.[54] Anticipating the 2019 start of *MSR EUA* prices have continuously risen since mid-2017 and reached a level of around EUR 21-23 in February 2019. **The increase of *EUA* prices might accelerate the shift to more carbon efficient ways of power generation.** Due to low energy prices and high *EUA* costs, for example German lignite power plants currently operate at a loss. Estimated losses between early 2016 and July 2018 totalled to EUR 2.3 billion.[55]

Figure B-3: Evolution of price per European Emission Allowance EUA (07.04.2008 - 14.02.2019)



Source: sandbag.org.uk/carbon-price-viewer.

[51] European Commission, 2003 and 2018a

[52] European Commission, 2018a.

[53] European Commission, 2016.

[54] Reuters, 2018.

[55] Der Tagesspiegel, 2018.

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Energy Performance of Buildings Directive

Another integral part of *EU*'s regulatory strategy is the ***Energy Performance of Buildings Directive*** **(*EPBD)*** defining requirements **towards energy performance of new buildings and major renovations**. With the *EPBD*, the *EU* is taking a leading role in the world, with all new buildings, from 2021 onwards required to achieve **'nearly zero-energy building'-standard**. For new public buildings, the nearly zero-energy standard must be attained from 2019. According to the *EPBD*, it is up to the member countries to develop clear definitions of this building standard and countries are free to define targets that go beyond those documented in the *EPBD*. The nearly zero-energy standard requests the lowest possible energy consumption and that the remaining consumption shall be supplied by a high share of on-site production from renewable sources.

Decarbonisation challenges

GHG emission targets are well defined on an *EU*-level for 2020, 2030 and 2050, but to transpose these targets into meaningful guidance for individual countries or industry sectors, a number of questions remain unanswered:

(1) What are the precise steps of needed to reach the target year objectives? For example, a linear reduction with the same amount of annual emission savings until the next target year.

(2) What are the implications and targets for individual sectors – like the real estate industry or subsectors like retail or office – or how can they be 'disaggregated' from general *EU* targets?

(3) How are the diverse initial conditions of each *EU* member state (climate, building stock, wealth, economic growth) taken into account?

In Sections C.2 and C.3 of this report, we present a methodology that addresses these challenges and defines country-specific targets for several real estate subsectors aligned to international climate pledges. The topic of the different initial conditions in each country has been recently addressed by the *EU,* as detailed in the following section.

Effort Sharing Decision ESD and contribution of member states

On 14th May 2018, the European Commission approved the ***Effort Sharing Decision (ESD)***[56], aiming to complement the *EU-ETS* system. This regulation also **includes new and existing buildings** and targets the **55% of *EU* emissions *not* covered by the *EU-ETS* system and emission and removals from land use change and forestry (LULUCF),** as they are covered by the Kyoto Protocol and from 2021 by the LULUCF Regulation. The *ESD* aims at reducing emissions in the covered sectors by 10% until 2020 and by 30% until 2030, below 2005 levels.

The ***ESD*** **translates the commitments adopted in 2015 into binding annual greenhouse gas emission targets for each member state for the periods 2013-2020 and 2021–2030**, based on the principles of fairness, cost-effectiveness and environmental integrity. Therefore, national targets are based on member states' relative wealth, measured by gross domestic product (GDP) per capita. Less wealthy countries have less ambitious targets allowing higher economic growth rates and taking into consideration their lower investment capacities. The *ESD* national emission **targets for 2020** range from a 20% reduction by 2020 (based on 2005 levels) for the richest member states to a 20% increase for the least wealthy one, Bulgaria. The binding annual emission reductions **targets for 2030** range from 0% to minus 40% from 2005 levels (see Figure B-4 and 'Decarbonisation pathways based on ' in section C.3). The *ESD* considers direct emissions only, for example for space heating by burning fuels. Indirect emissions associated with electricity consumption in buildings are assigned to the power sector which is covered by the *EU-ETS.*

Some *EU* member states have already passed national laws clearly exceeding *EU's NDC* as defined in *the Effort Sharing* legislation for 2030. For example, the Netherlands are expected to pass a law in 2019 intending to reduce GHG emissions

[56] European commission, 2003 and 2018b.

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by 49% until 2030 in comparison to 1990 (non-binding target) and by 95% until 2050 (binding target).[57] Beyond that several initiatives such as *Advancing Net Zero* of the *World Green Building Council* aim to make the building stock completely 'carbon neutral' (see Annex 5) by 2050.[58] Besides highly energy efficient buildings, this target requires a complete coverage of energy demand by on-site and off-site renewable energy sources.

Main challenges of improving the *EU* framework

EU efforts to reduce carbon emissions will have to tackle a range of challenges in order to provide an effective framework for mitigation measures. Central to attaining the target reductions across the *EU* will be to address emission levels within the existing commercial real estate stock. To date, there is **too little energetic refurbishment activity in all *EU* member states**. Combined with the poor energy efficiency status of these existing buildings, this is one of the biggest challenges for the *ESD* towards the reduction of GHG emissions. **With 0.4-1.2% (depending on the country), the annual refurbishment rate of the existing building stock in the *EU* is still significantly behind figures that would be necessary** to reach the ambitious climate targets. A recent study[59] states that retrofits are still primarily driven by cost-benefit analysis and seem to be unrelated to any sustainability-related motivations. Research by *Copenhagen Economics*[60] highlight that energy savings and a decreased **risk of premature obsolescence** might result in annual benefits of up to EUR 175 billion per year.[61]

Furthermore, future data collection will have to look beyond **emissions that can be controlled during the design stage of new buildings or large retrofit projects,** addressing all emissions related to the built environment. This includes plugged-in equipment as well as embodied carbon of new buildings and major retrofit works. Embodied carbon comprises all emissions related to building related upstream and downstream activities (new construction and refurbishment), including procurement, construction, maintenance and disposal. **The embodied carbon from newly constructed buildings from today until 2050 equals their cumulative operational GHG emissions in the same period.**[62] A **net positive environmental benefit of retrofit measures** can only be ensured if embodied carbon, as well as savings at operational level, are accounted for. See Section D.2 for further information on the role of embodied carbon in climate protection strategies.

The ***EPBD*** should include further guidelines defining a common methodology and key performance indicators as well as their format and units. The *EU* initiative *Level(s)* defines a common framework for the assessment of environmental performance of buildings and can be regarded as an important initial step in that direction[63]. Annex I and III of the *EPBD* define the common general framework for the calculation of energy performance of buildings. The national development of calculation methodologies and its application in building codes present several barriers to an effective assessment of carbon emissions. The results in different member states are not comparable, which inhibits the deployment of coordinated measures at *EU*-level. **Improved data collection** of *EU* carbon emissions is crucial to attain existing targets. Efficient policy making and scientific research require reliable data on building stock characteristics including **minimum performance indicators on energy and carbon performance**. Comparable data requires a **harmonisation of member states' assessment and reporting methodologies**, sufficient funding and infrastructure for regular data collection and monitoring. The current *EPBD* building classification system should be extended by further subcategories reflecting the existing **variety of energy consumption profiles across different types of use.**

[57] de Volkskrant, 2018.
[58] WGBC, 2017.
[59] Christensen, Robinson, Simons, 2018.
[60] Copenhagen Economics, 2012.
[61] Copenhagen Economics, 2012.
[62] Bionova Ltd., 2018.
[63] European Commission, 2019.

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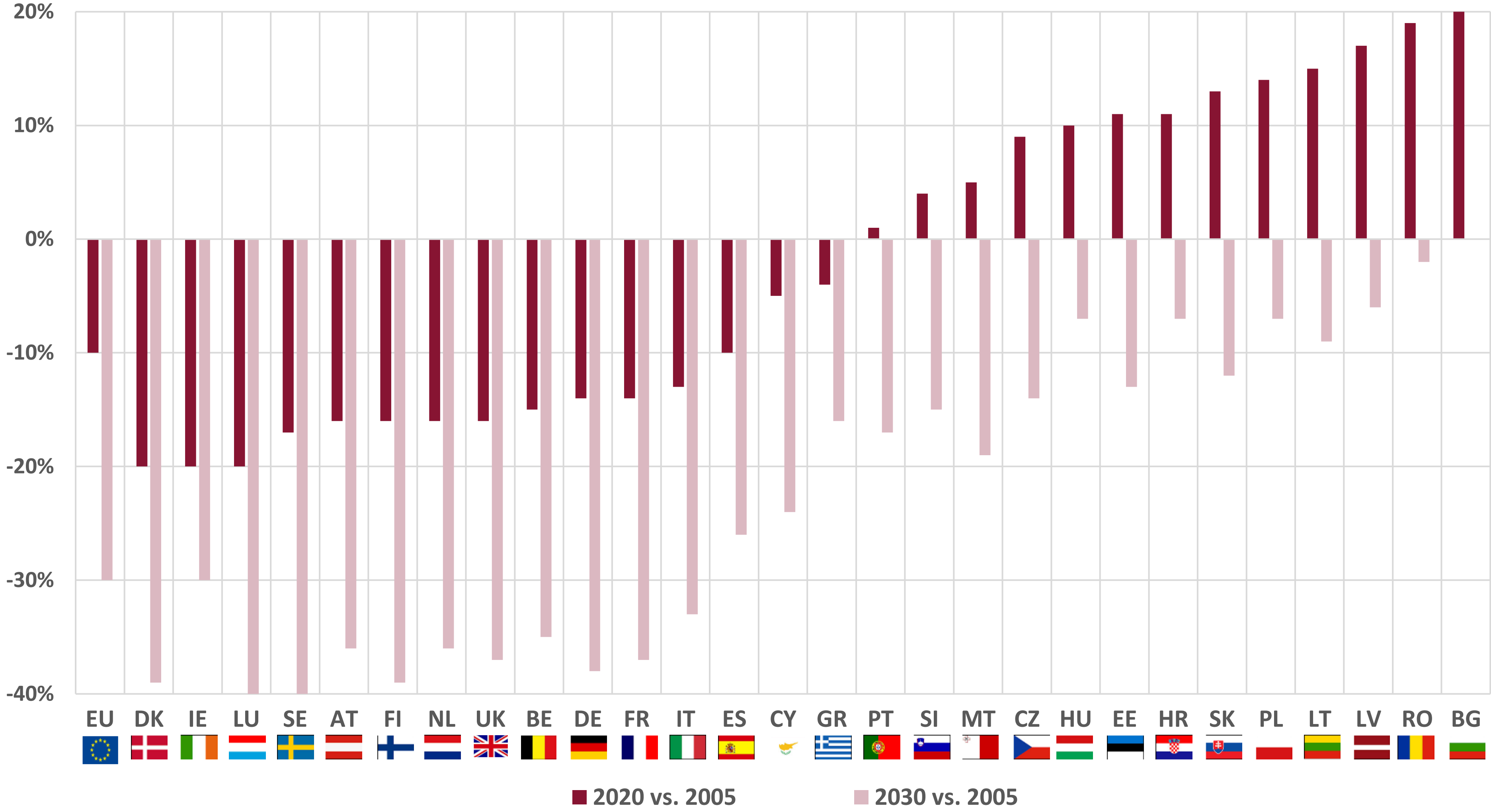
Figure B-4: EU and country level ESD GHG emission reduction targets



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B.2 CARBON ACCOUNTING AND THE GREEN HOUSE GAS PROTOCOL

CARBON ACCOUNTING STANDARDS

A consistent assessment of GHG emissions requires the clarification of basic definitions and concepts related to carbon measurement and reporting within the real estate sector and beyond. This section introduces different general concepts and points out limitations and challenges. The specific framework for accounting GHG emissions in real estate companies is described in Section D.2.

As signatory of the ***Kyoto Protocol***[64] and Annex I party of the *United Nations Framework Convention on Climate Change* (*UNFCCC*)[65], the *EU* and all its member states are required to **report to the *UN* their GHG emissions annually**[66]. The reporting methodology for national accounting was established by the 2006 *Intergovernmental Panel on Climate Change (IPCC)* Guidelines for National Greenhouse Gas Inventories[67], which were revised in 2013[68]. These guidelines define a **production-based methodology**: emissions are calculated premised on fossil fuel usage and other relevant processes such as industry and agriculture.

However, these production-based methodologies are not suitable for most **corporate carbon accounting processes**, as enterprises seek methodologies to collect, summarise, and report their carbon emissions that allow them for quicker and more cost-effective evaluations, definition of targets and planning of carbon reduction actions. The accounting approach for corporates is normally **consumption-based**: **based on emissions from final consumption**. This may also include embodied emissions (upstream and downstream emissions) - see Section D.2.

The most commonly used standards available for companies to monitor and report carbon emissions are the ***Greenhouse Gas Protocol*** and ***ISO 14064***[69]. The principles of both standards are equally valid to define the general requirements and fundamentals of carbon accounting:

- Which activities of a company need to be taken into consideration and how to set boundaries?
- What indicators shall companies use?
- Which GHG emissions have to be taken into consideration and how the aggregate on global warming should be calculated?

As part of the *ISO 14000* series of standards for environmental management, *ISO 14064* provides companies with an integrated set of information aimed at reducing greenhouse gas emissions. The standard 'specifies principles and requirements at the organization level for quantification and reporting of GHG emissions and removals. It includes requirements for the design, development, management, reporting and verification of an organisation's GHG inventory.' Annex 4 provides a summary of further norms and standards related to sustainability, carbon accounting and risk assessment with special focus on the built environment.

64 UNFCCC, 2008.
65 UNFCCC, 2018a.
66 UNFCCC, 2018b.
67 IPCC, 2006.
68 UNFCCC, 2013.
69 ISO, 2006c.

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GREENHOUSE GAS PROTOCOL

The ***Greenhouse Gas Protocol Corporate Standard***[70] provides a reporting framework including standards, guidelines and tools. Its classification of emissions is based on the capacity of stakeholders to reduce them. This approach is very useful in developing carbon reduction plans and it is widely adopted by most enterprises. The alignment of data collection, management methodologies and calculation methods ensure interoperability with other reporting initiatives that have adopted the *GHG Protocol* standard.

The ***GHG Protocol*** was developed by the ***World Resources Institute (WRI)*** – a leading global environmental and economic research organization – and the *World Business Council for Sustainable Development (WBCSD)*, which gathers more than over 200 environmentally led businesses. The standard was first published in 2001 and establishes a **framework to measure and manage greenhouse gas emissions from private and public sector operations**, value chains and mitigation actions. Furthermore, the standard is complemented by guidelines and a suite of calculation tools to enable organisations from any economic sector to transparently asses and report their carbon budgets and reduction commitments.

The *GHG Protocol* is governed by the principles of relevance, completeness, consistency, transparency and accuracy, and all the reporting and accounting developed under these standards need to be based on these principles. Reporting organisations firstly need to set up their business goals (participating in voluntary or mandatory GHG reduction programs, or GHG markets) and set up their **organisational and operational (emissions) boundaries** according to these goals.

The next step is to select a base year and calculate that year's **carbon emissions (inventory).** These emissions need to be tracked after the baseline, and the organisation also needs to define the conditions that will require recalculation of the inventory if substantial changes happen in the organisation structure, methodology and **emission boundaries**. To calculate the emissions, the organisation needs to identify the sources of carbon emissions, select a calculation approach, collect the data and report the inventory at corporate level.

This calculation process needs to define and implement an inventory quality management system that controls calculations as well as data, documentation and evidence gathering. Once the inventory is set up, the organization will then identify its opportunities to reduce carbon emissions, including offsets if they are part of the carbon reduction strategy, and set up their reporting and validation framework to report the carbon reductions achieved against the **baseline year.**

After identifying the opportunities and the policy requirements, the organisation can set **carbon reduction targets.** Target setting involves commitment at senior management to inform on the decisions about **type of target (absolute, relative, intensity)**, reduction boundary (type of emissions, geographical and organisations) and **length of commitment** so that a specific level and year of completion can be clearly set.

[70] GHG Protocol, 2004.

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GHG emission intensity: The need for a consistent reference value

The *GHG Protocol* recommends companies to calculate **carbon intensity values**. In order to calculate intensity vales, absolute GHG emissions are set against any other appropriate denominator like added value, workplaces or – in the context of buildings – floor area. One argument for calculating intensity values instead of absolute values is to ensure comparability between assets and certain products.

To compare a building's carbon performance, *the United Nations Environment Programme* **(*UNEP)***, in alignment with the *GHG protocol*, recommends calculating the carbon intensity per square metre, using the following formula[71]:

$kgCO_2e/m^2/year$ (kilograms of carbon dioxide equivalent per square metre per year)

Operational boundaries: GHG Protocol emission scopes

The GHG protocol defines **three different categories (so-called 'Scopes') of carbon emissions depending on the level of control an organisations has in respect of each scope (direct or indirect emissions)** and their capacity to reduce them. Companies need to account for and report emissions from each scope separately.' Figure B-5 **provides contextualization of the scopes and the activities that generate direct and indirect emissions.**

This section aims to clarify the different types of emission scopes for any type of organisation in any economic sector. Further details on how to classify carbon emissions from buildings and portfolios into these three GHG scopes, as well as the methodology to calculate indirect Scope 3 emissions in the real estate sector, can be found **in 'Buildings: Assessment and distribution of carbon emissions' within Section D.2 of this report. Section 'Stakeholders: Allocation of carbon reduction responsibilities'** also within Section D.2 provides further information on the question who – with regards to the real estate industry, the tenant or the landlord – shall be regarded responsible for certain emissions and should therefore report on them. SECTION D also highlights certain pitfalls and challenges the real estate industry faces in this respect.

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*.

[71] UNEP, 2009.

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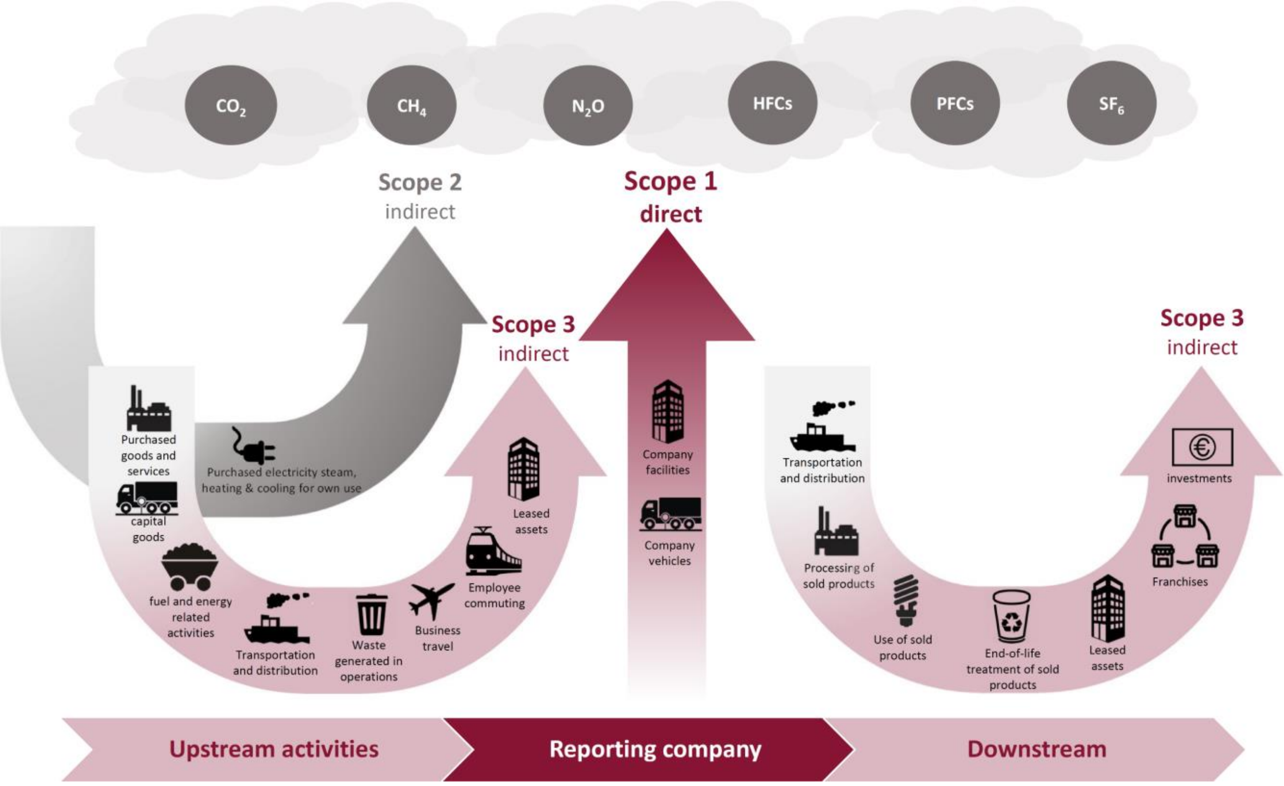
Figure B-5: Overview of scopes and emissions across a value chain



Source: GHG Protocol, 2013, p. 6. [72]

The *'Scope 3 Calculation Guidance'* provides a more detailed breakdown in further categories to classify Scope 3 emission:

1. **Purchased goods and services:** Extraction, production, and transportation of goods and services purchased or acquired by the organization
2. **Capital goods:** Extraction, production, and transportation of capital goods purchased or acquired by the reporting organization
3. **Fuel and energy related activities not included in Scope 1 and 2:** Extraction, production, and transportation of fuels and energy purchased or acquired by the reporting company
4. **Upstream transportation and distribution:** Transportation and distribution of products purchased by the reporting company in the reporting year between a company's tier 1 suppliers and its own operations
5. **Waste generated in operations:** Disposal and treatment of waste
6. **Business travel:** In vehicles not owned or operated by the reporting company
7. **Employee commuting**
8. **Upstream leased assets:** **Operation of assets leased by the reporting company**
9. **Downstream transportation and distribution:** Transportation and distribution of products sold by the reporting company
10. **Processing of sold products:** Processing of intermediate products (e.g. manufacturers)
11. **Use of sold products:** End use of goods and services sold by the reporting company
12. **End-of-life treatment of sold products:** Waste disposal and treatment at the end of the sold product's life.
13. **Downstream leased assets:** **Operation of assets owned by the reporting company (lessor) and leased to other entities in the reporting year**
14. **Franchises**
15. **Investments**

[72] See Annex 2 regarding the global warming potential of different GHG and their conversion to CO_2-equivalents.

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Category 13 defines an optional possibility that is critical for the real estate sector. This category can include 'The life cycle emissions associated with manufacturing or constructing leased assets'. These life-cycle emissions will include the emissions of many other categories: purchased and manufactured goods (Cat. 1), upstream and downstream transportation (Cat. 4 and 9), tenants' operations (Cat. 13) and waste management produced upstream and downstream (Cat. 5 and 12). General guidance regarding reporting responsibilities between tenants and landlords is outlined in the section 'Stakeholders: Allocation of carbon reduction responsibilities' within Section D.2.

From the **perspective of the real estate industry**, this systematic raises the following questions:

1. What are the particularities when reporting on property level and from an investor or tenant perspective?
2. What particular buildings parts (tenant, landlord and common areas) have to be considered? How can the term 'control' be defined and does it encompass also tenant spaces?
3. How can one take into consideration embodied carbon of construction and retrofit measures?
4. How can 'green energy' (generated onsite or offsite) improve the carbon performance?
5. How can 'double counting' of emissions be avoided?
6. How to ensure that the assessment focuses on the total emissions of individual buildings and that carbon reduction measures are decided regardless whether carbon is allocated into Scope 1, 2 or 3 for any stakeholder?

SECTION D covers the very specific topic of carbon reporting in the real estate industry and provides a comprehensive discussion of pitfalls related to these questions.

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CRREM

Downscaling carbon budgets and setting science-based decarbonisation targets

SECTION C DOWNSCALING CARBON BUDGETS AND SETTING SCIENCE-BASED DECARBONISATION TARGETS

What is the decarbonisation pathway of individual properties and portfolios? Currently, there are no carbon targets broken down for the different markets within the real estate sector. *CRREM* translates the global and *EU* carbon reduction targets outlined in Section B into country and sector specific targets and decarbonisation pathways at property level. Section C illustrates this methodology and process, that results in targets consistent with climate scenarios limiting global warming to 2°C or even 1.5°C. Since current political pledges are insufficient to keep global warming below 2°C, the described definition of targets and pathways relies on scientific data and models from the *IPCC*, the *International Energy Agency* as well as further research centred on climate change implications for the real estate industry. The resulting science-based decarbonisation pathways provide real estate stakeholders with clear targets and defined timelines of future carbon performance targets at property level.

KEY FACTS AND FINDINGS

C.1 GLOBAL CARBON BUDGETS AND EMISSION SCENARIOS

This section defines the concept of 'carbon budget' and provides details on the different warming scenarios defined by the *IPCC*, amongst other sources. We chose *IEA's* 2°C-consistent scenario *2DS* and the 1.5°C-consistent scenario by *Rockström et al.* (2017) ensuring that real estate carbon reduction targets described in this report are 'science-based' and aligned with the official commitments of the *Paris Climate Conference COP21*. The global carbon budget available for the period 2019-2050 is 669 $GtCO_2e$. This is the maximum amount of carbon that the global economy can emit according to climate science without exceeding a global warming of 1.5°C. Considering a limit for global warming of 2°C, the available carbon budget is 784 $GtCO_2e$. 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. Investors should consider and apply these pathways to decarbonise their assets

C.2 DOWNSCALING FROM GLOBAL TO PROPERTY LEVEL: SCIENCE-BASED TARGETS AND PATHWAYS

FUNDAMENTAL APPROACH AND METHODOLOGY: Discussion of different available approaches for downscaling global carbon budgets and their alignment with climate targets. Detailed explanation of the chosen approach and clearly defined steps to downscale based on the methodological framework of the *Sectoral Decarbonisation Approach (SDA)*[73], developed by the *Science Based Targets (SBT)* initiative.

DOWNSCALING TO COUNTRY LEVEL: Derivation of two decarbonisation pathways (consistent with 1.5°C and 2°C warming) for the *EU* commercial real estate sector based on the *EU Reference Scenario 2016 EUREF16* (decarbonisation model, future energy consumption, economic growth etc.) integrated with other sources of information including *EUROSTAT* or the *Carbon Transparently Initiative (CTI) 2050 Roadmap Tool*. *CRREM* defines converging decarbonisation pathways for the non-domestic real estate sector in each *EU* member state: all countries need to achieve a comparable target, but pathways towards target attainment are country specific depending on the current carbon performance of the building stock in each state.

[73] CDP et al, 2015

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DOWNSCALING TO BUILDING LEVEL: There are inherent variations between the emissions of different building types like hotel or office due to their specific functional requirements. *CRREM* reflects the distinct nature of building types and sets specific targets and decarbonisation pathways for office buildings, hotels, different types of retail properties etc. by applying a so-called contraction approach. The calculations consider also the size of the building stock and expected growth rates in all *EU* countries.

C.3 CARBON INTENSITY TARGETS ALIGNED WITH EU POLICIES

A third set of pathways and targets (in addition to the science-based 1.5°C and 2°C-targets) is calculated according to current *EU´s NDC*. As explained in SECTION B, this commitment is not enough to keep warming below 2°C, but the pathways and targets will be included in *CRREM's* outputs to compare current political requirements with science-based calculations.

RELATED TOPICS

TYPES OF CARBON EMISSIONS IN THE BUILT ENVIRONMENT — SECTION D.2

FURTHER DETAILS ON POLICIES TOWARDS CLIMATE CHANGE MITIGATION — SECTION B.1

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C.1 GLOBAL CARBON BUDGETS AND EMISSION SCENARIOS

The determination of so-called 'carbon budgets' that limit the total amount of GHG that remain to be emitted until a specific year (e.g. 2050) has become a widely used concept in climatology but especially in climate politics and communication. **Cumulative GHG emissions** are assumed to be the dominant factor for global warming by many authors, whereas others point out that the specific pathway of emissions may indeed affect the final degree of warming.[74] Besides the definition of near-term emission goals as set out in the *Paris Agreement*, the **determination of carbon budgets constitutes another approach that can help to communicate climate targets** to the public, tenants, shareholders and other stakeholders. **The remaining carbon budget clearly demonstrates the urgency of immediate actions.** Besides a global emission budget, it is also possible to determine budgets for individual countries or for individual industry sectors, for example **real estate.**

Carbon budgets generally provide a probability for not exceeding a certain increase of temperature until 2100 above pre-industrial levels, for example a 50% chance of limiting global warming to 2°C. The **'Representative Concentration Pathways' (*RCP*)** used in accordance with the *Intergovernmental Panel on Climate Change (IPCC)* demonstrate that even in a **socio-economic 'sustainability scenario' (*RCP2.6*),** global warming will reach approximately 2°C by the end of the 21st century. *RCPs* are defined by future trajectories of atmospheric concentrations of CO_2, leading to certain values of 'radiative forcing' in 2100 (see Figure C-1). The term 'radiative forcing' quantifies the warming or cooling effect of any natural or anthropogenic factor (gases, aerosols, land-use) on the climatic system (measured in Watt per square metre). The four defined *RCPs* are named in accordance with that radiative forcing values: *RCP2.6*, *RCP4.5*, *RCP6.0* and *RCP8.5*.

The **future CO_2 emission pathway significantly depends on the assumptions made regarding non-CO_2 emissions (see Annex 2).** A 2017 paper from *Millar et al.* received large attention due to unexpected high remaining CO_2 budgets that would still allow to limit global warming to 1.5°C. One explanation[75] for the above-average budget is, that the authors applied a scenario with very strong mitigation of non-CO_2 GHG, effectively resulting in a higher CO_2 budget[76]. A comprehensive summary of different approaches for estimating cumulative carbon budgets and the reasons underlying their differences can be found in *Rogelj et al. (2016)*.

However, the process of climate modelling is characterised by a **high degree of uncertainty**, especially when it comes to so-called tipping points and feedback mechanisms. A 2018 study by the *International Institute for Applied Systems Analysis IIASA*[77] considered how **emissions budgets are affected if CO_2 and methane (CH_4) emission from permafrost thaw are included into modelling**. The first result directly hits the key assumption commonly associated with the idea of carbon budgets, namely that final global warming depends predominantly of the cumulative amount of GHG emissions. The researchers found that permafrost carbon release makes emission budgets path dependent (that is, budgets also depend on the pathway followed to reach the target).' [78] Depending on the realized future emission pathway and whether net negative emissions are regarded as feasible, the study concludes that the remaining budget for the 2°C target reduces by 8% to 25% in comparison to models that do not consider permafrost thaw in that detail. **This clearly demonstrates that the property industry might face an even more ambitious decarbonisation than assumed at the moment, if climate research** evolves (of course, it is also conceivable that new research discovers that less efforts are sufficient) and politics adopt that new knowledge. Investors with a pre-cautionary approach to risk management should aim 'at least' for the ambitious decarbonisation targets developed in this study.

[74] Sanderson et al., 2016.

[75] Carbon Brief, 2017.

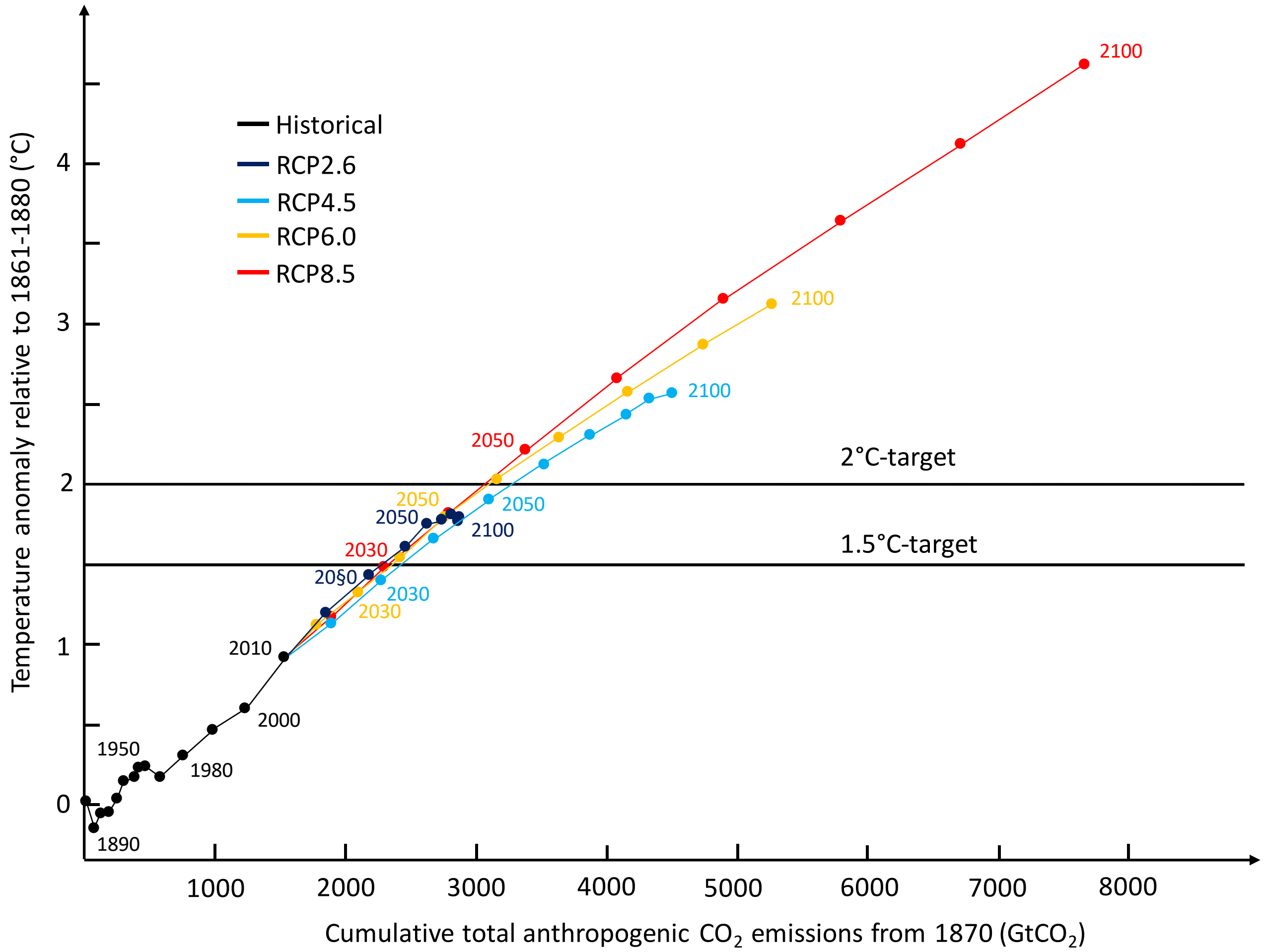
[76] Carbon Tracker, 2018.

[77] Gasser et al., 2018.

[78] Gasser et al., 2018.

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

Figure C-1: Cumulative anthropogenic CO_2 emissions and global warming in four RCPs



Source: IPCC, 2014, own presentation.

The ***Paris Agreement*** aims at limiting global warming to below 2C°. This requires the apex of GHG emissions to be reached not later than 2020 and fossil CO_2 emissions need to be completely suspended by around 2070[79]. However, current emission reduction pledges might rather result in a global warming of more than 3°C[80] (see SECTION B). According to ***IPCC's*** **fifth assessment report (AR5)**, those scenarios with a 'likely' chance to limit global warming to below 2°C exhibit atmospheric concentration levels of about 450 ppm CO_2e by 2100 and demand for 'large-scale changes in energy systems and potentially land use'[81]. *IPCC's* latest *Special Report (SR15)*[82] widely confirms this finding. Figure C-1 depicts the temporal evolvement of cumulative total anthropogenic CO_2 emissions and temperature change in the four *RCPs*, clearly demonstrating the huge differences between them. The ***IEA*** **has derived a 2°C consistent scenario (*2DS)* from *RCP2.6***, providing additional information on regional and sectoral level. The *2DS* scenario offers, like *RCP2.6*, **a 50% chance of limiting global warming to 2°C** and was **adopted by the *SDA*[83]**. The authors of this report follow this

[79] OCI, 2016.
[80] UNEP, 2017.
[81] IPCC, 2014.
[82] IPCC, 2018.
[83] CPD et al., 2015.

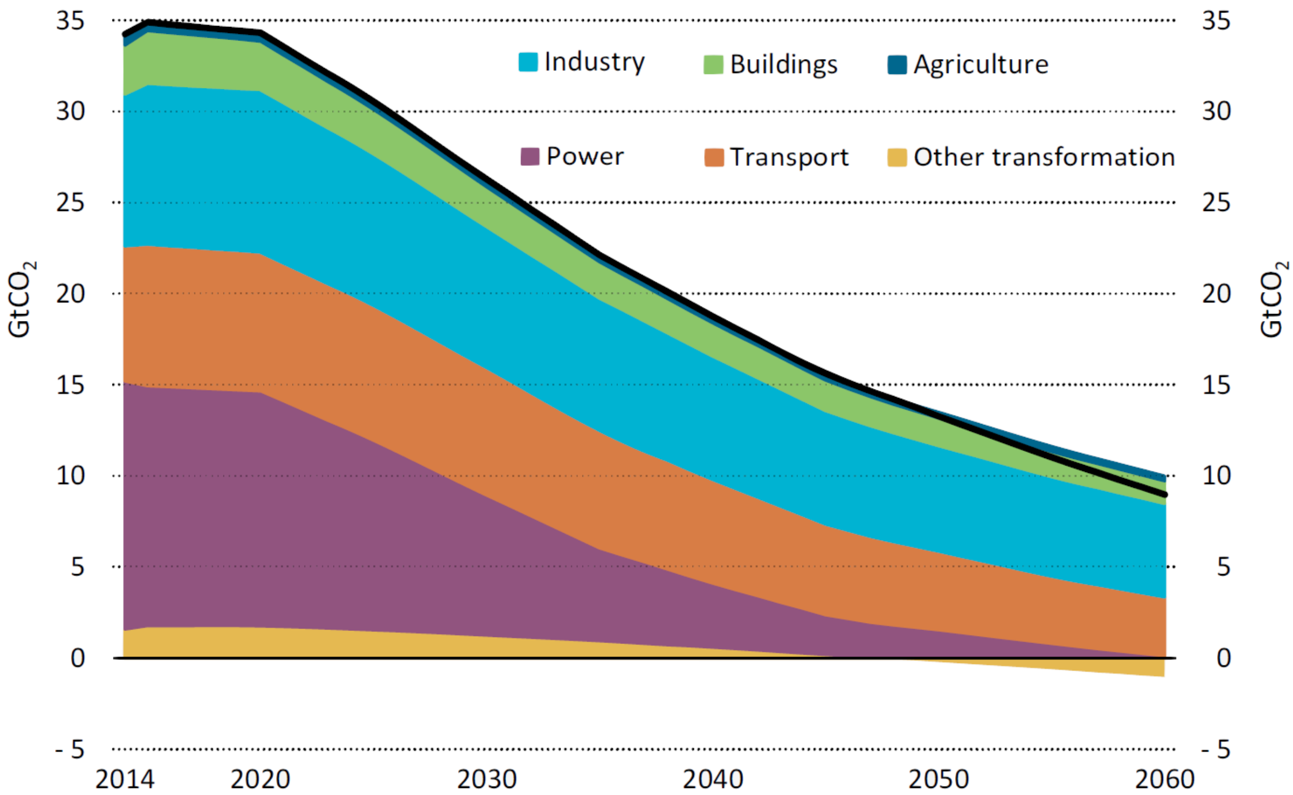
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 785058.

example and use the *IEA 2DS* as their global starting point for the derivation of 2°C-consistent decarbonisation pathways for the European commercial real estate sector. *2DS* is primarily based on an energy system pathway, assuming a 70% reduction of 2017 annual energy-related CO_2 emissions until 2060 and cumulative CO_2 emissions of around 1,067 $GtCO_2$ between 2018 and 2100.[84] The entire set of anthropogenic emissions, anthropogenic removals and biosphere carbon sink figures are represented in Figure C-2. **The *IEA 2DS* scenario assumes cumulative CO_2 emissions of around 784 $GtCO_2$ between 2019 and 2050 (excluding LULUCF)**.

Rockström et al. (2017) published a much-referenced *COP21*-related 'roadmap for rapid decarbonization'. The study presents a **(1) detailed decarbonization scenario** and a **(2) simplified 'global carbon law' of halving total global anthropogenic CO_2 emissions every decade from 40 $GtCO_2$ in 2020 to 5 $GtCO_2$ in 2050** (these figures include CO_2 emissions from burning fossil fuels, other industry activities and LULUCF).

The **deep decarbonisation scenario** presented by *Rockström et al.* is marginally less ambitious than the 'global carbon law' but still offers **a 50%-chance of reaching the 1.5°C-target and a 75%-chance of reaching the 2°C-target.** The scenario was calculated with a carbon cycle and climate model, with **global CO_2 emissions from fossil fuel and industry processes adding up to around 669 $GtCO_2$ between 2019 and 2050**. LULUCF emission become negative around 2050 and contribute to reducing total cumulative CO_2 emissions by 173 $GtCO_2$ (2018-2100). The scenario assumes peak CO_2 emissions in 2020 and requires distinct efforts to technically remove CO_2 from the atmosphere. Around 2050, CO_2 emissions reach net zero and anthropogenic CO_2 removals will accordingly lead to an effective decrease of cumulative emissions.

Figure C-2: Global CO_2 emission reduction until 2060 in the IEA 2DS scenario



Source: IEA, 2017b.

[84] IEA, 2017.

The scenario of *Rockström et al.* is discussed in the latest *IPCC Special Report (SR15)*[85] on the 1.5°C target: *SR15* estimates a remaining cumulative budget of 580 $GtCO_2$ from 2018 onwards for having a 50% chance of limiting global warming to 1.5°C.[86] Although *Rockström et al.* assume rather drastic reductions of anthropogenic CO_2 emissions, cumulative CO_2 emissions exceed the *SR15*-threshold before 2050 and global warming will temporarily increase above 1.5°C (the estimated peak median temperature increase is 1.7°C - 'overshoot', see fact box). However, minimised gross anthropogenic emissions and increasing CO_2 removals finally result in a warming of less than 1.5°C in 2100. CRREM uses the scenario developed by *Rockström et al. (2017)* as basis for the derivation of 1.5°C decarbonisation pathways for the commercial real estate sector (see Section C.2).

In summary, the authors suggest applying a 2019–2050 cumulative global CO_2 emissions budget of

- **669 $GtCO_2$ (consistent with 1.5°C global warming) and**
- **784 $GtCO_2$ (consistent with 2°C global warming).**[87]

Note: the remaining global carbon (or better GHG / CO_2e) budget from now on until 'full' decarbonization needs to be allocated to countries and sectors on a defined timeline. Investors should understand the rationale behind the assumptions on which these budgets were derived and the potential uncertainties climate science might face (leading to a revision of these budgets). Based on this knowledge, investors can accept and apply pathways to decarbonise their assets which are in accordance with these assumptions.

[85] IPCC, 2018.

[86] 'Global warming' in relation to the ‚global mean surface air temperature' (GMST) like in AR5. Regarding the 'global mean surface temperature', remaining budgets in SR15 are slightly higher, but the figures in the predominant number of research papers refers to GMST.

[87] Latest data on actual CO_2 emissions from *PBL Netherlands Environmental Assessment Agency (PBL, 2018)* are applied to adapt the original scenarios to the latest developments. The consideration of the latest global emission figures led to a redistribution of future emission values ensuring a similar cumulative emission budget and similar 2050 emissions as in the original scenario.

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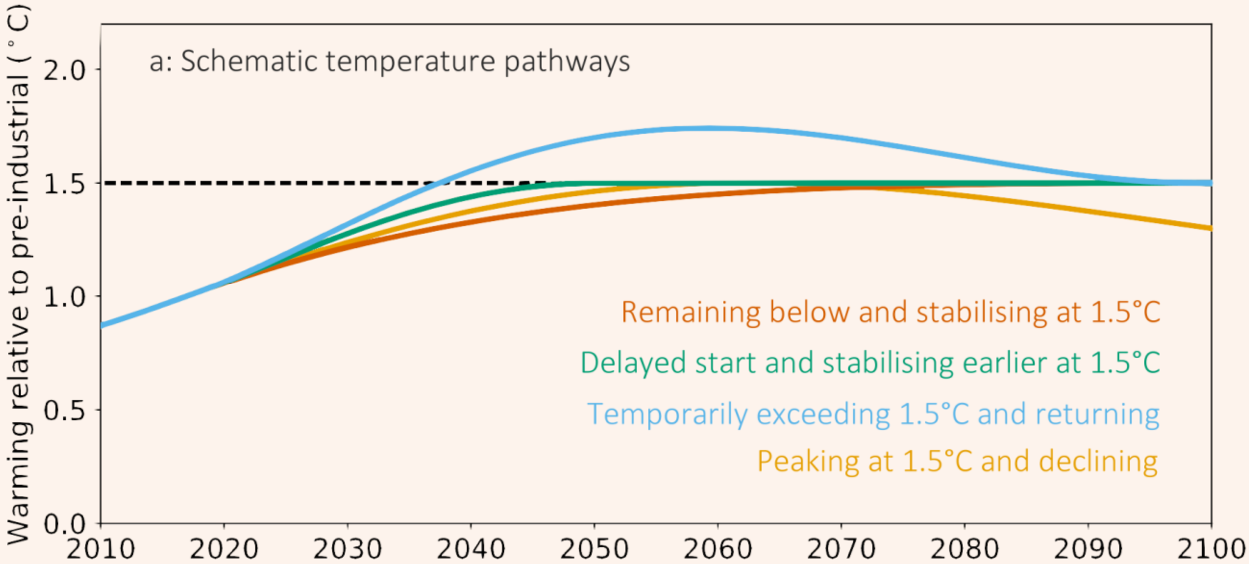
FOUR ARCHETYPE 1.5°C-CONSISTENT PATHWAYS FROM *IPCC*'S *SR15*

The following figures illustrate the complex interaction of **(a) global warming, (b) annual and (c) cumulative CO_2 emissions**, and **(d) time-integrated impact.** The relationships are presented for four different archetype pathways that are all consistent with the 1.5°C-target:



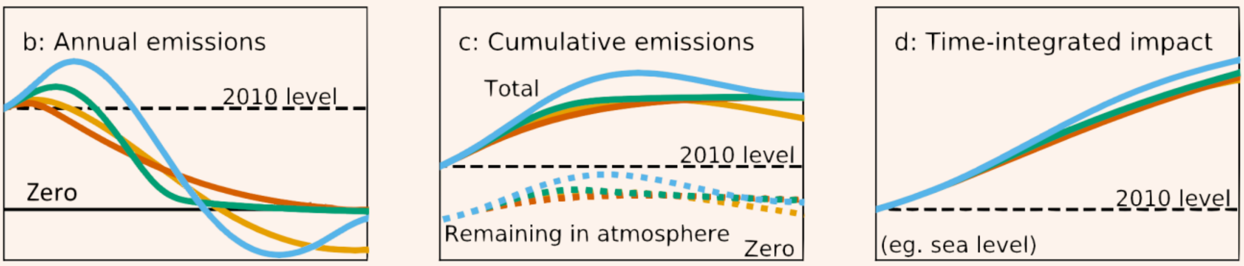
Source: IPCC, 2018.

Brown: The increase of global mean surface temperature (GMST) remains below and stabilises at 1.5°C in 2100.

Green: Reaches warming of 1.5°C earlier due to delayed start but faster implementation of mitigation measures

Blue: Global warming temporarily exceeds 1.5°C (**'overshoot'**), but returns to 1.5°C in 2100.

Yellow: GMST peaks at 1.5°C before 2100 and declines.



If global warming is proportional to cumulative emissions (c) and shall be limited to a maximum of 1.5°C from 2100 onwards, annual emissions (b) have to reach net zero or below in the long term. If cumulative emissions exceed the remaining budget (blue) due to delayed mitigation measures, net negative emissions are necessary to return to the 1.5°C target. Time-integrated impacts (d) like sea-level rise will increase even after GMST stabilises and are higher, the earlier and longer global warming progressed.

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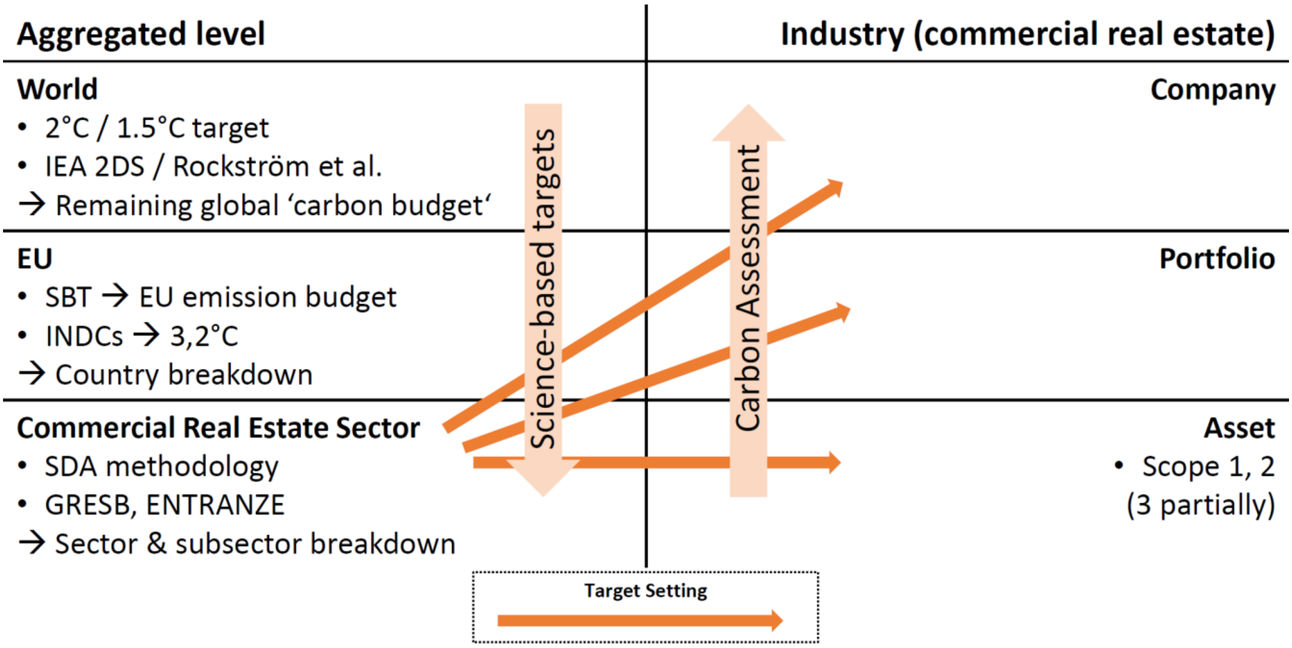
C.2 DOWNSCALING FROM GLOBAL TO PROPERTY LEVEL: SCIENCE-BASED TARGETS AND PATHWAYS

SCIENCE-BASED SETTING OF DECARBONISATION TARGETS

There are a number of **different approaches for downscaling a given remaining global carbon budget to single countries and industry sectors**. Figure C-3 shows a scheme of the top-down process of breaking down a global budget to the country and sector level, alongside the bottom-up approach of defining sectoral emissions based on property, portfolio and finally company specific emission figures. There is no strict 'right' or 'wrong' when deciding which approach shall be applied, but the choice of model depends as well on ethical questions and framework assumptions.

Figure C-3: Top-down approach for downscaling global carbon budgets and bottom-up approach from asset to commercial real estate sector carbon counting



Source: CRREM.

The **downscaling of a global emission budget** to country and sector-specific decarbonisation pathways **requires decisions on several relevant questions that influence final results.** The most relevant topics which will be explained further are**:**

1. What is the proper sequence of dividing the global budget (regional or sectoral)?
2. Which real estate subsectors shall be considered?
3. Which assumption on future sector growth shall be applied?
4. What are suitable assumptions regarding future grid decarbonisation?

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The calculation of emission targets on the property level is based on respective global figures and takes place in a series of single downscaling steps. Each step in the downscaling process is characterised by assigning an individual (absolute or intensity based) emission pathway to:

1. a certain region (e.g. countries or the *EU*),
2. an industry sector (e.g. the commercial real estate sector or the office subsector),
3. or combinations of both (e.g. the *EU* office sector).

This assignment is generally derived from a specific **'reference' pathway,** e.g. from the respective higher order region or sector.

So-called **convergence approaches** assume reductions to a common value of GHG emissions per capita or GDP within a certain time period that has to be defined. These approaches assume equal emission intensities in the year of converge (and afterwards)[88]. Some convergence-models are further based on a kind of **historic justice approach** that considers historic (absolute or per capita) GHG emissions when calculating future budgets and pathways for single countries. Regarding the real estate industry, the commonly applied converging indicator is the energy intensity or GHG intensity (see Section D.2), in terms of annual energy consumption or GHG emissions per square metre. For example, the so-called ***Sectoral Decarbonisation Approach (SDA)*** provides a mathematical framework that can be used to calculate converging emission intensity pathways also considering different growth rates between individual companies and the whole commercial real estate sector.

In contrast to that, **contraction approaches** assume the same rate of absolute or intensity-based reduction for all regarded entities (countries, sectors, companies).

The authors of this study recommend the **application of convergence as well as contraction approaches in different parts of the total downscaling process**. For example, we apply the convergence approach for downscaling global carbon emissions to *EU* level. Regarding the carbon intensities of different subsectors of the commercial real estate industry, like hotels or offices, *CRREM* assumes NO convergence, due to certain immanent differences in their specific functional requirements and related energy demands. The authors assume that the variance in carbon intensity between subsectors will remain consistent and perpetuate into the future, being the same in the target year as in the base year. The entire ***CRREM*** **downscaling framework** was developed to downscaling processes that adhere to a given budget, while considering **different activity growth rates <u>and</u> simultaneously preserving the initial proportion of carbon intensities between commercial real estate subsectors**.

Science Based Targets SBT

The ***Science Based Targets initiative*** *(SBTi)* was launched by the *Carbon Disclosure Project (CDP), the United Nations Global Compact (UNGC), World Resources Institute (WRI),* and the *World Wide Fund for Nature (WWF)*. Its main objective is to establish science-based GHG emission targets (on corporate level) as standard business practice.

The *SBTi* approach is based on *IPCC's* fifth *Assessment Report* and a set of possible methods for downscaling global targets to certain industry sectors and companies (see Figure C-4):

1. **setting a temperature increase threshold** (e.g. 2°C above pre-industrial levels),
2. **determining a representative concentration pathway in line with this threshold** (e.g. *RCP2.6* or *IEA 2DS*),
3. **deriving a global carbon budget**,
4. **determining sector specific carbon budgets and intensity pathways,**
5. **set science-based targets on corporate level.**

[88] Gignac/Matthews, 2015.

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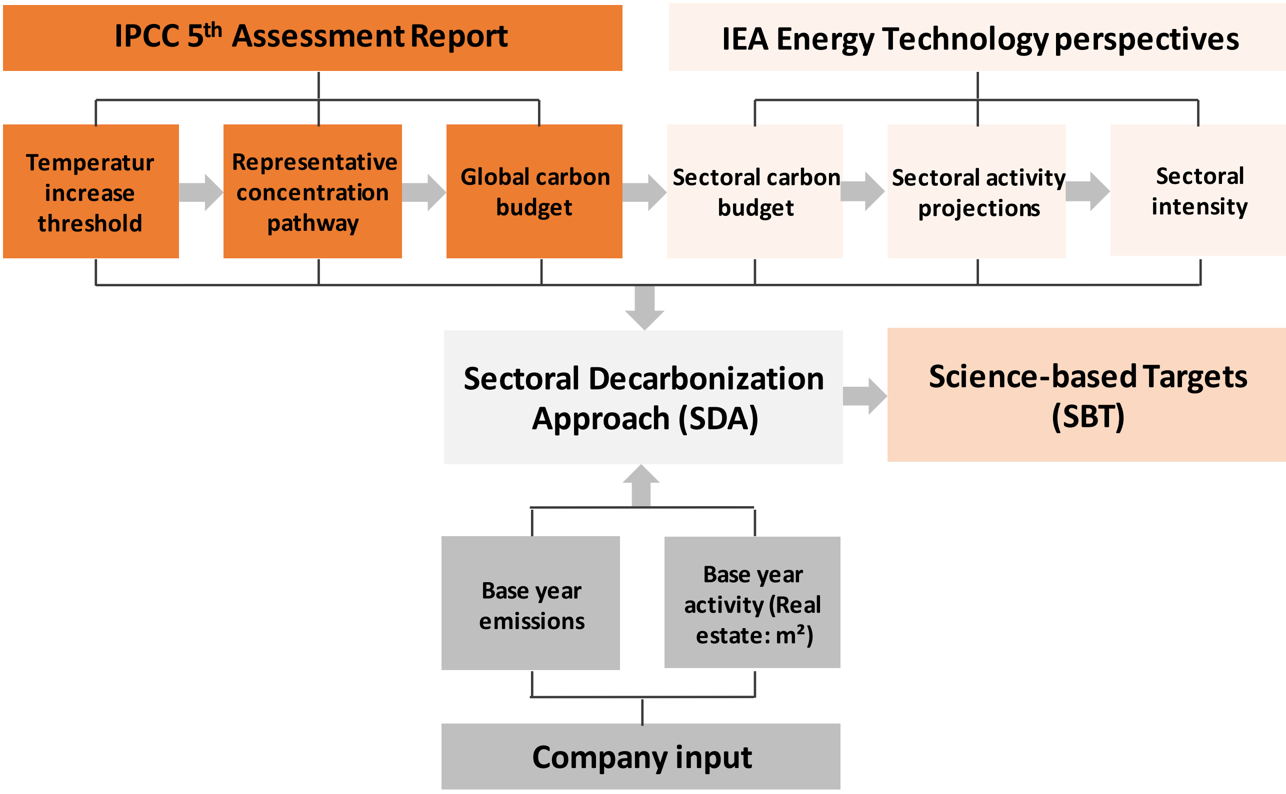
***SBT* describes six different methods** that can be used for potential downscaling[89]. The methods are proposed for different target groups and sectors and use different emission scenarios and allocation mechanisms. ***SBT* recommends the application of the *SDA* method especially for energy and carbon intensive industries like real estate**. On the one side, *SDA* comprised sector specific budgets and intensity pathways that were derived from the *IEA's Energy Technology Perspectives 2014*[90] report and its projections on sectoral activity and marginal abatement costs. On the other side, *SDA* contains a basic mathematical framework enabling the derivation of intensity pathways on the company level converging to the sector-wide pathway.

Figure C-4: Schematic procedure of determining science-based targets within the SBT/SDA framework



Source: SBT, 2015; own representation.

Sectoral Decarbonization Approach SDA

The *Sectoral Decarbonization Approach (SDA)* is more complex than other *SBT* methods and requires the assessment of intensity data as well as present and predicted data on economic activity. **Carbon intensity values are calculated by dividing a company's carbon emissions by a sector specific activity indicator**. In the building sector, this activity indicator is the **floor area** (other sectors use value added). This is consistent with the GHG Protocol Standard recommendations (see Greenhouse Gas Protocol in Section B).

[89] *Absolute emissions contracting, SDA, Green House Gas Emissions per Value Added (GEVA), Climate Stabilization Intensity Targets (CSI), Context-based Carbon Metric (CSO), Corporate Finance Approach to Climate-stabilizing Targets (C-FACT).*

[90] IEA, 2014.

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SDA was developed to enable companies to set their own *SBT*-conform decarbonisation targets and pathways. The methodological framework is based on **carbon intensity performance in 'homogeneous sectors' and contraction of absolute emissions for heterogeneous sectors.** The *SBT* initiative combined emission and activity scenarios from the 2°C consistent *IEA 2DS* scenario and derived sector-specific global intensity reduction pathways. *SDA* provides these global intensity pathways and the necessary mathematical framework (see fact box on page C.15) that enables its users to derive their individual pathways that will converge with the sector in the target year 2050. *SDA* automatically reflects the assumptions made in the *2DS* scenario, for example regarding sector-specific abatement costs, affecting the share of one sector on total global mitigation targets. **Since *SDA* regards the commercial real estate sector as 'homogeneous', it provides only one global carbon intensity pathway for the entire commercial building sector without differentiation of subsectors or regions.**

Deriving a carbon emissions budget for the European commercial real estate sector

Instead of assuming globally homogeneous sectors, **we firstly downscale the remaining global budget to the *EU* before calculating a real estate sector specific pathway. This EU pathway for the real estate sector is afterwards downscaled for each member state.** This offers a much more homogeneous region for further analysis than a global approach and seems more realistic than a global convergence in the same time frame. The authors assume converging emission intensities within each of the covered commercial real estate subsectors in 2050, taking further into consideration country specific differences in energy demand due to different climatic conditions.

However, the *SDA* convergence methodology offers a very flexible framework not only for companies willing to meet certain future sector standards or expectations. In combination with further methods, the *SDA* framework offers a useful tool that can be applied for setting science-based, country and subsector-specific targets. For example, ***CRREM* uses the *SDA* intensity-convergence approach to derive carbon intensity pathways for commercial real estate on country-level from the respective *EU*-wide pathway**.

The *SDA* methodology uses intensity values instead of absolute emission levels for benchmarking the carbon performance of a company. The use of intensity parameters enables the **consideration of different growth rates** between and within sectors. **Since total cumulative emissions are restricted to the given remaining budget and carbon intensities shall converge in the target year, the future carbon intensity pathway of, for example, the commercial real estate sector in a specific country will depend on the future growth of building area in this country.** If Country A grows faster than the *EU* average, *SDA* methodology allows for additional absolute emissions in this country at the expense of the other countries' budgets. At the same time, higher growth rates in Country A have the effect that its carbon intensity pathway will converge to the target intensity value earlier. This can be interpreted as follows: **The applied methodology does not penalise activity growth per se, but links it to a higher responsibility and therefore expects the growth to take place at future-proof carbon intensity standards.** The *SDA* framework applies a so-called ***Market Share Parameter* expressing the different growth rates** and a so-called ***Sector Decarbonisation Index***, expressing the decarbonisation progress of the sector (or in general, the higher-level entity) - see ***SDA fact box*** on page C.15.

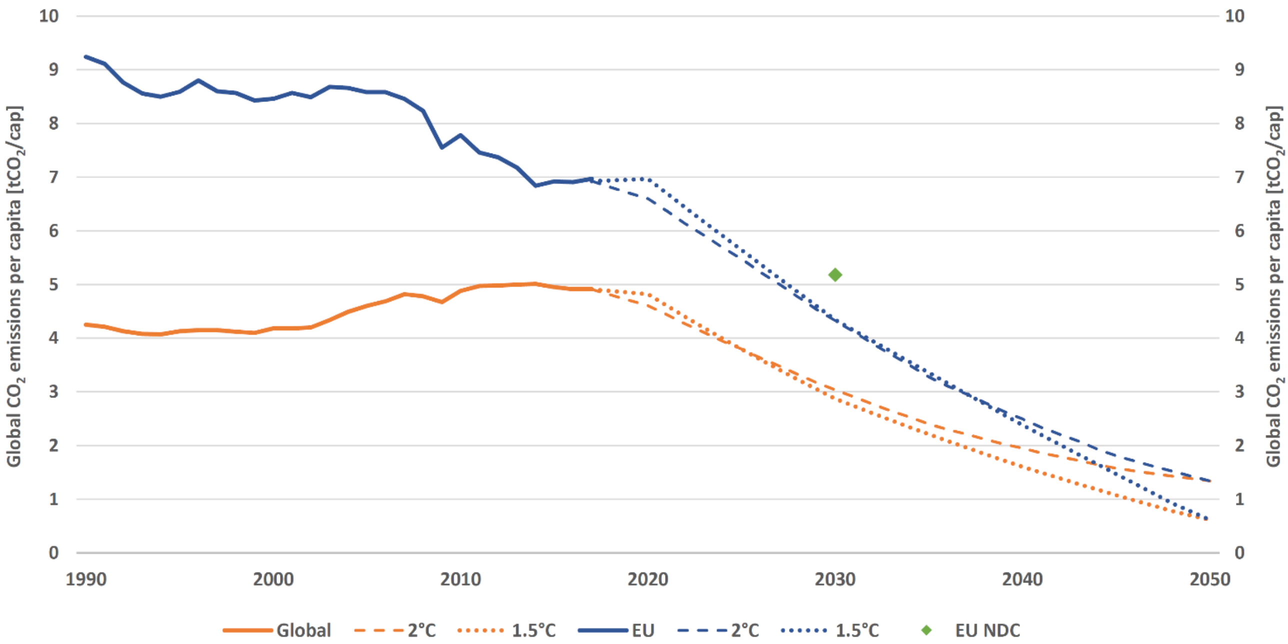
The mathematical *SDA* approach is adopted for the **first step of the *CRREM* downscaling procedure, which is the derivation of an *EU*-wide (all economic sectors) CO_2 emission pathway**. Calculations are based on the global CO_2 emissions pathway due to the *IEA 2DS* scenario or the 1.5°C scenario of *Rockström et al. (2017)*. **We assume converging per capita emissions until 2050, using population forecasts from the *United Nations Department of Economic and Social Affairs*[91].** This implies one **basic difference in the downscaling process between *SDA* and the approach recommended in this study**. *SDA* assumes global convergence within 'homogeneous sectors'. Since our research clearly demonstrated, that structural and climatic differences vary substantially even within the European commercial real

[91] UN DESA, 2017.

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

estate sector, the authors argue that global intensity convergence might be very hard to reach until 2050. Therefore, we derive an *EU*-wide decarbonisation pathway based on the **'equal per capita emissions' principle of justice** in advance of **any further downscaling to sectors and countries.** This approach enables the direct application of a variety of *EU*-wide data sources like ***Eurostat*[92], the *Building Stock Observatory*[93]** or the ***European Reference Scenario EUREF16*[94]** in the subsequent downscaling steps. Since all databases used in the further downscaling process rely on **CO_2e instead of CO_2 emissions** (Figure C-6), values were converted based on present information from the *European Environment Agency*[95]. Figure C-5 shows global and *EU* per capita CO_2 emissions from a historic perspective as well as under the assumption of convergence until 2050 following both emission reduction scenarios (1.5°C and 2°C) discussed in this study. The *EU* starts from a distinctly higher baseline in 2019 than the global average, making a much higher reduction of its per capita emissions necessary. Figure C-5 also demonstrates – as stated earlier - that current *EU* NDC pledges are not enough to attain its ambitious climate targets.

Figure C-5: Global and EU historic CO_2 emissions per capita and convergence until 2050 under 1.5° and 2° scenario vs. 2030 EU NDC target



Source: Own calculations; IEA, 2017; Rockström et al.; 2017; UN DESA, 2017; PBL, 2018.

[92] Eursotat, 2018

[93] BPIE et al, 2016

[94] E3M-Lab, 2016.

[95] EEA, 2018.

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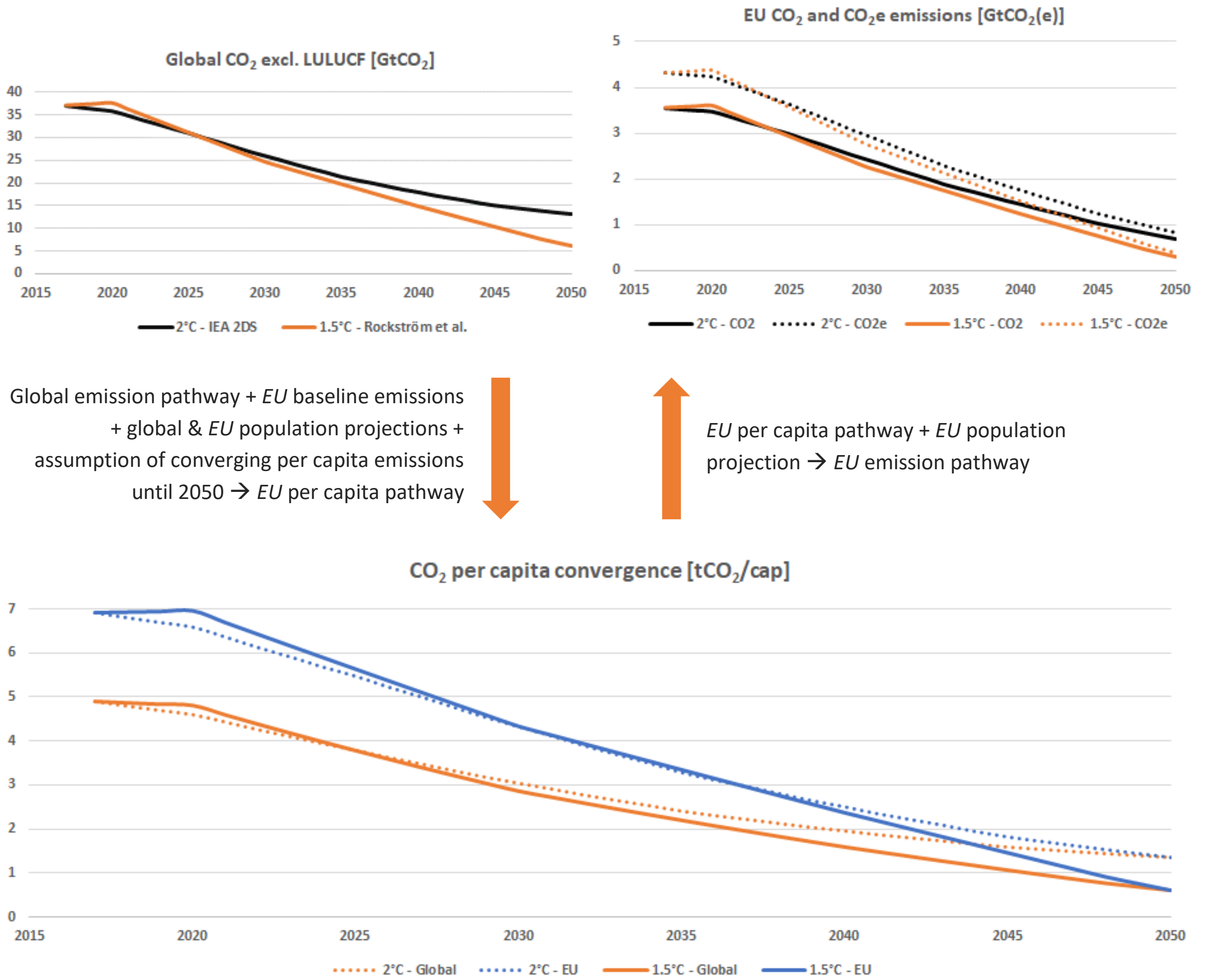
Figure C-6: Stepwise downscaling of 2°C and 1.5° consistent global pathway to Europe



Source: Own calculations; IEA, 2017b; Rockström et al.; 2017; UN DESA, 2017.

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OUTLINE OF BASIC SDA MATHEMATICAL FRAMEWORK

Absolute emissions can generally be calculated for each sector (or region) by multiplying sector activity (e.g. floor area) with sector intensity (e.g. emissions per floor area). The sum of annual absolute emission has to remain within the defined sector budget:

$$\sum_{2018}^{2050} A_y SI_y \leq Budget_{2050}$$

where:

A_y	*Activity of sector in year y*
SI_y	*Intensity of sector in year y*
$Budget_{2050}$	*Cumulative carbon budget 2018-2050 of sector compatible with a below 2°C scenario*

Since *SDA* applies an intensity convergence approach, it is necessary to consider **company and sector future activity levels** for the derivation of individual carbon reduction pathways for a specific company or asset:

$$m_y = \frac{CA_b/SA_b}{CA_y/SA_y} = \frac{SA_y/SA_b}{CA_y/CA_b}$$

where:

m_y	*Market share parameter of company in year y*
CA_b	*Activity of company in base year b*
SA_b	*Activity of sector in base year b*
CA_y	*Activity of company in year y*
SA_y	*Activity of sector in year y*

The market share parameter m_y presents the ratio of a company's (activity) market share in the baseline year *b* to that in year y (in case of the real estate industry, activity is measured in square metres of floor area). In other words, m_y *presents* the ratio of the sector's activity growth from baseline year *b* to year *y* to that of the specific company. If a company has tripled its activity within a certain period, whereas total sector activity has 'only' doubled, m_y is 2/3, resulting in a lower company intensity target CI_y (see figure below**)** as in the case of same growth rates of company and sector:

$$m_y = \frac{SA_y/SA_b}{CA_y/CA_b} = \frac{2\,SA_b/SA_b}{3CA_b/CA_b} = \frac{2}{3}$$

SDA makes use of a so-called sector decarbonization index p indicating the **remaining share of sectoral decarbonisation** until 2050 ($p = 1$ in the base year and $p = 0$ in 2050):

$$p_y = \frac{SI_y - SI_{2050}}{SI_b - SI_{2050}}$$

where:

p_y	*Sector decarbonization index in year y*
SI_{2050}	*Intensity of sector in 2050*
SI_b	*Intensity of sector in base year b*

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The **target intensity of a company CI_y** according to *SDA* can be derived from the formulas above as follows:

$$CI_y = SI_{2050} + (CI_b - SI_{2050}) * p_y * m_y$$

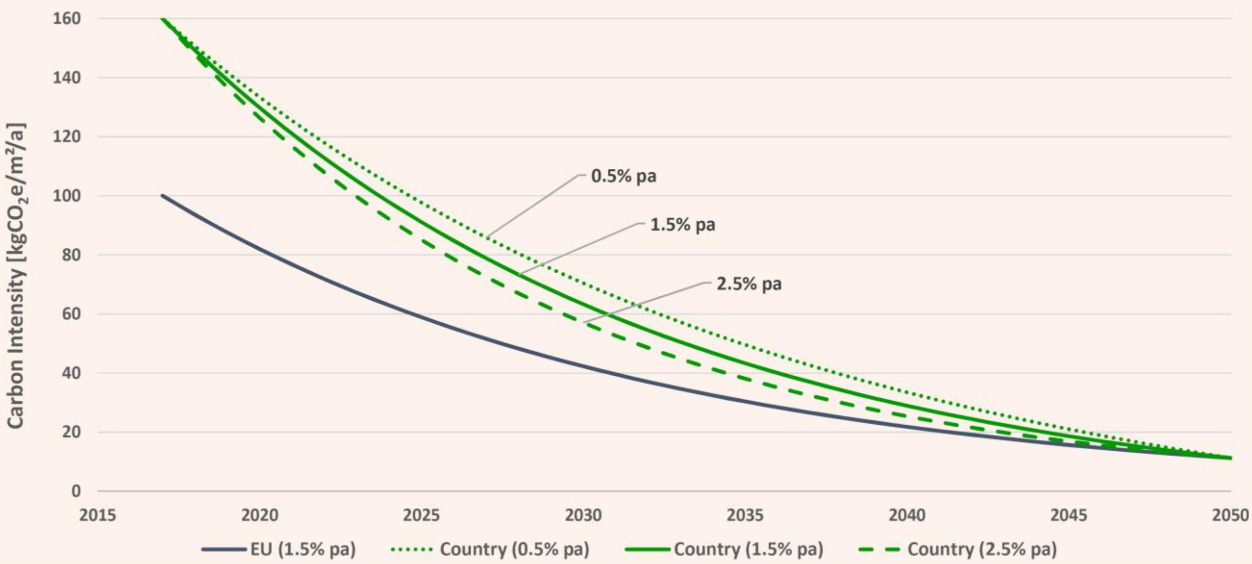
where:

CI_y	*Intensity of company in year y*
CI_b	*Intensity of company in base year y*

This formula begins with the sectoral target intensity for 2050 SI_{2050} which is also the target for the respective company in 2050 CI_{2050} (due to the convergence approach). The second part of the formula presents the difference between company intensity in baseline and target year, multiplied with the *Sector Decarbonisation Index (*presenting the general rate of decarbonisation within the concrete sector) and the *Market Share Parameter* presenting the effect of different growth rates between sector and company.

The example supported by the figure below, is characterised by intense decarbonisation efforts in the initial years, reaching half of the total intended decarbonisation until 2050 already in 2026 (blue line). Whether a certain country has to half its baseline carbon intensity before or after 2026 depends on the growth of floor area in that country with regard to total *EU* floor area growth.

Figure C-7: Effect of different floor area growth rates on future carbon intensity pathways (SDA)



Source: Own calculation and presentation.

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DOWNSCALING TO COUNTRY LEVEL

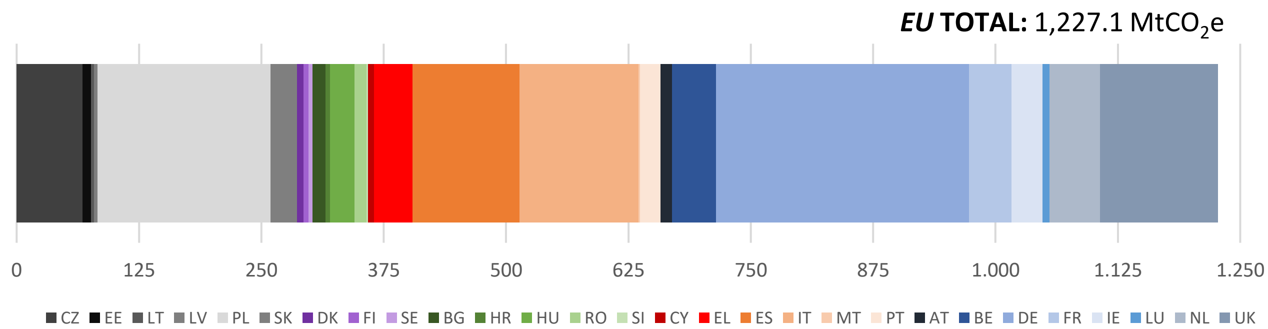
The ***EU Reference Scenario 2016 (EUREF16***) is an update of its 2013 predecessor and provides a model-derived simulation of future energy consumption, growth rates in the construction sector, other economic activities, GHG emission and a large variety of further country-specific parameters directly or indirectly related to decarbonisation. *EUREF16* assumes that 'legally binding GHG and (renewable energy sources) targets for 2020 will be achieved and that the policies agreed at *EU* and member state level until December 2014 will be implemented.'[96] The data provides a **realistic projection of data necessary for downscaling carbon intensity pathways to the country level.**

CLIMACT together with the *European Climate Foundation* and *ClimateWorks Foundation* developed a simulation model called the ***CTI 2050 Roadmap Tool***[97] which explores potential pathways to net-zero *EU* GHG emissions by 2050[98]. The project developed three different scenarios and compares them with the *EUREF16* scenario, broken down to different sectors for each scenario. The significance of the *CTI 2050 Roadmap Tool* for this study lies primarily in distributing future GHG emissions and building areas to non-residential building sector which is not explicitly done in *EUREF16* itself.

The *ENTRANZE*[99] database provides detailed information on annual GHG emissions for several commercial real estate subsectors in each of the 28 *EU* member states (see Figure C-8). In order to estimate **future emission values of the commercial real estate sector**, data from the *ENTRANZE* database is combined with the *EU* total GHG emission pathway (see page C.12) and data from the *CTI 2050 Roadmap Tool* (*EUREF16* scenario) on the **future share of the commercial building sector on *EU* total GHG emissions** (excl. LULUCF).

A carbon intensity pathway can be calculated by combining this emission pathway with information on present and future floor space of the *EU commercial real estate sector* clearly demonstrating **sectoral decarbonisation** (see Figure C-5 and Figure C-9)**.** Data from the *CTI 2050 Roadmap Tool* was used to determine *EU* floor area growth rates on an annual basis that are finally applied to the *ENTRANZE* baseline value to calculate *EU* commercial real estate floor area until 2050.

Figure C-8: Absolute emissions of the EU commercial real estate sector by country (million tCO_2e)



Source: CRREM.

The ***EU* commercial real estate carbon intensity pathway** can subsequently be used to apply the ***SDA* methodology** to the commercial real estate sector of each *EU* member state converging to the same carbon intensity value in 2050. The effect of different climatic conditions between the 28 countries strongly depends on the specific subsector of commercial real estate, especially due to the different share of heating and cooling demand, for example between the retail or the office sector. With regard to deriving country and subsector-specific decarbonisation pathways, these

[96] European Commission, 2016.
[97] European Climate Foundation, 2018
[98] CLIMACT, 2018.
[99] Enerdata, 2018.

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

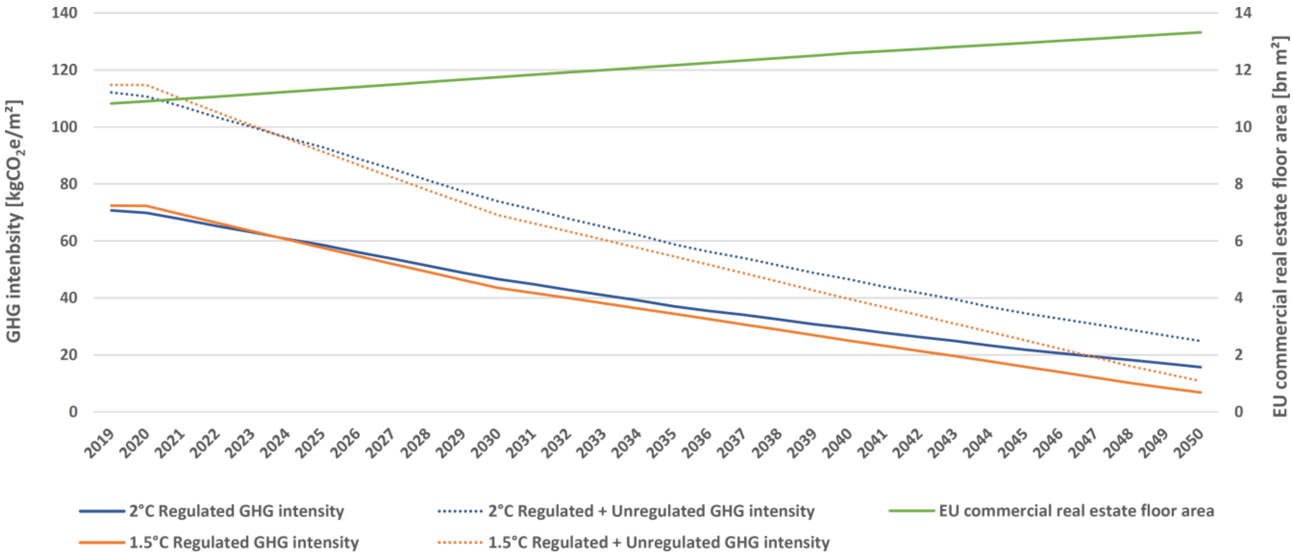
climatic conditions are considered directly in the subsector downscaling described in section 'Downscaling to the building sector', since these subsector pathways define the final benchmarks used at asset-level.

Country-specific data on construction sector activity *in EUREF16* until 2050 and data from the *ZEBRA* project[100] on growth of non-residential floor area was used to determine actual increase in floor area in each country. In a first step, we derived a statistical relation between construction sector activity and floor area growth for every country enabling an initial calculation of floor areas until 2050. The total sum of floor area of all countries obtained in this way was compared with the previously calculated total *EU* figures derived from the *CTI 2050 Roadmap Tool* and *EUREF16.* This results in a calibration factor for each year that is applied to the before-calculated figures on country-level. **This methodology results in country-specific figures on floor areas consistent with total *EU* growth figures and presenting the different relative growth assumptions from *EUREF16*.**

Carbon intensity pathways for the commercial real estate sector in each *EU* member state are finally derived by letting each country's baseline intensity converge to the *EU* pathway until 2050. The exact convergence trajectories are calculated using the *SDA* formula framework ensuring that the sum of all country specific emissions adheres to the available cumulative emissions budget (see Figure C-10).

Compared to a contraction approach, the convergence approach results in **higher reduction targets for countries with high initial emission intensities**. Carbon reduction activities in advance of the baseline set in this study are rewarded (as it is the case of *SDA),* since previous carbon intensity reductions result in less remaining efforts to reach the sector convergence target in 2050. Expecting higher/faster carbon reduction efforts from those with higher current emissions is also favourable from an economic point of view because **marginal abatement costs are considerably lower in buildings with poor energy efficiency and high consumption.** In Section C.3, we derive property specific carbon intensity targets that are consistent with official *EU* climate pledges and *ESD*-legislation that assigns different emission reduction responsibilities to the 28 member states. The same country specific responsibility to reduce emissions can also be applied to targets that go beyond *EU* pledges and are consistent with 2°C or 1.5°C global warming.

Figure C-9: EU commercial real estate carbon intensity pathway and floor area (2°C and 1.5°C scenario)



Source: Own calculations; Enerdata, 2018; Rockström et al., 2017; European Climate Foundation, 2018.

[100] Enerdata, 2016.

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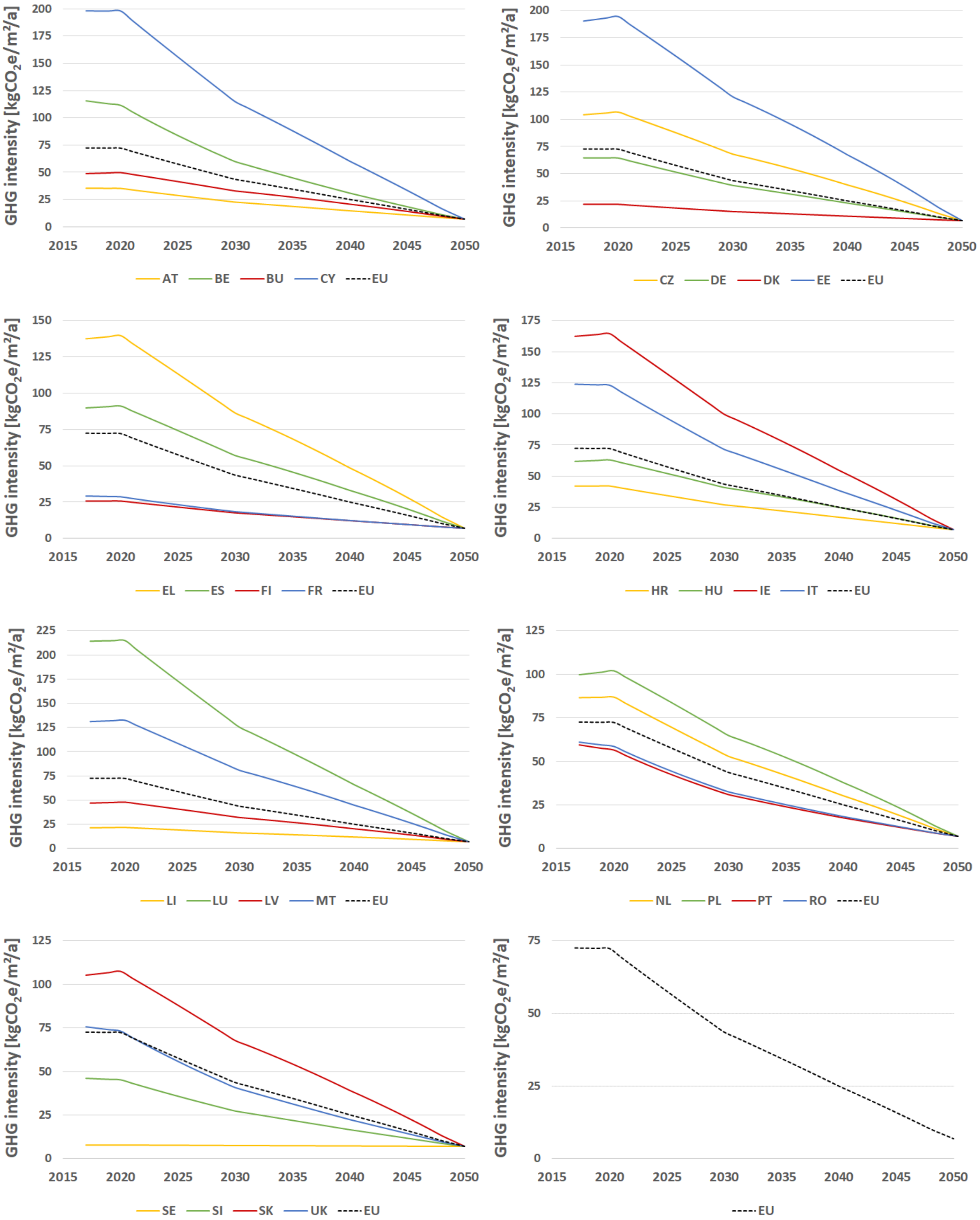
Figure C-10: (Regulated) GHG intensity pathways of EU28 member states' commercial real estate sector (1.5°C scenario)



Source: Own calculations; Enerdata, 2018; European Climate Foundation, 2018.

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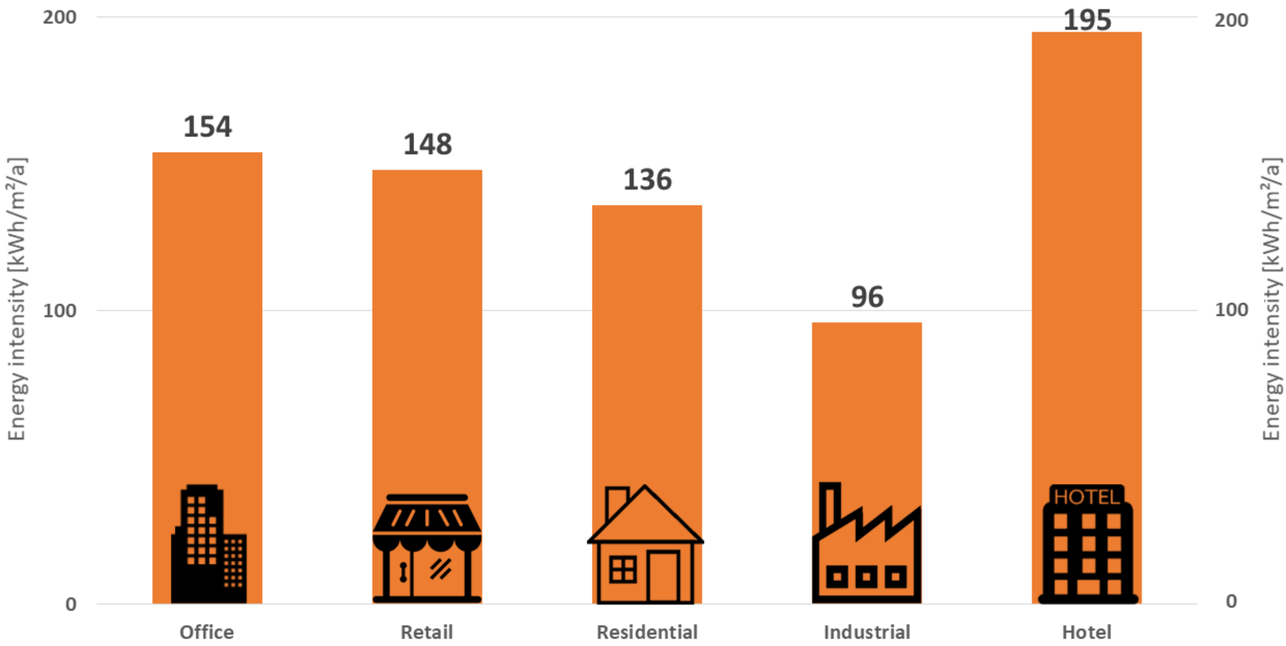
DOWNSCALING TO THE BUILDING SECTOR

The country-specific carbon intensity pathways derived in the previous section need to be further differentiated to account for a range of commercial real estate subsectors. The approach proposed by the authors considers **the inherently different energy demand and respective GHG emissions across different types of commercial real estate** (see Figure C-11) and assumes **constant relative differences for the entire period under consideration of country-specific heating loads**[101] (until 2050). At the same time, we propose to consider country-specific emission factors and climate conditions, providing a better differentiation of the diverse European commercial building stock.

Country-specific floor area growth rates were derived from *EUREF16* and the *ZEBRA* database, **assuming the same growth of each subsector within a given country**. The *CRREM* tool will apply country-specific growth rates for each subsector of the commercial real estate sector.

Figure C-11: Average energy intensities by property type as assessed for Europe by GRESB [kWh/m²]



Source: GRESB, 2018. Whole building including common, landlord and tenant areas.

[101] Country-specific cooling has not been considered due to the high uncertainty of future use of air-conditioning.

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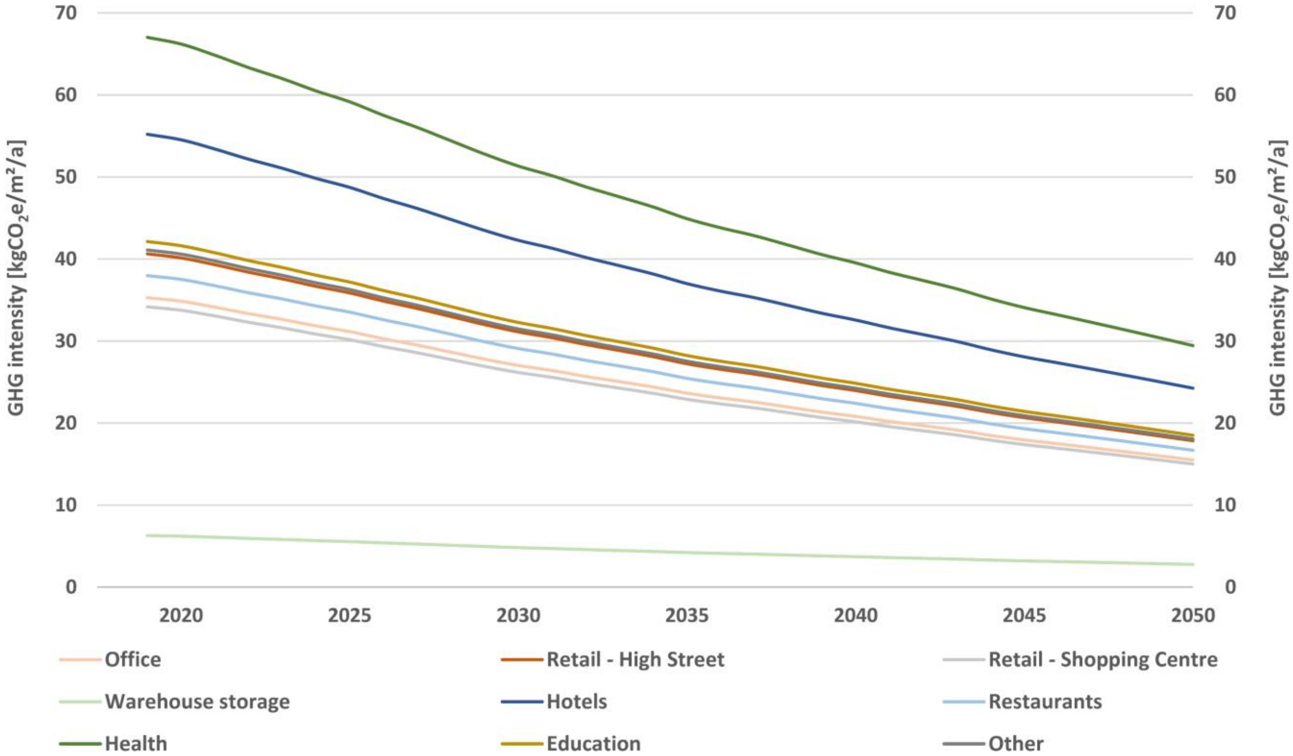
Figure C-12: 2°C GHG intensity target pathways of Austrian commercial real estate subsectors



Source: Own calculations.

The results so far cover only so-called 'regulated' carbon emissions that are accounted and controlled by *EU* member states' building regulations (see section D.2 for further details). The ratio of regulated to unregulated emissions largely depends on the specific type of use of a building. The *Building Energy Efficiency Survey (BEES)* survey (see end of Section D.2) provides a detailed breakdown of energy use per end-use in several commercial real estate subsectors based on a large dataset from England and Wales. **Taking into consideration country-specific figures on heating degree days and electricity emission factors, the authors derived correction factors that can be applied to determine subsector-specific figures that include as well unregulated emissions** (see Figure C-12 and Figure C-13 for Austria). Unregulated emissions are all carbon emissions released by buildings that are not controlled by the EPBD (for further details see Buildings: Assessment and distribution of carbon emissions in section D.2). Asset level data from *CRREM* project partner *GRESB - the global ESG benchmark for Real Assets*, enables a further **differentiation of the subsector retail into shopping centre and high street retailers.**

The calculation of these correction factors is based on the assumption that (1) *BEES* figures for England and Wales are representative for the whole of the United Kingdom (UK) and that (2) the proportion of a subsector's carbon intensity relative to the total commercial real estate sector is the same in every *EU* country if the effects of different heating degree days and electricity emission factors are accounted for.

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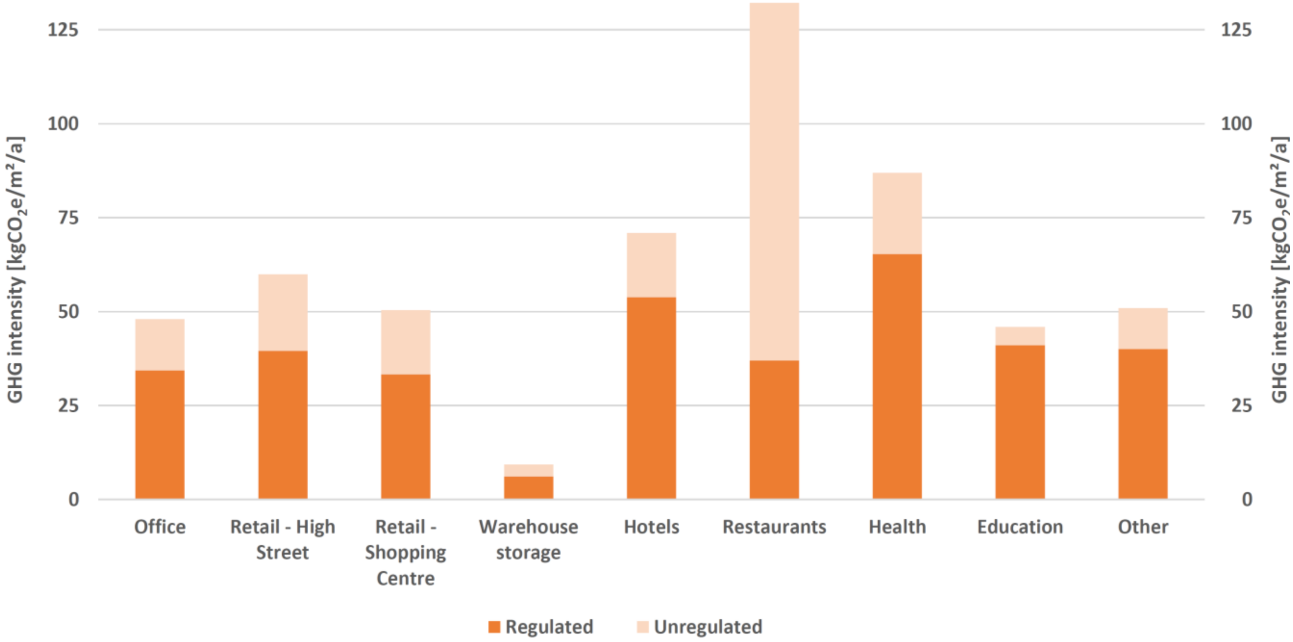
Figure C-13: 2°C GHG intensity target of Austrian commercial real estate subsectors in 2018



Source: Own calculations.

DOWNSCALING PROCESS: FROM GLOBAL EMISSION BUDGETS TO DECARBONISATION PATHWAYS ON PROPERTY LEVEL

Defining relevant carbon intensity targets and pathways for the *EU* commercial real estate sector – that could also be used as a basis for company specific target-setting – is a multi-step process requiring a variety of input data from different sources, different mathematical calculation approaches and, finally, certain decisions regarding specific assumptions. This process can also be used as a basis for company specific target-setting. The authors are aware that these decisions involve a subjective element. However, the provided maximum amount of transparency regarding the chosen assumptions enables verifiable results and their reliable assessment. The steps are:

1. Maximum amount of global warming until the end of the century according to the targets set in the *Paris Agreement* of *COP21*: 1.5°C and 2°C

2. Global CO_2 emission pathways and budget consistent with 1.5°C and 2°C warming. 2019-2050 Budget:

- 1.5°C: 669 $GtCO_2$ (*Rockström et al. 2017)*
- 2°C: 784 $GtCO_2$ (*IEA 2DS*)

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3. *EU* CO_2 emission pathway and budget based on the assumption of converging per capita emissions until 2050 (applying the *SDA* methodology to assure emission pathways that respect the total global budget and different population projections):

- 1.5°C global warming:
  - Global: 2019: 4.8 tCO_2/cap 2050: 0.6 CO_2/cap Reduction: -88%
  - EU: 2019: 6.9 tCO_2/cap 2050: 0.6 CO_2/cap Reduction: -91%
- 2°C global warming
  - Global: 2019: 4.8 tCO_2/cap 2050: 1.4 CO_2/cap Reduction: -71%
  - EU: 2019: 6.8 tCO_2/cap* 2050: 1.4 CO_2/cap Reduction: -79%

4. *EU* GHG (CO_2e) emission pathway and budget for all carbon emitting economic sectors:

- 1.5°C global warming:
  - EU: 2019: 4.3 $GtCO_2e$ 2050: 380 $MtCO_2e$ Reduction: -91%
  - EU: Budget 2019-2050: 72 $GtCO_2e$
- 2°C global warming:
  - EU: 2019: 4.2 $GtCO_2e$ 2050: 873 $MtCO_2e$ Reduction: -79%
  - EU: Budget 2019-2050: 78 $GtCO_2e$

5. Direct and indirect (electricity and district heating) emissions and budget of *EU* commercial real estate sector:

- 1.5°C global warming:
  - CRE: 2019: 1.2 $GtCO_2e$** 2050: 144 $MtCO_2e$ Reduction: -88%
  - CRE: Budget 2019-2050: 22 $GtCO_2e$
- 2°C global warming:
  - CRE: 2019: 1.2 $GtCO_2e$ 2050: 332 $MtCO_2e$ Reduction: -72%
  - CRE: Budget 2019-2050: 24 $GtCO_2e$

6. *EU* commercial real estate sector carbon intensity pathway ($kgCO_2e/m^2$) based on emissions pathway and projected development of floor area:

- 1.5°C global warming:
  - CRE: 2019: 114 $kgCO_2e/m^2$ 2050: 11 $kgCO_2e/m^2$ Reduction: -90%
- 2°C global warming:
  - CRE: 2019: 112 $kgCO_2e/m^2$ 2050: 25 $kgCO_2e/m^2$ Reduction: -78%

7. Carbon intensity pathways of the commercial real estate sector in individual *EU* member states based on the assumption of converging carbon intensity until 2050 (applying the *SDA* methodology to assure emission pathways that respect to total *EU* commercial real estate budget and different floor area growth rates between countries).

8. Carbon intensity pathways for individual commercial real estate subsector (office, retail, education, etc.) within each *EU* member state based on different climate conditions and the assumption of constant relative differences between each subsector.

**) Different emissions figures for 2019 in the 1.5°C and 2°C pathways result from the underlying assumptions in the used climate models. Both pathways were adapted to meet actual global emissions in 2018.*

***) The comparatively high emission figures result from the consideration of all energy consumption in buildings, including unregulated emissions emerging from tenant activities. The figures further include non-process-related energy consumption in industrial buildings.*

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C.3 CARBON INTENSITY TARGETS ALIGNED WITH EU POLICIES

Besides emission targets based on scientific analysis of carbon budgets and their compatibility with global warming maximum targets (see Section C.1), it is also possible to benchmark building carbon performance against *EU*'s official *NDC* target. **In the end, any answer to the question what sustainability targets are considered to be the optimal choice for a specific company, fund or property, is a matter of strategic decision-making of the organisation management board** (See Section D.1)**.**

Emissions within the building sector are part of the *ESD* framework, which includes all emissions which are not covered by *ETS* or *LULUCF* (see Section B.1 for further policy background). The term ***ESD* stands for *Effort Sharing Decision***, since it defines different commitments for each *EU* member state to reduce their emissions in the *ESD*-sectors. Regarding the real estate industry, it is important to bear in mind that the *ESD* framework considers direct emissions only, since indirect emissions mainly associated with electricity and district heating consumption are assigned to the power sector, which is covered under the *ETS* framework. In order to complement indirect emissions and derive total targets for the commercial real estate sector at property level, ***NDC*-based targets proposed in this study are based on each country's official *ESD* reduction targets for 2020 and 2030 as well as reduction targets of *ETS* emissions**.

EFFORT SHARING DECISION (ESD): REDUCTION OF DIRECT EMISSIONS IN THE COMMERCIAL REAL ESTATE SECTOR

According to *Regulation (EU) 2018/842*[102], *ESD* emissions shall be reduced by 10% in 2020 and by 30% in 2030 against 2005 levels. The *INDC* submitted by the *EU* intends a 40% reduction of GHG emissions in 2030 against 1990 levels (see section B.1 for a broader discussion of EU's climate policy and instruments). Table C-1 provides a summary of 1990, 2005 and 2030 GHG emissions in *ETS* and *ESD* sectors, comparing the total reduction that would results from *ETS* plus *ESD* target attainment with the *INDC* target: **Obviously, the fulfilment of those targets set out in the two *EU* emission reduction frameworks *ETS* and *ESD* would result in a fairly accurate fulfilment of the *NDC* target.**

[102] European Commission, 2018b.

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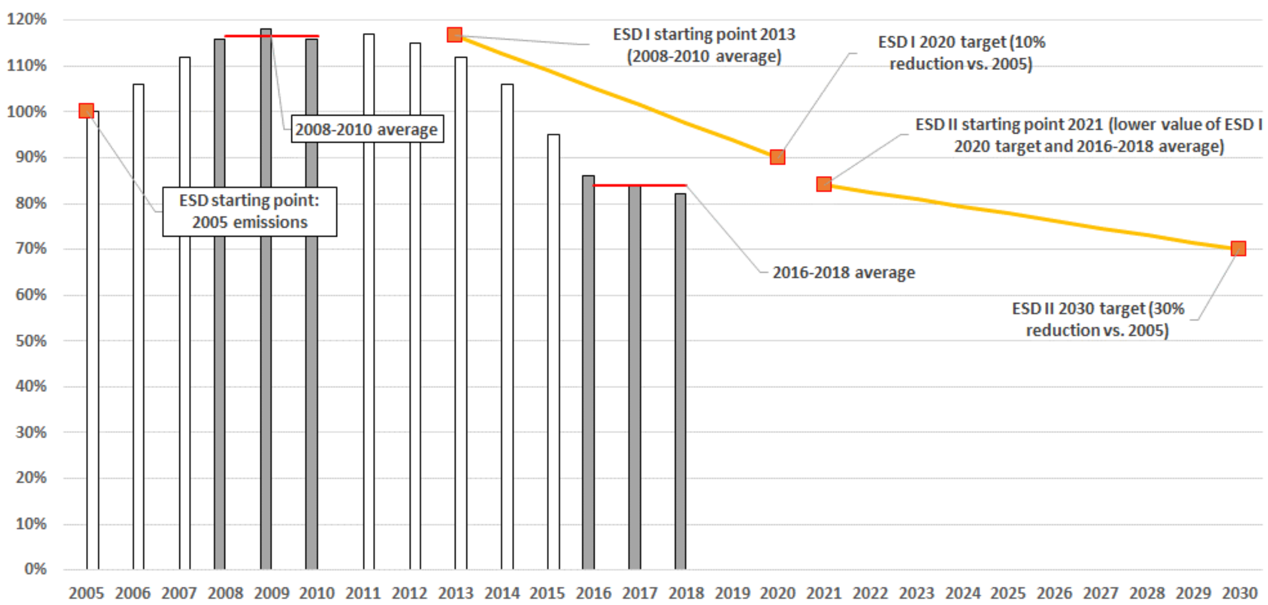
Table C-1: Summary of ETS, ESD and INDC emissions and targets

Year		ETS reduction target vs. 2005	ETS emissions [tCO_2e]	ESD reduction target vs. 2005	ESD emissions [tCO_2e]	Total ETS and ESD emissions [tCO2e]	INDC reduction target vs. 1990	Total EU emissions (excl. LULUCF & internat. aviation) [tCO_2e]
1990	Past emissions							5,650,360,000
2005			2,373,338,110		2,849,181,171	5,222,519,281		
2020	Targets	-21%	1,874,937,107	-10%	2,564,263,054	4,439,200,161		
2030		-43%	1,352,802,723	-30%	1,994,426,820	**3,347,229,543**	-40%	**3,390,216,000**

Source: European Commission (2018a), European Commission (2018b), European Environment Agency (2018a), European Environment Agency (2018b), European Environment Agency (2018c).

Figure C-14: ESD reduction targets



Source: Own presentation; European Commission (2018b).

The first phase of *ESD* set country-specific emission reduction targets for 2020 against 2005 levels, defining a linear reduction pathway from 2013 to 2020 with average 2008 to 2010 emission levels as a starting point (see *Figure C-14*). Country-specific reduction targets for 2020 *and 2030 are based on member states' relative wealth, measured by gross domestic product (GDP) per capita (see* Section B.1*).*

In a first step, an *EU*-wide emission pathway was derived from country-specific 2020 and 2030 targets, recent data on observed *ESD* emissions until 2017[103] and official projections of emissions until 2020 for each country[104]. A detailed study on behalf of the *European Commission*[105] presents figures on **cost-effective abatement potentials for all sectors** that are encompassed by *ESD* regulation (see Table C-2). The study measures from Cost Band A and Cost Band B as cost-

[103] European Environment Agency 2018c.

[104] European Environment Agency, 2018d.

[105] *Ecofys/Fraunhofer/Alterra Wageningen, 2012.*

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effective, implying a carbon price of EUR 25 / tCO_2e. These figures on sector-specific abatement potentials can be used to derive the building sector's share of the total emissions reduction in the *ESD* sector (housing and commercial real estate sectors are assumed to contribute the same share of reductions).

Calculations demonstrate that the ESD-based carbon reduction efforts for the building sector are slightly above-average, as it considers sector-specific abatement potentials. Country-specific emission reduction pathways for the commercial real estate sector were derived from the *EU*-wide commercial real estate reduction pathway. The process adopts the same share of effort defined by the *ESD* framework for each country. This approach is used to calculate the final *ESD*-based emission reduction pathways for each country. The data to complete the downscaling process is derived from baseline emission figures from *ENTRANZE* and *BSO* (see Section C.2).

Table C-2: Abatement potential per ESD sector and Cost Band

Abatement costs per $MtCO_2e$	**Abatement potential [$MtCO_2e$]**					
	EU27	**Agriculture**	**Building**	**Transport**	**Industry**	**Waste**
Cost Band A (< EUR 0)	156	19	84	11	43	0
Cost Band B (EUR 0-25)	56	31	4	7	14	0
Cost Band C (EUR 25-50)	56	31	2	23	0	0
Cost Band D (> EUR 50)	129	41	29	58	0	0
EU wide per sector	**397**	**122**	**118**	**100**	**57**	**0**

Source: Ecofys/Fraunhofer/Alterra Wageningen, 2012.

If 2020 emissions are below average 2016-2018 emissions (which is taken as starting point for 2021 if it is lower than the 2020 *ESD* target), the *ESD* framework theoretically allows for an increase of emissions between 2020 and 2021. For the period of 2018-2020, *NDC*-based targets should be based on the lower value of each year's *ESD* targets and actual (projected) emissions.

The results so far cover only so-called 'regulated' carbon emissions that are accounted and controlled by *EU* member states' building regulations (see Section D.2 for further details). The ratio of regulated to unregulated emissions largely depends on the specific type of use of a building. The calculation of figures on 'unregulated' emissions for *NDC*-based targets can apply the same methodology as in the case of science-based targets as described in Section C.2.

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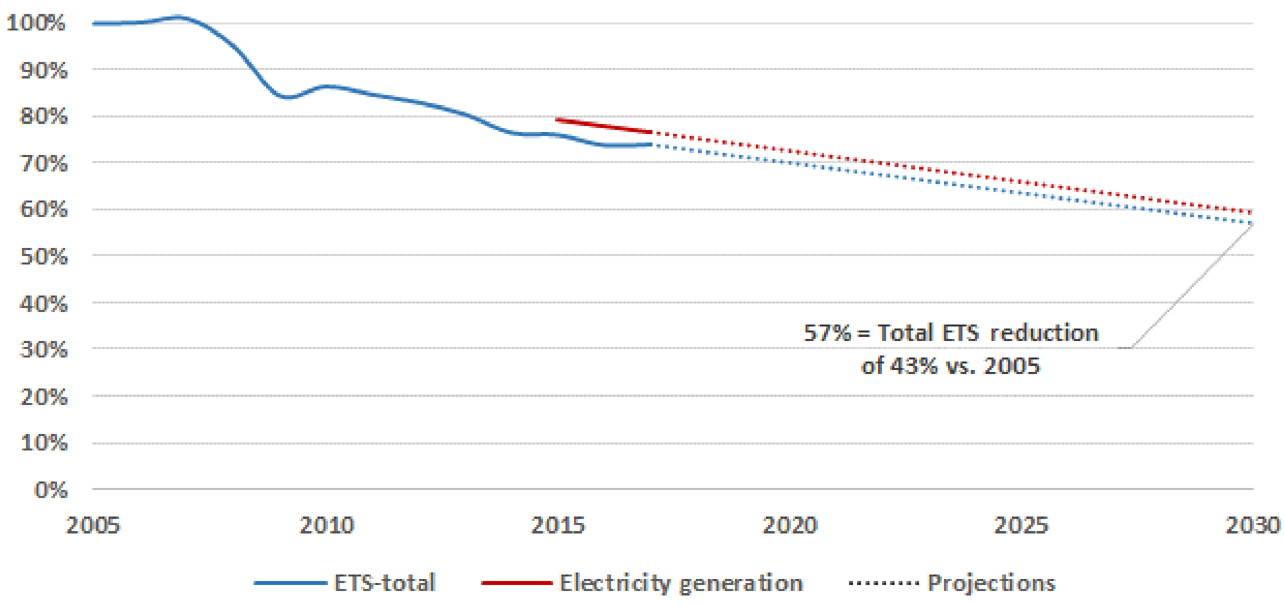
EMISSIONS TRADING SYSTEM (ETS): REDUCTION OF INDIRECT EMISSIONS IN THE COMMERCIAL REAL ESTATE SECTOR

Reduction targets for indirect emissions in the commercial real estate sector were derived from the targets defined by the *ETS* framework. A reduced demand of electricity (and district heating energy) in *ESD* sectors decreases the amount of electricity that has to be produced within the *ETS* framework. Estimations on emission reductions that might be achieved in *ETS* power generation by switching to clean energies are rather unreliable so far and have been excluded.

We assume a linear reduction pathway of 2017 *ETS* emissions to reach the target of a 43% reduction in 2030 against 1990 levels (see Figure C-15). It was further assumed that the relative reduction progress in the power generation sector will continue to slightly stay behind total *ETS* sector[106] and that all activities bear the same share of reducing their indirect emissions. The reduction targets derived following these assumptions were applied to the baseline indirect emissions in the commercial real estate sector from *ENTRANZE* and *BSO*. The calculation of unregulated emissions was undertaken in a manner analogous to that for *ESD* emissions[107] (see Section C.2).

Figure C-15: ETS emissions reduction 2005-2030 (incl. electricity generation subsector)



Source: European Environment Agency, 2018a and 2018b.

DECARBONISATION PATHWAYS BASED ON NATIONALLY DETERMINED CONTRIBUTIONS (NDC)

An *NDC*-based emissions reduction pathway for the commercial real estate sector has to combine reduction targets derived from both *ESD* (direct emissions) and *ETS* (indirect emissions). **Direct and indirect emissions are therefore combined with present and future data accounting for the floor area on country-level** to derive carbon intensity pathways until 2030. Both figures can be of particular relevance for real estate investors, but **carbon performance on**

106 The demand of relative future emission reductions for the generation of district heating was regarded equal to that for electricity generation.

107 Country-specific grid emissions factors don't have to be considered since they apply to both, regulated and unregulated emissions from electricity consumption.

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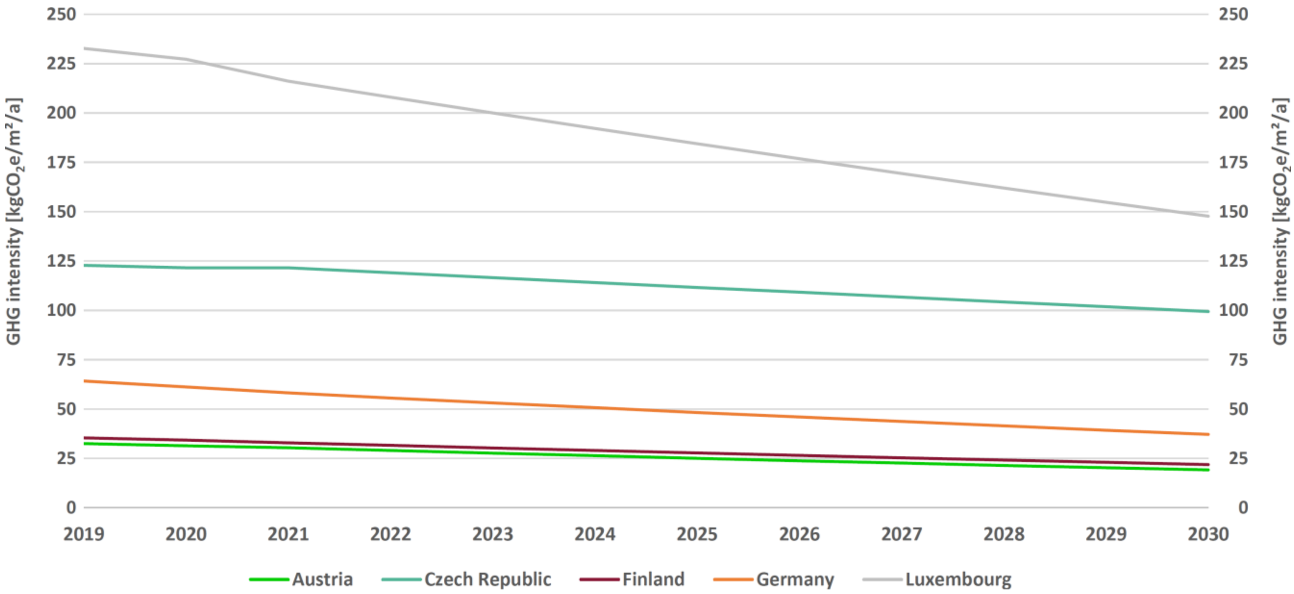
asset level will be benchmarked against the combined carbon intensity figure of direct and indirect emissions. *ESD* might set specific reduction targets for direct emissions in the building sector, but we strongly recommend not to focus on a one-sided reduction of direct emissions that was achieved only by shifting to indirect emissions: for example, the replacement of a modern gas heating system by electric heating might reduce direct emissions to zero, but this change may not reduce the energy demand of the asset, but probably increase it due to poorer energy efficiency or electric systems.

The following calculation of *NDC*-based carbon intensity pathways for commercial real estate subsectors in each *EU* member countries was done adopting the same methodology as described in Section C.2 to define science-based targets. Figure C-16 displays for example carbon intensity reduction pathways for office buildings in five selected countries. The pathways follow neither the concept of convergence nor simple contraction with equal reduction efforts (see Section C.2), since emission reduction targets as defined in the *ESD* framework vary significantly between countries.

Figure C-16: NDC-based GHG intensity pathways for office buildings in five EU countries



Source: CRREM, 2019.

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CRREM

Corporate management of stranding risk

SECTION D CORPORATE MANAGEMENT OF STRANDING RISK

Climate change and stranding risks present new challenges to the real estate industry. The awareness of potential risks must be regarded as low, even though long-term investors take a leading role in adapting to the new framework conditions. Taking measures aimed at reducing stranding risks requires an initial assessment of those carbon emissions each stakeholder is responsible for. Only a comprehensive carbon assessment enables the successful management of risks and development of strategies to mitigate them.

KEY FACTS AND FINDINGS

D.1 RISK MANAGEMENT: CORPORATE DECISION-MAKING

CORPORATE STRATEGY: Many investors and asset managers still have not defined a clear strategy to assess, quantify and mitigate the stranding risk of their portfolios. Aiming to achieve a target compliant with *EU* commitments to *COP21*, carbon risk mitigating strategies needs to be aligned with corporate Environmental, Social and Governance (ESG) principles and define instruments to transparently track and monitor the success of risk mitigation actions as well as cost-benefit trade-offs (see Figure D-1).

CARBON RISK AWARENESS: Carbon risk assessment has increased over the course of the last decade, but instruments and coverage of assets are still limited, focusing on assets with longer holding periods. Organisations' own operational emissions also receive more attention than embodied carbon or indirect operational emissions.

D.2 RISK ASSESSMENT: CARBON RESPONSIBILITIES

Risk assessment is one of the first steps in a carbon risk mitigation plan. The analysis of carbon risk in commercial portfolios requires the quantification of all carbon emissions released by buildings, as well as a clear understanding of the different responsibilities of the stakeholders who generate these emissions.

BUILDING PERSPECTIVE: There are different methods to classify carbon emissions released by properties (see Figure D-6). Depending on the capacity of stakeholders (like tenants and owners) to **control** these emissions, they are classified into Direct or Indirect carbon emissions. The GHG Protocol standard divides emissions in three scopes: Scope 1 'Direct', Scope 2 'Indirect energy', Scope 3 'Other indirect'. Considering the **life-cycle** of a building, emissions are classified in operational and embodied, which together add up to Whole-Life carbon emissions. *Operational emissions* are generated through energy consumption during the in-use stage of the building: e.g. heating, cooling, lighting or hot water. Depending on the degree of authority by the *EPBD* directive, building regulations and other policies, operational emissions are usually divided between regulated and unregulated. *Embodied emissions* include the remaining carbon emitted during the life of a building, which include the energy used in the manufacture of building components, transport, construction, replacements, etc. until the asset is deconstructed and disposed.

STAKEHOLDERS PERSPECTIVE: Stranding risk and its potential impact on any asset's value, is defined by all the emissions emitted within the asset. Therefore, to maintain assets' value and avoid depreciation, **investors and asset managers need to ensure that all emissions from their buildings are assessed and if required, mitigated**. However, in the case of investment properties these emissions are partially controlled by the buildings' tenants (units) and only to a certain extent by the owners/landlord (common parts and shared services). *CRREM* assesses the carbon risk within the boundary of buildings and portfolios. Investors and asset managers will need to liaise with their tenants and other stakeholders (e.g. energy suppliers) in order to avoid gaps or double.

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CORPORATE CARBON REPORTING BOUNDARIES ARE DIFFERENT FROM BUILDING REPORTING BOUNDARIES: Direct and indirect emissions from the tenant´s perspective are different than from the landlord's perspective, but usually these categories are complementary. Owners corporate boundary to report emissions may or may not include the emissions of buildings they own, which depends on their capacity to control these emissions. The GHG Protocol Standard accepts different reporting boundaries: equity, financial and operational, which enable to report emissions based on various investment approaches. *CRREM* reconciles these complex and overlapping boundaries to ensure all carbon emissions from buildings are accounted and fairly distributed avoiding gaps or double counting.

FUTURE EVOLVEMENT OF EMISSIONS: Current emissions will vary in response to continued global warming, resulting in increased cooling and potential reductions in heating demands. Therefore, the stranding risk of assets will need to be sensitive to and in a position to address these changes. *CRREM* adopts the most recent climate models to quantify and control these future variations and reflect them in the assessment of stranding risk.

D.3 RISK MITIGATION: CARBON REDUCTION MEASURES

This section outlines the approaches available for building designers, asset managers, investors and occupants to reduce the risk related to operational carbon emissions of the real estate sector.

TRANSPARENCY AND PROCESS: Effective reduction of carbon emissions in real estate portfolios require the definition of a clear strategy. Deriving a strategy requires a sound information basis and clear processes and responsibilities:

a. **DATA** collection mechanisms: for operational and embodied carbon including smart metering and technical building assessments.
b. **COST-IMPACT** assessment tools to decide the priorities in each project or building – MAC analysis, payback calculation, whole-life analysis.
c. **ENSURE ENGAGEMENT** of all stakeholders in the process from corporate decision making to building users.
d. **DEFINE PROCESSES AND ALLOCATE RESPONSIBILITIES** to ensure that required actions are embedded in the organizations' usual operations.

TARGETS AND STRATEGIES: Retrofit action is the result of implementing a pre-defined strategy aiming to achieve clear and sound targets. Carbon emissions reduction in existing buildings is therefore only one mitigation option:

a. **CARBON TARGETS:** Targets depend on individual convictions of corporate leaders and shareholders.
b. **CARBON STRATEGIES:** The evaluation of each asset should lead to a decision (sell, buy, hold, upgrade, retrofit) and a time reference (do-now, wait, milestone, etc.)

MEASURES TO REDUCE CARBON EMISSIONS: Retrofit actions should be implemented according to the following hierarchy:

a. **REDUCE ENERGY DEMAND:** Design to preserve heat and cooling and reduce energy consumption.
b. **MEET THE ENERGY DEMAND EFFICIENTLY:** Choose equipment that provides the required output with the least energy and carbon.
c. **SUPPLY ENERGY FROM RENEWABLE SOURCES**

RELATED TOPICS

SCIENCE-BASED TARGETS AND SECTORAL DECARBONISATION APPROACH SECTION C.2

GHG PROTOCOL SECTION B.2

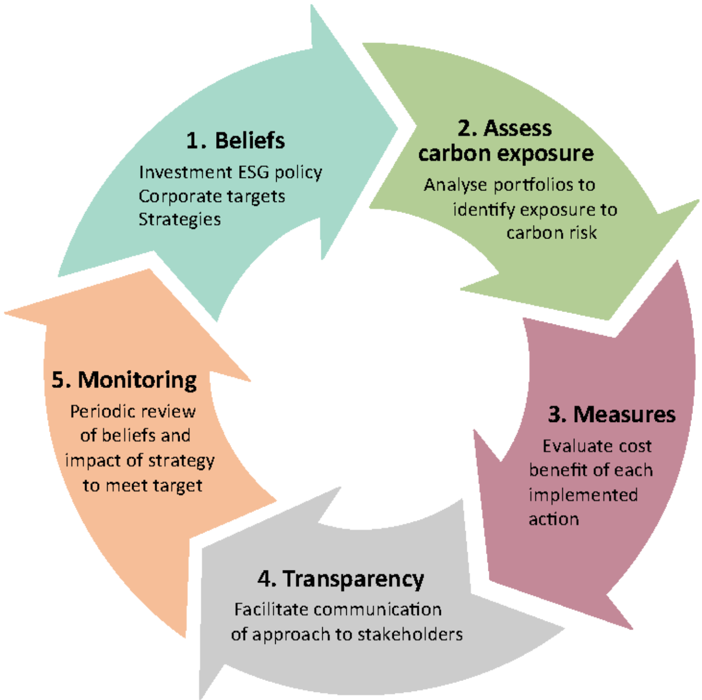
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 785058.

D.1 RISK MANAGEMENT: CORPORATE DECISION-MAKING

CORPORATE STRATEGY

To reduce asset exposure to stranding risk, real estate investors need to develop a clear **risk management strategy** supported with strong **ESG policies and appropriate carbon reduction commitments**. These commitments lead to the **development of carbon risk reduction plan** that need to be adopted and implemented by all stakeholders within the organisation.

Figure D-1: Roadmap for carbon risk management



Source: CRREM, based on Towers Watson, 2015.

Towers Watson developed a carbon management roadmap to control the carbon risk of fossil fuels for energy investors. Figure D-1 illustrates the adaptation of this roadmap to the real estate market, which also involves five main stages:

1. BELIEFS: Investment beliefs can help guide decision making when there is a high degree of uncertainty. Investors should define their beliefs with respect to climate risks and stranded assets and reflect them in a strong ESG policy. The adoption of science-based carbon reduction targets compliant with *EU* commitments to *COP21* (see Section B.1) should be a consequence of this decision, which can respond to different reasons, like economic or moral. In other words, investors need to set corporate carbon objectives and targets. To achieve these goals a clear roadmap with timeline and **carbon strategies** to meet the targets needs to be developed.

2. ASSESS CARBON EXPOSURE: Investors are encouraged to measure their carbon exposure across their portfolio. Most of investors already report the direct and indirect carbon emissions that they are responsible of as an organisation. However, for the real estate sector to comply with decarbonisation targets and mitigate carbon risks, the boundary of carbon assessment needs to include other emissions that currently lay outside corporate reporting boundaries. Section D.2 further explores carbon emissions in the built environment and the allocation of responsibilities.

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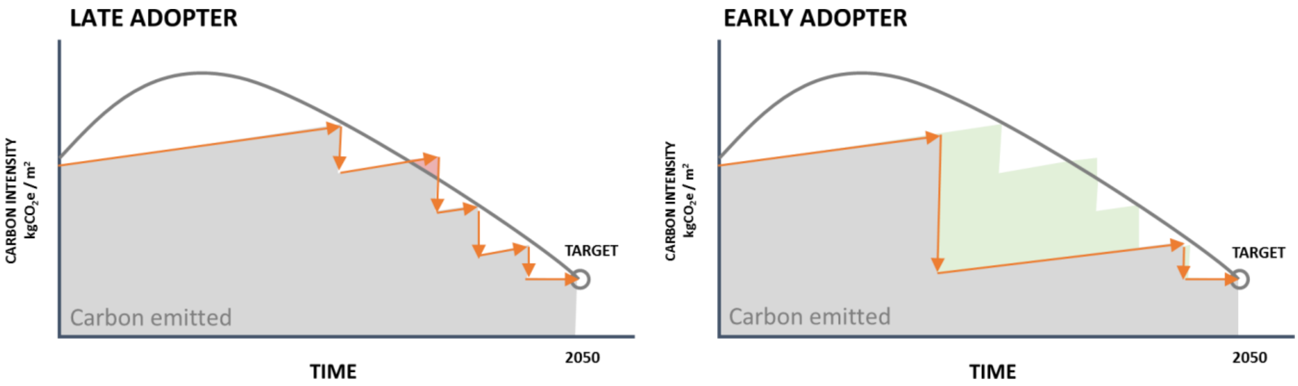
3. IMPLEMENTATION OF CARBON RISK MITIGATION MEASURES: Based on investors' climate related beliefs, adopted targets, defined strategies to achieve these goals and their current portfolio exposure, an appropriate **carbon reduction plan / roadmap including a timeline** involving a range of carbon risk mitigation options can be selected and implemented. Section D.3 outlines the approaches available to reduce the operation al carbon emissions of real estate assets.

4. TRANSPARENCY: The success of a plan to reduce the exposure to carbon risk largely depends on the disclosure of the assumptions and level of uncertainty inherent to the assessment of risks depending on future, variable parameters. These assumptions need to be regularly updated to ensure the pathway to meet the target – and even the target itself – satisfies the original objective of the corporate strategy. Transparency is therefore twofold: on the one hand transparency regarding the assessed data and the carbon status quo of the asset/portfolio, and on the other hand transparency regarding beliefs, underlying assumptions etc.

5. MONITORING AND REVIEW: Carbon risk mitigation plans should incorporate a **regular review process** to assess the success of the corporate strategy as well as the impact of each implemented carbon risk reduction measures. The evaluation of impact indicators should inform (if required) any modifications to the existing plan to ensure that the target is met and that external changes are taken into account. Besides a clear process also **requires the definition of responsibilities** within the organisation.

The *CRREM* tool and guidelines help investors and asset managers define the carbon management plans required to assess carbon footprints and exposure to stranding risk, implement carbon risk mitigation measures and transparently monitor their impact. CRREM provides the science-based carbon reduction targets required to meet EU commitments to COP 21 (see SECTION C), as well as the flexibility to adapt carbon management plans to different ESG commitments, investor profiles portfolio characteristics and location and market segments. In other words, different levels of ambition to tackle climate change and address mitigation measures. Figure D-2 compares two different investor profiles and the advantages and disadvantages that each corporate decision-making strategy entails.

Figure D-2: Different ambitions regarding stranding risk



Source: CRREM

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Early intervention in assets will greatly reduce stranding risk until 2050, with only minor interventions expected at later stages to compensate any deviation from target. Plans who aim to adopt policy changes only when they are in force are less flexible to organize the implementation of carbon reduction measures. Therefore, the stranding risk of assets and portfolios is much higher (see red area). The strategic decisions of 'waiting' or 'doing-it-now' would require to consider the following questions that corporate leaders must firstly address internally:

- Will retrofit become cheaper (or more expensive) in the future?
- Will policy tighten or loose energy and carbon requirements and when?
- Do we believe that everyone – from peers to the world – will continue following the Paris agreement?
- If we offer properties with higher or lower energy costs than our competitors, will this make a difference to our prospective tenants?
- Are strong ESG values becoming more relevant for investments analysts and the general public and therefore may increase our share price and assets values?
- Can we link our retrofit plan within the usual end-of-life replacement and maintenance cycles? If so, when?
- Do we believe that carbon taxes for the real estate sector will be cut or increased?

Some arguments underpinning this discussion, which might provide answers are:

EVOLUTION OF RETROFIT COST: Investors will benefit from a wider range of new technology and innovation, which may also be more carbon-cost effective. Besides, technologies from mature markets tend to become cheaper. For example, the cost of photovoltaic panels has significantly dropped in the last decade. Therefore, early interventions to reduce carbon need to carefully undertake cost-benefits assessments.

ABSOLUTE EMISSIONS REDUCTION: Market leaders will save much more absolute carbon emissions than portfolios (see green area) who react later, which facilitate their carbon reporting and meeting their carbon targets.

INDIRECT CARBON REDUCTION: As the rest of the economic sectors, including the electricity grid, will need to achieve their respective carbon reduction targets, the indirect carbon impact of each retrofit intervention is likely to reduce as time passes by. Therefore, the indirect carbon footprint of late adopters will be lower.

VALUE: Early adopters will secure stronger green credentials against competitors. Besides, if more refurbishments are carried out, demand will rise.

EVOLUTION OF ENERGY PRICES AND TAXES: Late adopters will have to absorb the impact of likely future increases in carbon taxes and energy prices. On the other hand, the assets of early adopters will be less exposed to taxes and increases in energy price.

There is no single answer to determine which approach is the most suitable to reduce carbon risk. As pointed out above, the strategy which fits best largely depends on corporate leaders' perception of future market development and of course their ideology towards climate protection. Ultimately, the decision will greatly depend on each organisation's ESG policy and choices. However, heterogeneous portfolios will require different approaches depending on the exposure of each building type to carbon risk, location and age, cost of retrofit, etc. Each investor or asset manager needs to define their individual approach depending on their beliefs, the evaluation of their portfolio and available budget.

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CRREM TRANSPARENCY: COPING WITH UNCERTAINTY

The calculations developed by the *CRREM* project are based on the most recent and accurate data currently available for the *EU* commercial real estate sector. However, future research is expected to improve the accuracy and completeness of data, particularly the projections of climatic indicators, future energy prices, policy changes and carbon abatement costs. The following areas define and main areas of uncertainty or potential difficulties within carbon and climate risk assessment:

BOUNDARIES: The allocation of carbon responsibilities between different stakeholders is sometimes difficult. Setting clear boundaries is critical to avoid gaps in reporting and double counting. See 'Stakeholders: Allocation of carbon reduction responsibilities' in Section D.2 for further information

CLIMATE: Projections on the impact of climate change in the energy demand of assets has been calculated using the degree-day methodology, which is described in Section D.2.

MODELLED DATA: Outputs adopt modelled data from third parties to predict the future evolution of many indicators, including projections of carbon price and taxation, carbon abatement costs, projections of future energy cost, operational and embodied impact of retrofit works, amongst others.

THE CRREM APPROACH TO REDUCE THESE UNCERTAINTIES IS:

CRREM project has created databases by collecting and processing data from different sources, including modelled data and assumptions. Outputs disclose key assumptions and modelled data sources.

Future research initiatives may generate more accurate and complete databases that should complete and upgrade current *CRREM* data. Besides, policies to meet *EU* commitments to *COP21* will change over time. Both will be displayed on the project's webpage and be incorporated in reports, databases and tools to ensure the most accurate results.

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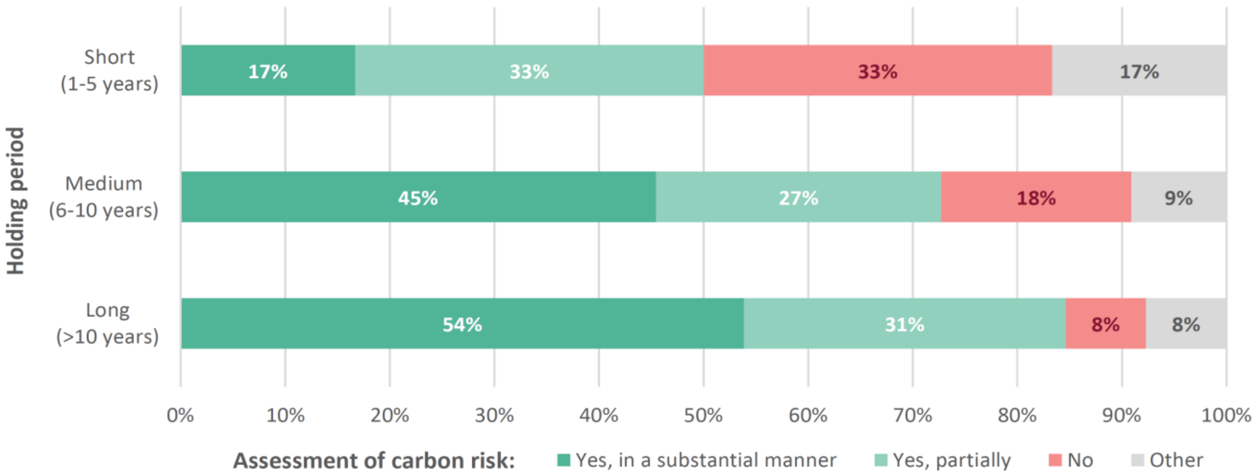
RISK AWARENESS IN THE *EU* REAL ESTATE SECTOR

CRREM conducted an industry survey representing **EUR 260 billion assets under management** to understand how European real estate Investors currently measure and reduce carbon risks. Respondents to the survey ranged from large listed real estate companies to smaller unlisted real estate funds.

Board attention for carbon-risk needs further improvement. Of all survey participants, **50% state that decarbonisation is not discussed in the board room** or only to a limited extent. In line with that finding, 18% do not perform any carbon risk assessments for their portfolio and 32% only do so partially.

Long-term holdings stressing the need for carbon assessment. Holding periods are deemed a key factor in conceptualising carbon risk assessment and mitigation strategies (see Figure D-3). Participant regarded assets as **medium-to-long term investment**, as **holding periods of five to ten years** was the most common amongst respondents (38%). More than 19% of total respondents deemed their real estate assets to have a useful economic life in **excess of 30 years.** Given such extended holding periods the **long-term refurbishment strategies and potential retrofitting of assets should be a primary consideration**.

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



Source: CRREM.

The survey shows that the **use of carbon risk assessments has increased**. 50% of respondents first introduced carbon risk assessment tools within their corporate structure after 2010 – compared to 19% who did so earlier. **Less than 60% of all respondents were familiar with the term 'stranded assets' (not only in relation to the real estate sector), a fundamental term to carbon risk management**, as it describes the risk of premature write-downs or devaluations due to, for example, strengthened carbon regulation or market expectations regarding energy efficiency. Carbon risk assessments were common, with 33% or respondents undertaking one for their entire real estate portfolio and a further 38% detailing partial application. In contrast **25% of respondents did not undertake any carbon risk assessments.**

Looking beyond pure operational energy consumption will be a key challenge. Operating energy consumption is well captured across the industry with 59% of respondents confirming portfolio coverage of 76% and upwards. However, there is **still significant scope for greater data capture**, **monitoring and analysis of operational energy consumption** what is deemed a key base line indicator for informing carbon reduction strategies (see Figure D-4).

Embodied carbon is not well captured with two thirds of the respondents not accounting for this. Most market **participants stated that they currently only focus on operational carbon from buildings.** To fully decarbonize the construction supply chain, more advanced techniques like Life Cycle Assessments (LCA) and Whole-Life Carbon (WLC) assessments will need to be further promoted.

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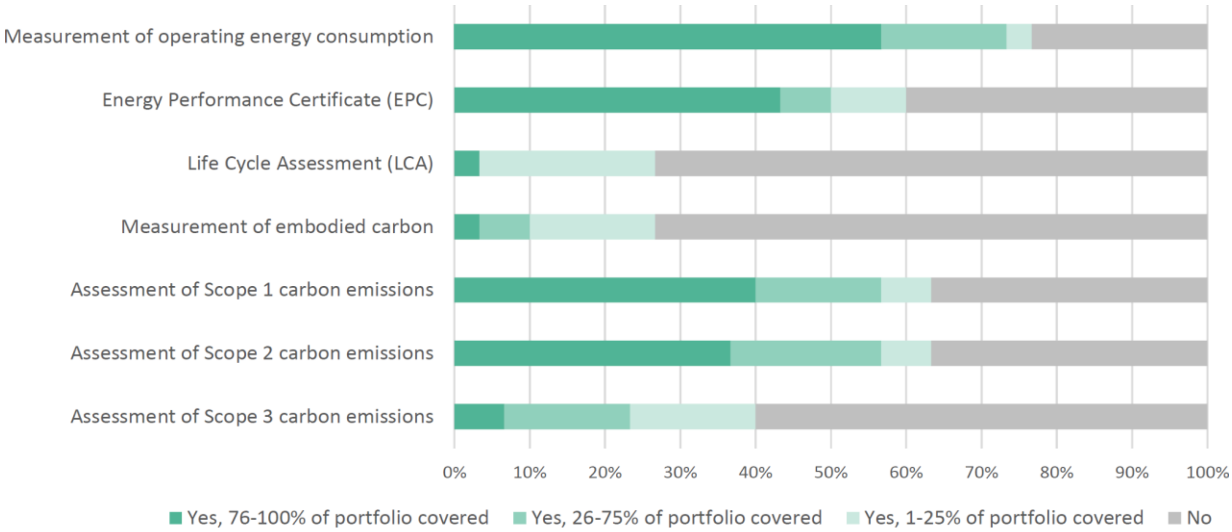
Figure D-4: Applied measures for assessing carbon risks

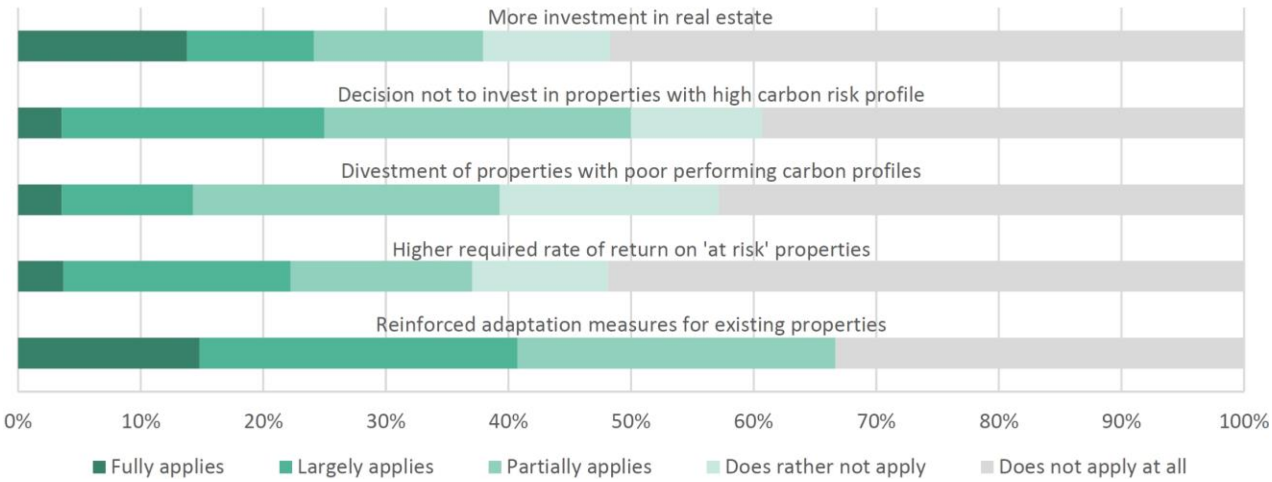


Source: CRREM.

Already 24% of the investors stated that they would require a risk-premium for properties with a poor carbon footprint. 15% even consider disinvestment of buildings with poor performing carbon profiles (see Figure D-5).

Carbon impact on allocation, transaction and prices on the rise. Respondents also made a clear statement regarding their **motivation for energetic retrofits**: it's either **compliance with regulation (60%) or higher profits (74%).** This is an important finding for policy makers to select the 'right' instruments to trigger higher retrofitting rates for the existing building stock. **40% of market participants state that their internal targets are already higher than what is presently required by regulation**. 74% are even aiming to increase their financial budget for retrofits within the next five years significantly. **Energy efficient improvement was seen as the key approach to decarbonise**. More than one third of respondents used green lease terms. **Changes still largely driven by regulation and profits**

Figure D-5: Impact of carbon assessment on real estate decision making



Source: CRREM.

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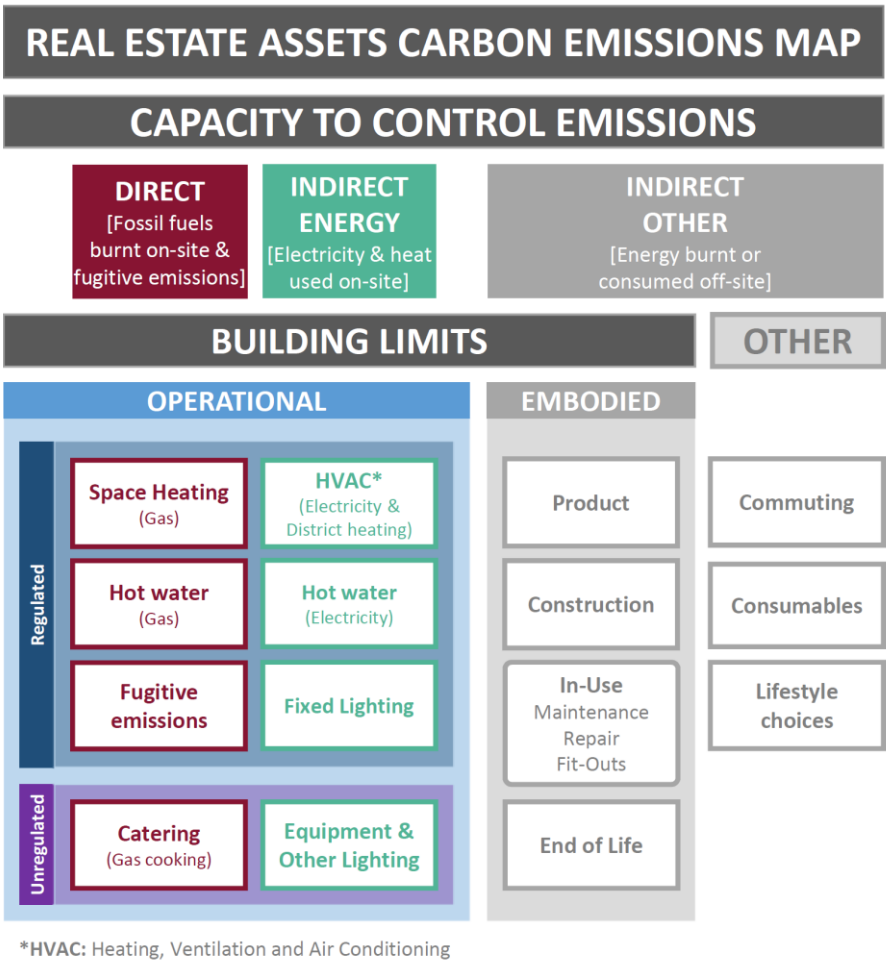
D.2 RISK ASSESSMENT: CARBON RESPONSIBILITIES

BUILDINGS: ASSESSMENT AND DISTRIBUTION OF CARBON EMISSIONS

There are **different classifications that structure the energy consumption and carbon emissions** released by the built environment. Figure D-6 shows an overview of how carbon emissions released within the built environment can be classified[108]. The main categories differentiate emissions between **(1) direct and indirect emissions, (2) operational and embodied** and **(3) regulated and unregulated.** Emissions can be further classified as **(4) emission accountable to different stakeholders: landlords/investors, tenants, property managers, supplier** or, in particular regarding reporting, as **(5) Scope 1 (direct), Scope 2 (indirect purchased energy) or Scope 3 (indirect other) emissions.** Table D-1 provides a summary of minimum input data on property level that is necessary to conduct a comprehensive assessment of current and projected future carbon performance.

Figure D-6: Carbon emissions in the built environment



Source: CRREM.

[108] The figure does not intend to provide an exhaustive list of all possible emission sources, but an illustrative example of the most common situation.

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CALCULATING EMISSIONS: CARBON EMISSION CONVERSION FACTORS

Energy consumption in buildings can be easily monitored using the metered energy supplied by energy providers. The most common method to calculate the carbon emissions released by the built environment is converting the amount of **energy consumed in the asset (kWh) into carbon emissions (kgCO_2e)**. This conversion is done by means of so-called **Carbon Emission Conversion Factors** (also called emissions factors, carbon factors, fuel intensity factors). These are fuel-specific coefficients, generally expressed in kgCO_2e/kWh, that are normally **calculated or validated by national or supra-national administrations for a consistent GHG reporting within their geographical boundaries.**

The calculation of carbon emission factors for end-use energy sources includes the upstream carbon emissions released by fuel management, including 'well-to-tank' (extraction), transportation, and conversion processes. These upstream emissions vary depending on the energy source and location of extraction point, but they often represent a minimal proportion of the final carbon factor.

Biomass is a renewable source that can be used as a primary energy source (wood, pellets) or as a secondary energy source, after processing it into biofuels. The emission factors of biomass vary depending on the source of the biomass (wood chips, logs, pellets, straw), but they **are close to zero** (0.00023-0.02089 kgCO_2e/kWh) because they account for the fact that this CO_2 was absorbed from the atmosphere during the plants' growth stage.

Static carbon intensity factors: The conversion factor of some energy sources can be considered static, both geographically and in time. Despite the differences in the upstream emissions, the variation in carbon intensity of burning these fuels is negligible as most of the emissions are released during the burning process. The end-use energy sources that fall into this category are all fossil fuels and the renewable sources generated and consumed in the same location. The emission factor of **on-site generated end-use renewable sources (photovoltaic panels) is normally assumed to be zero.**

Variable carbon intensity factors: The conversion factors of electricity and biomass vary in time and in location. The conversion factor of **electricity** varies depending on the mix of fuels used to generate it. The combination of fuels largely depends on each country's energy policy and strategies. As electricity grids are usually controlled at a national level, conversion factors are usually calculated annually with generation data from electricity providers. Figure D-7 shows the proportion of fuel mix in eight European countries. According to data from *European Environment Agency*[1] the emission factors of electricity in France (0.0348 kgCO_2/kWh) and Sweden (0.0105 kgCO_2/kWh) are low because of the high proportion of nuclear and renewable energy sources in their fuel mix. On the other hand, the factors for Greece (0.8299) and Ireland (0.4556) are much higher due to the high proportion of fossil fuels used to generate electricity.

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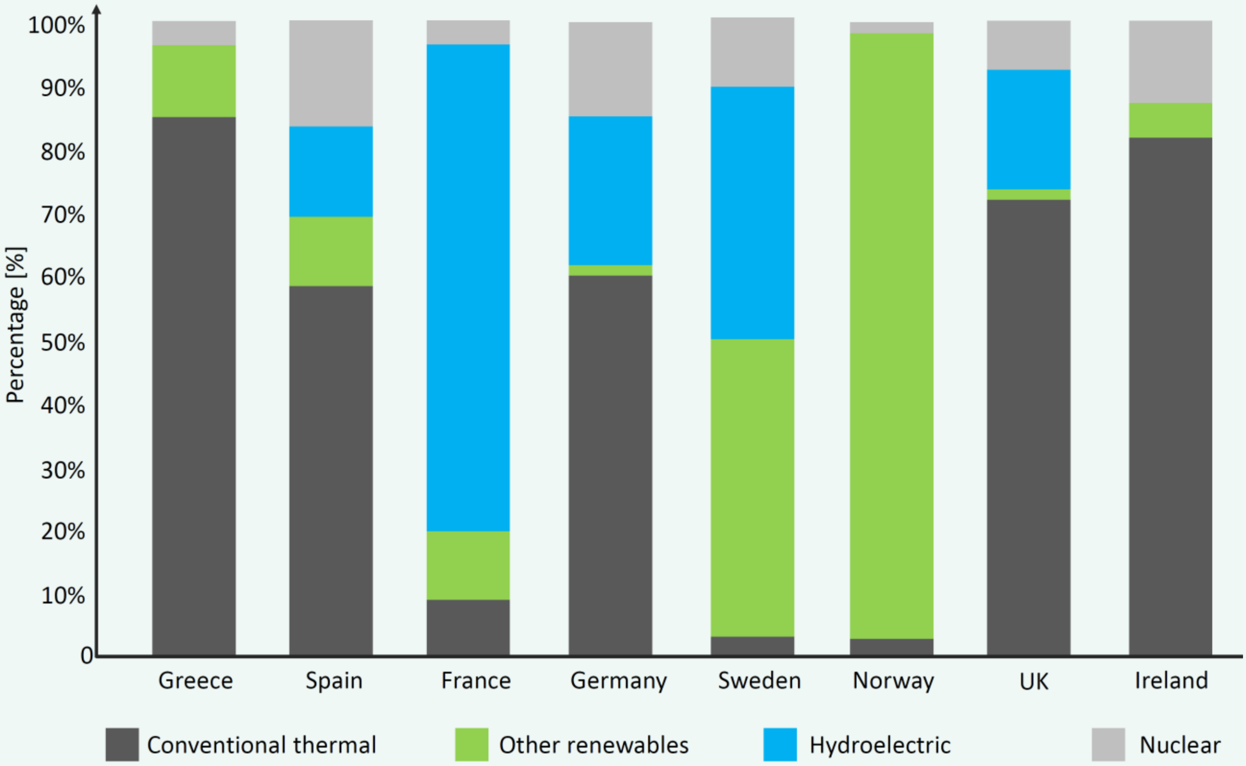
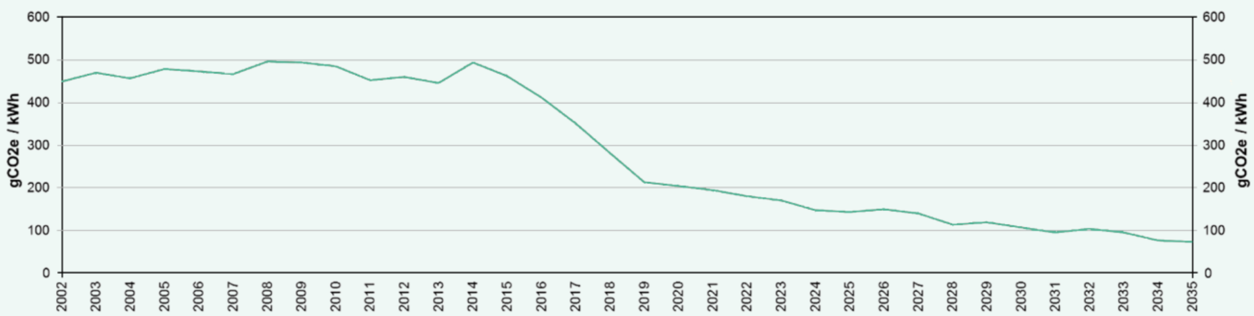
Figure D-7: Proportion of fuels in the electricity generation in 8 European countries (in %)



Source: Roberts et al., 2015.

These emission factors can also vary over time if new policies are introduced to change the fuel mix. For example, since 2016 *UK* policy aims to terminate the use of coal to generate electricity by 2025[1]. Figure D-8 illustrates the impact that this policy change has in the *UK* electricity grid.

Figure D-8: Past and future projections (2002-2035) of UK electricity grid factor (gCO_2e/kWh)



Source: CRREM with data from BEIS.

Regarding the real estate industry, the progressing **decarbonisation of electricity generation will 'automatically' result in a reduction of the carbon footprint of buildings**. The same amount of consumed electricity will result in lower Scope 2 emissions without the need for any costly retrofit or other saving measures. 'Grid decarbonisation' also affects many Scope 3 emissions since the lower emission factor applies to all electricity consumption in the relevant downstream and upstream activities. See Page D.23 for further information on this topic.

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Table D-1: Necessary input data on property level for comprehensive carbon accounting

INDICATOR	UNIT
Total electricity consumption (Elec-Abs)	kWh
Imported (standard mix)	kWh
Imported (renewable sources)	kWh
On-site generation and consumption from on-site renewables (e.g. PV)	kWh
Total district heating consumption (DH-Abs)	kWh
Source of district heating	
Total district cooling consumption (DC-Abs)	kWh
Source of district cooling	
Total fuel consumption (Fuels-Abs)	
Fossil fuels (Specified by type of fossil fuel)	kWh / m^3 / lt
On-site renewables (e.g. DHW solar panels)	kWh
On-site burning of off-site renewables (e.g. bio fuels)	kWh
Total direct greenhouse gas (GHG) emissions (GHG-Dir-Abs)	$kgCO_2e$
Including emissions from burning fossil fuels and fugitive losses	
Total indirect greenhouse gas (GHG) emissions (GHG-Indir-Abs)	$kgCO_2e$
Location-based emissions	$kgCO_2e$
Optional: Market-based emissions	$kgCO_2e$
GHG emissions intensity from building energy consumption (GHG-Int)	
(GHG-Dir-Abs + GHG-Indir-Abs) / floor area*	$kgCO_2e$ / floor area*
Share of vacant floor area	%
Floor area	m^2
Type of use	
Length of reporting period	months
Year of assessment	yyyy
Location	NUTS-3 unit**

**) if not the whole building area, the applied floor area has to correspond to that areas for which energy consumption and GHG emissions are indicated for (landlord, common and/or tenant areas)*

***) NUTS-3 is the most detailed level of the EU-wide, hierarchical geocoding system ('Nomenclature des unites territoriales statistiques')*

Source: CRREM; EPRA, 2017.

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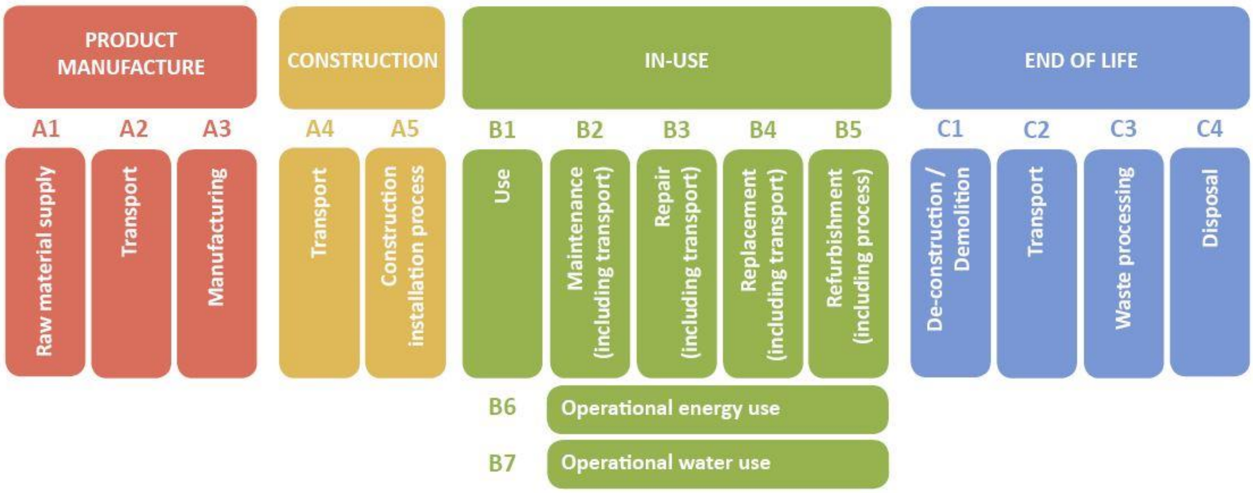
Operational and Embodied carbon – Life-Cycle emissions

A Life Cycle Assessment (LCA) seeks to '*quantify and address the environmental aspects and potential environmental impacts throughout a product's life cycle from raw material extraction through to end-of-life waste treatment*'.[109] The Product Life Cycle is defined by different standards, including **ISO 14040:2006**[110] and **ISO 14044:2006**[111]. The **GHG Product Life Cycle Accounting and Reporting Standard**[112] seeks to consistently report and quantify LCA analyses. The standards that define the different sources of carbon emissions in buildings are ***CEN/TC 350***[113] and the national application of ***EN 15978***[114]. *EN 15978* identifies four stages in the life of a building: product manufacture, construction, in-use and end-of-life (see Figure D-9). It also details subcategories to pinpoint specific sources of emissions. **'Product manufacture'** includes the extraction of raw materials, transport to a point of manufacture and the process of transforming them into construction products. **'Construction'** involves the transportation of construction products to site and the on-site processes involved in assembling them into a building. **'In-use'** covers the maintenance, repair, replacement and refurbishment cycles of the building as well as the use of energy and water during its occupation. In the final stage, **'End-of-Life'**, the building is deconstructed and its redundant components transported off-site, processed and disposed of.

Figure D-9: EN 15978 Building Life-Cycle Stages



Source: EN 15978, BSI, 2011.

OPERATIONAL CARBON EMISSIONS: According to *EN 15978*, operational carbon emissions are those caused by the **energy consumed by building-integrated technical systems** during the operation of the building. Operational carbon emissions include heating, cooling, ventilation, lighting, cooking, IT and equipment, etc. Following *EN 15978* classification, these emissions fall within **stage B6**, but they are usually the largest source of emissions during the lifetime of the building.

[109] GHG Protocol, 2011b, p. 21.
[110] ISO, 2006a
[111] ISO, 2006b
[112] GHG Protocol, 2011b.
[113] European Committee for Standardization CEN/TC 350 – Sustainability of construction works.
[114] BSI, 2011.

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EMBODIED CARBON EMISSIONS: Embodied carbon can be defined as the total GHG emissions generated to produce, maintain and dispose a built asset. This includes emissions related to the extraction, manufacturing, transportation and assembly of every building material used to build an asset. **Most frameworks also include maintenance, replacement, retrofits, and disposal/demolition of an asset.** Generally, it excludes operational emissions[115]. According to ***EN 15978*****,** embodied carbon emissions in the built environment are the emissions that fall **into all the categories defined in Figure D-9 except for category 'B6: Operational Carbon Emissions'**. These emissions include **the downstream and upstream supply chain activities** to construct, maintain and deconstruct buildings and all their materials and components throughout the asset's life.

The proportion between embodied and operational carbon in the life cycle of building components is often underestimated. Even without considering any future grid decarbonisation, **embodied carbon from newly constructed buildings from today until 2050 equals their cumulative operational GHG emissions in the same period**[116]. Foreseeable grid decarbonisation will further decrease the GHG emission related to operational energy consumption and increase the importance of reducing embodied carbon.

Figure D-10 illustrates an example of this varying proportion between operational and embodied carbon. It describes the LCA impact (embodied and operational carbon) of four retrofit scenarios in the same building, each with different targets of energy efficiency. The reduction of operational carbon emissions usually compensates the surplus of embodied carbon that can be attributed to the retrofit. However, **once the operational emissions reach a certain low carbon intensity, the embodied carbon impact of further reducing these emissions can exceed the expected operational benefits**.[117,118,119] Figure D-10 also provides an actual example from a constructed building: the *UK WWF* headquarters in Woking. This building was already designed to achieve a very high environmental and carbon emissions standard. The life cycle analysis demonstrated that upgrading the glazing system from double to triple glazing could have saved an extra 11.6 tCO_2e in operational carbon emissions. However, the embodied carbon cost of this change will have exceeded 13 tCO_2e and therefore, the building was constructed with double glazing. In summary, it is not automatically the best environmental option to always aim for zero-operational-carbon-emissions; investors should always aim to achieve the right balance between embodied and operational carbon.

This example demonstrates, that a net positive environmental benefit can only be ensured, if one takes into account the reduction of operational carbon emissions of a retrofit measure as well as the amount of embodied carbon emitted as a consequence of the retrofit.

115 UK Green Building Council, 2017, p. 4.
116 Bionova Ltd., 2018.
117 Xing/Hewitt/Griffiths, 2011.
118 Strachan, 2017.
119 Simpson et al., 2015.

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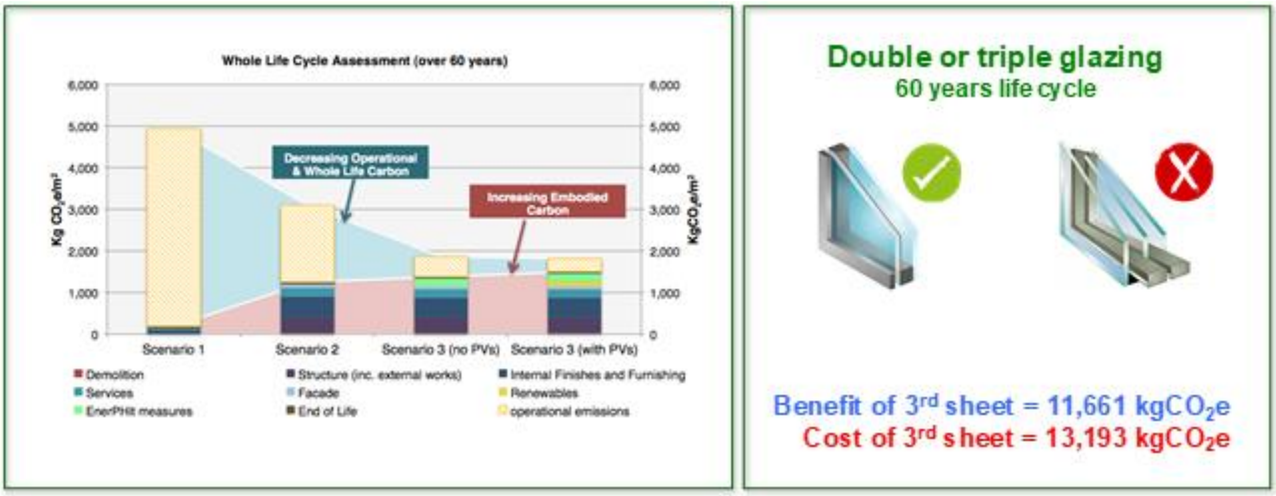
Figure D-10: Whole-Life Carbon emissions – Operational vs Embodied



Source: Simon Sturgis – Sturgis Carbon Profiling.

The quantification of the embodied carbon impact of any intervention in buildings is a complex analytical exercise currently performed on a building by building basis. However, the quantification and reduction of embodied carbon emissions is crucial to **drive product choices (demand) towards less carbon intensive markets (supply). Embodied carbon reduction influences the choice between markets and sectors** and their specific carbon reduction targets, for example, between the concrete, timber and steel manufacture sectors. Therefore, design teams must specify the lowest carbon material, driving the growth of low carbon markets towards the lowest carbon intensive economy possible.

CRREM APPROACH FOR CONSIDERING EMBODIED CARBON

The consideration of embodied carbon due to retrofit measures must be aligned with the life-cycle approach, considering all GHG emissions related to the disposal of replaced material as well as the production, transfer and installation of new materials. The number of variables included in the process (transportation distance and means of transport, carbon intensity of electricity grids in multiple manufacturing countries, quantities of materials used, design approaches) makes any prediction of the precise embodied carbon intensity of retrofit interventions a very complex task. Against this background, in order to derive more reliable input owners are encouraged to acquire data from their suppliers and in accordance with *ISO 21930: 2017* and *EN 15804*, which define core rules for environmental product declarations (EPD) for the construction sector.

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Regulated and unregulated emissions – Energy Performance Certificates

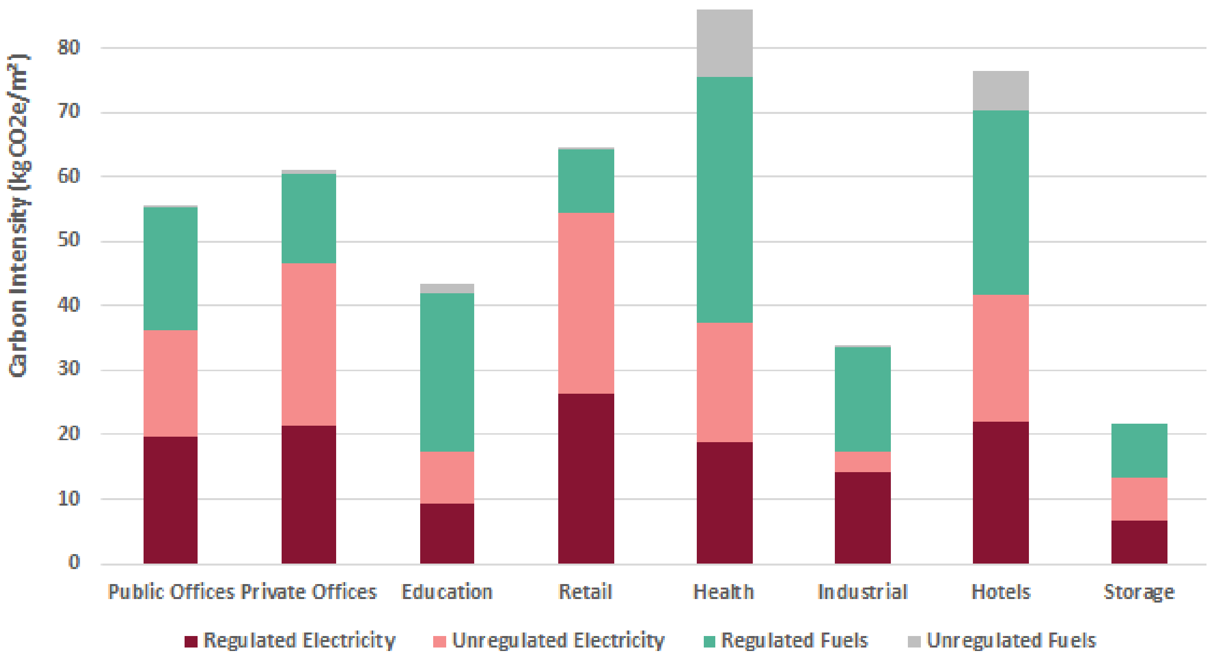
Depending on their level of control by building regulations, **operational carbon emissions** are normally divided into:

Regulated carbon emissions are the emissions accounted **and controlled by *EU* member states' building regulations**, compliant with the minimum scopes set by the *EPBD* in its Annex I[120]. Building regulations control the thermal characteristics of the fabric; **heating, ventilation and air conditioning (HVAC) and hot water installations, built-in lighting, the impact of building design and orientation, and the production of renewable energy**. Therefore, all energy consumption that is affected by these components is regulated by *EPBD* and national building regulations. These are the only carbon emissions included in the Energy Performance Certificates (EPC), whose calculation methodology framework is also outlined by the *EPBD*.

Unregulated carbon emissions are all other operational carbon emissions released by energy consumption within a building, which are **not controlled by the *EPBD*** and subsequent building regulations. These emissions are not accounted in EPCs. They usually encompass equipment and lighting and emissions from cooking/catering. The amount and source of unregulated carbon emissions can greatly vary depending on the building use, occupant behaviour and culture. In office buildings these usually include IT equipment, small appliances and lighting, in hospitals they entail large medical equipment, and in the industrial sector they may include the energy consumption of any manufacturing process. Figure D-11 illustrates some of these differences.

EN 15978's definition of operational carbon is 'emissions from energy used by building-integrated technical systems during the operation of the building'. This definition was developed to 'comply with the *EPBD (2002/91/EC, 2010/31/EC)* and its national implementations'. However, *EN 15978* also acknowledges unregulated carbon emissions, which can be accounted within B6 stage (see Figure D-9), but need to be reported and communicated separately.

Figure D-11: Differences between regulated and unregulated emissions in different commercial real estate subsectors (England and Wales)



Source: BEES, 2016b, own calculations.

[120] European Commission, 2011.

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Following the *EPBD*, all *EU* member states have developed methodologies to calculate **regulated carbon emissions** from buildings and report them in official *EPC*s. These methodologies are **based on building modelling** software that predict energy consumption at the design stage and predictions often vary from actual performance of buildings (performance gap). Calculations follow the same framework set by the *EPBD*, but they are different in each country and therefore, results and *EPC*s are usually not comparable.

The *EPBD* targets the carbon emissions that are dependent on the building fabric and installed equipment before occupation. The reason why the *EPBD* limited the scope is because these emissions are easier to model and control during the design stage, when projects need to comply with building regulations. Most data collected by projects and initiatives within the *EPBD* framework – including the development of EPCs, the *BSO*, *ENTRANZE* – only include regulated carbon emissions. However, the carbon budgets and targets set for the real estate sector in SECTION C aim to reduce emissions released by all energy consumption within commercial buildings, whether regulated or not. This is in line with the efforts of the ***Science-based Targets Initiative*** and the *'Framework for "carbon-neutral buildings and sites"'* of the *German Sustainable Building Council*[121], both aiming to set targets to emissions released by all energy consumption within buildings, whether they are regulated or not.

Unregulated energy consumption largely depends on the fit-out and use of the building rather than on the building characteristics or location. **Benchmarks based on actual energy consumption of buildings for each typology can be used to complement regulated carbon emissions data.** These unregulated energy consumption profiles are considered comparable in all *EU* countries for the same sector and subsector.

Energy Performance Certificates – only a starting point for carbon strategies

EPCs need to be issued when buildings or units are constructed, sold or rented out. They are intended for owners or tenants to compare and assess the energy performance of different buildings or units. EPCs also include recommendations for cost-effective improvement of the energy performance of buildings.

The implementation of the *EPBD* in all *EU* member states has made EPCs **widely available** for all assets in the real estate market. Besides, as they need to be issued for every building sale or rental transaction, the development of the document **cannot involve a costly or lengthy process** and therefore, all governments have developed their own simplified calculation methodology to develop EPCs and calculate energy performance. As a result, the use of EPCs has extended beyond its original intention – providing a reference to prospective tenants or buyers – to **become a widely used tool for investors, asset managers and landlords to assess the energy efficiency of their assets.** This approach is understandable because EPCs are the only source of information available for most buildings. However, **currently EPCs are not a valid tool to assess stranding risks**, for a number of reasons:

- **Focus and intended users:** EPCs are developed within the *EPBD's* framework and therefore they only asses part of the carbon emissions released by buildings: Regulated carbon emissions. This information is useful for occupants aiming to assess and compare different options to rent or buy. Occupants can control their unregulated carbon emission, which depend on their own activities. However, they cannot predict the amount of energy required to condition the building: cooling, heating, lighting, etc. Therefore, EPCs aim to provide them with this information. However, to avoid stranding risk, both regulated and unregulated emissions and energy demand need to be targeted.
- **Accuracy:** In order to ensure a wide implementation of *EPBD*, EPCs needed to be developed and issued within a reduced cost and time frame, while ensuring a minimum quality. **Data** to develop EPCs are collected following a non-invasive and often quick survey of the property. EPC calculation uses **simplified methodologies** to estimate the energy efficiency of buildings to ensure quick results. The calculations heavily rely on rough **assumptions** (often worst-case scenario) applied where specific values could not be surveyed. For example, if valid evidence of

[121] DGNB, 2018.

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insulation in a specific wall cannot be gathered, the calculation methodology will normally assume there is no insulation in that wall. Consequently, results shown in EPCs can significantly vary: some studies[122] estimate that the results in EPCs can differ from different assessors in up to ±45% for the same property because of the different approaches in data collection (survey), selection of default values (assumptions) and simplified calculation methodologies.

- **Performance gap:** The simplified calculation methodologies used to issue EPCs also needs to estimate the energy efficiency of new buildings or retrofits at design stage, before they have been occupied. Therefore, methodologies often rely on building models instead of actual data. Initiatives like *Carbon Buzz*[123] demonstrate that often there are large differences between the predicted results and the actual consumption and emissions obtained from metered data after the building is occupied.
- **Indicators:** *EPBD* requirements on data indicators to be included in the final EPCs are very limited. They are only required to include the 'energy performance of buildings and reference values such as minimum energy performance requirements'. EPCs may also include 'additional information such as the annual energy consumption for non-residential buildings and the percentage of energy from renewable sources in the total energy consumption.' However, there is no clear definition of indicators, units, calculation methodology and scope. This lack of definition has led to a situation where EPCs are calculated following different methodologies in each country. Therefore, even if EPCs contain the same indicators, they are often not comparable.
- **Embodied carbon:** EPCs do not include any reference to the wider carbon implications that improving the energy efficiency of a building entails.
- **Performance measurement:** EPCs are static. They do not comprise any science-based and dynamic target setting in terms of emissions reduction pathways and they are not linked to any ongoing monitoring process or corporate controlling tools. In order to wind down the carbon footprint by 2050, investors need to assess and monitor their assets' environmental footprint on an ongoing basis, which would not be possible just using EPCs. Furthermore, EPCs do not account for the effects of electric grid decarbonisation (see Page D.23) and the effect of climate change on future heating and cooling loads (see Page D.35).
- **Cost-benefit Analysis:** EPCs only provide a basic set of cost-effective measures that could be implemented to improve the carbon footprint of the building. However, they often do not provide exact results of the level of carbon intensity reduction of each measure. Furthermore, EPCs don't provide stakeholders with any information on the future costs of energy and GHG emissions (keyword carbon tax). Therefore, it is very difficult to perform cost-benefit analysis based on different mitigation strategies/options (regarding the timing and extent of retrofit actions) with the information provided in the EPC only.

In spite of these limitations, *EPBD* and EPCs are still the most widely available and affordable source of energy efficiency information to assess the current energy profile of the EU building stock. The European Commission is currently (2019) providing funding to develop the 'Next-generation of Energy Performance Assessment and Certification' to 'enable the roll-out of next-generation of energy performance assessment and certification, with a view to achieve enhanced reliability, cost-effectiveness and compliance' [124] This is aligned with *CRREM's* policy recommendations to the *EC* to increase the efforts to collect more and better data in order to improve existing databases on the building stock like the BSO. Nevertheless, considering the time and cost constrains, it is unlikely that the next generation of EPCs will include all the information required to assess stranding risk and execute a defined carbon strategy for a given real estate portfolio. However, if data collection, estimations, output indicators and normalization of the calculations of carbon emissions (even if only regulated) achieve sufficient accuracy to assess stranding risk, future updates of *CRREM* outputs will adopt these changes to facilitate data input from users. Meanwhile**, *CRREM* recommends investors gather data and estimate energy demand and carbon emissions using metered data.**

[122] BPIE, 2010, p. 13.

[123] CIBSE, 2018.

[124] European Commission, 2018c.

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CRREM APPROACH FOR CALCULATING UNREGULATED OPERATIONAL CARBON EMISSIONS

The primary source considered by *CRREM* is the data collected by the ***Building Energy Efficiency Survey (BEES)***. This survey, promoted by the United Kingdom's *Department for Business, Energy & Industrial Action (BEIS)*, reports on the energy consumption (regulated and unregulated) of the non-domestic building stock in England and Wales in 2014–15. Within this overall scope the stock is split into 10 sectors. These are in turn made up of 38 subsectors, each of which was analysed separately. The energy consumption data collected by a large sample of telephone surveys were the primary input into two models: an energy use model, tailored to each subsector, calculated each premises' annual energy use, broken down by end use. For each subsector, *BEES* consumption data is broken down into a range of end uses such as heating, hot water, fans, lighting. This enables the consideration of climate conditions and emission factors, when calculating the **typical ratio of unregulated and regulated emissions for each country and subsector of commercial real estate**.

The secondary source of information to define unregulated energy consumption are the databases provided by ***GRESB***, linked to their ***Global Environmental, Social and Governance Benchmark assessment for Real Assets***. Data provided by *GRESB* is further used to cover some commercial real estate subsectors where the *BEES* typology deviates from that used by *CRREM*.

Direct and Indirect emissions – Scopes 1, 2 and 3

The *GHG protocol* classifies carbon emissions in three Scopes depending on the capacity of the reporting institution to control them (see section B.2 for a general introduction of the *GHG protocol*). The classification into one of the three Scopes is closely related to the concept of **direct and indirect emissions**. In the context of the built environment, **direct emissions occur through fuel burning (mainly fossil fuels and biomass) within the building boundaries, whereas indirect emissions are released outside the building's boundaries (including the generation of electricity consumed in the building).**

Energy related carbon emissions of the global commercial real estate sector depicts a steadily rising trend (see Figure D-12). The steepest rise, however, is attributable to indirect emissions associated with purchased electricity and heat, while direct emissions from real estate have remained predominantly constant. This increase of indirect emissions is to a large degree associated with the growing number of electronic appliances in all types of buildings, diminishing the effect of improved energy efficiency of appliances.

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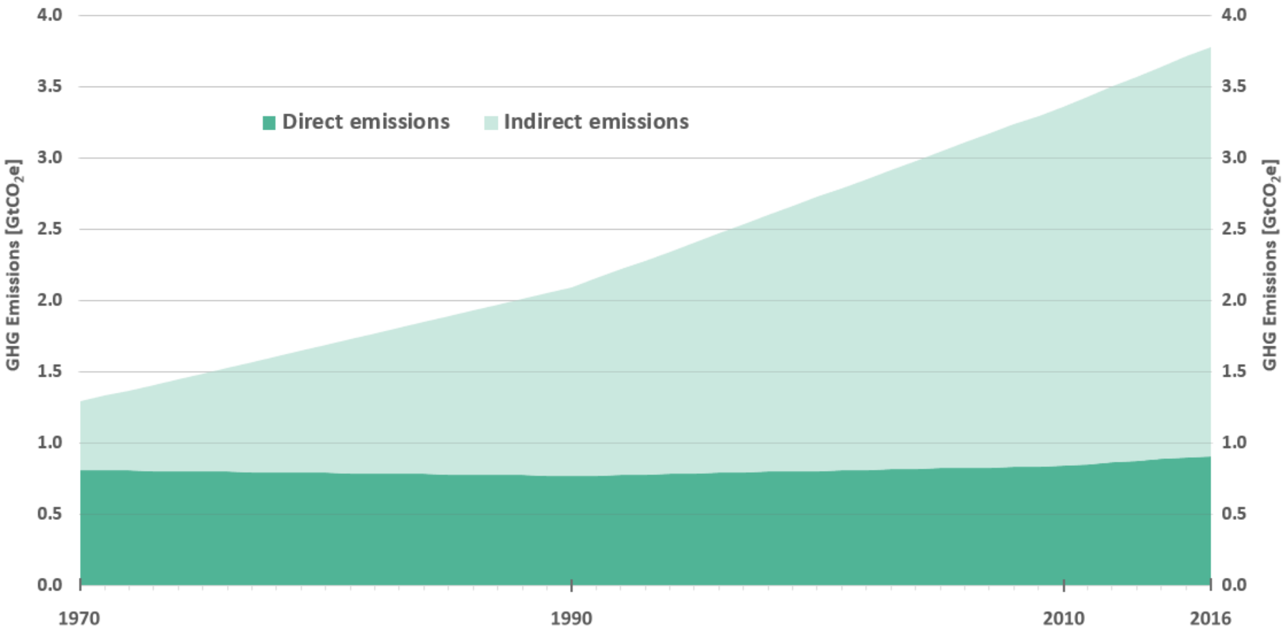
Figure D-12: Global direct and indirect emissions (from electricity and heat production) in commercial buildings (in $GtCO_2e$)



Source: IPCC, 2014; UN Environment and International Energy Agency, 2017.

Scope 1 – Direct emissions: fossil fuels and refrigerant losses

Scope 1 includes all **direct carbon emissions**. Regarding buildings, the main source of Scope 1 carbon emissions is burning fossil fuels and to a lesser extent biomass to **produce heat**: space heating, production of domestic hot water (DHW) and cooking. The most common fuels used in the built environment are gaseous (natural gas being the most common), liquid (e.g., heating oil) or solid (mainly coal and biomass).

The other significant sources of Scope 1 GHG emissions are **fugitive emissions** released through leaks during the use of refrigeration and air conditioning equipment. Globally and considering all economic sectors, Fluorinated gases (F-gases) aggregate to around 2% of Global Warming Potential (GWP) weighted share of global GHG (see Annex 2). **According to the 2014 *Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)*, buildings account for 'an eighth to a third of F-gases'** [125]**.** Fluorinated gases are emitted **'primarily from cooling/refrigeration and insulation with foams'.** Emissions associated with cooling or refrigeration are regarded as direct emissions, whereas emissions produced during manufacturing insulation materials rank among indirect emissions (embodied carbon, see page D.24). As a consequence of stricter regulation, the use of F-gases has significantly dropped in the *EU*.

Most of the databases, *EU* data repositories and sources available – such as *Building Stock Observatory* – collect information on fuel in a set of simplified categories: natural gas, oil, biomass and coal, which are easier to identify by the general public and compromise most of the energy consumption of the *EU*. HFC fugitive emissions largely depend on the specific equipment within a certain building. The global warming potential of the refrigerants listed by the *Kyoto Protocol* and *Montreal Protocol* is known, based on *IPCC's Fourth Assessment Report (AR4)* over a 100-year period (see

[125] IPCC, 2014.

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Annex 2: Global warming potential of Green House Gases: CO_2E).

The downscaling of global carbon emissions budgets to the property level (see section C.2) requires consistent information on carbon emissions in the individual *EU* member states and subsectors of commercial real estate. These emissions data can be derived from *EU* databases with information on energy consumption of each of these sources and the refrigerant leaks using the *UK's* official conversion factors for GHG reporting[126]. These conversion factors are considered constant over time for Scope 1 fuels and refrigerants, and the technology used to burn the fuels is considered consistent throughout the *EU* member states.

Scope 2 – Energy indirect emissions: electricity and district heating/cooling

As defined in the *GHG protocol*[127], (see Section B.2) **Scope 2 includes indirect 'emissions from the generation of purchased or acquired electricity, steam, heat, or cooling'**. In buildings, the typical source of Scope 2 carbon emissions is electricity consumption, but the carbon emissions from purchased heat or cooling are also included – for example, heat purchased from district heating networks or from an external combined heat and power (CHP) plant.

Due to the versatility of electricity, every system within a building can be powered by electricity and release Scope 2 emissions, including systems that could be powered on-site by burning fossil fuels. Data sources on consumption or emissions by fuel or end use (e.g. *ENTRANZE*[128], *Odyssee*[129]) only provide average consumption values, either per fuel without specifying the end use, or per end use without specifying the fuel. Therefore, the comparison of any specific building with the average sector may present differences when an asset deviates from the average distribution of fossil fuels and electricity.

The **carbon footprints (kgCO_2e/kWh) of the electricity grids vary depending on the mix of fuels that it is used for generation.** Variations amongst territories respond to the energy strategy of each country. Furthermore, the carbon footprint of the electricity grid also varies over time. Energy providers need to meet the electricity demand and use fossil fuels to complement renewable and nuclear electricity generation, because these sources of electricity cannot be adjusted to meet the demand. **Organisations may choose energy providers which only supply renewable energy** (see 'market-based method' below)**.** Alternatively, they can use available technologies (batteries) to store less carbon intensive electricity during off-peak times and use it afterwards. To accommodate these possibilities, the ***GHG Protocol*** defines two calculation methods:

(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 (**using mostly grid-average emission factor data**). Emission factors are often defined using geographic locations. These can be based on local, or subnational boundaries, but most often are based on national boundaries.

(2) The **market-based method** quantifies Scope 2 GHG emissions **based on emissions by the generators from which the entity purchases electricity**. The market-based method reflects the GHG emissions associated with the choices an entity makes on its electricity supplier.

Since a 2015 update of the *GHG Protocol*, companies are recommended to report separately on both location-based and market-based Scope 2 GHG emissions if this is possible. ***EPRA Sustainability Best Practice Recommendations (sBPR)*** **define the location-based method as the minimum reporting requirement.** Emission figures based on the market-based method can be reported optionally as an 'additional performance measure'[130].

[126] BEIS, 2018b.

[127] Greenhouse Gas Protocol, 2015,

[128] Enerdata, 2018

[129] Ademe, 2018

[130] EPRA, 2017.

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The authors suggest the same approach for carbon risk assessment in the real estate sector, since the location-based approach provides comparable data and reflects the average GHG emission in the specific electricity grid a building is connected to. In addition, the market-based method has led to the proliferation of contractual emissions claims that have been difficult to verify and have been prone to errors or double counting. To counter this issue, the *GHG Protocol* has introduced eight market-based Scope 2 minimum quality criteria, that relate to the integrity of contractual instruments[131].

EU countries periodically publish the carbon emissions factors of their electricity grid at a national level. To ensure consistency in calculation methodology and publishing time, the authors encourage pan-European investors to use conversion factors from a single data provider, for example the *European Environment Agency* (*EEA*)[132].

Electricity grid decarbonisation – Evolution of emission factors

In the ***Energy Roadmap 2050***, the ***European Commission (EC)*** defends that 'a secure, competitive and decarbonised energy system in 2050 is possible'[133] and therefore, the *EC* is promoting the progressive decarbonisation of the electricity grid by 2050. **Lower carbon intensity of electricity implies that Scope 2 emissions will decrease in the future due to the efforts of the energy sector to reduce their Scope 1 emissions.** This will happen thanks to a less carbon intensive mix of fuels to produce electricity, which will need to include a higher proportion of renewable and potentially also nuclear energy sources.

The shift from fuel to electricity for providing a certain building with heating energy is a strategic decision of the owner and might substantially affect the chances to meet carbon reduction targets. **However, the real estate industry shall not exclusively rely on the decarbonisation of the grid in order to meet these targets.** This can be regarded as an absolute no-go strategy that will not be enough to reach the ambitious 1.5°C and 2°C targets. Furthermore, leaning back and relying upon grid decarbonisation could lead to something very similar to the well-known **'*Rebound effect*'**: In the context of energy consumption, the *Rebound effect* describes the frequently observed situation that an initial gain in energy efficiency will finally result in far less absolute energy savings (or even an increase of consumption) than originally estimated. Assuming the existence of a potential carbon taxation, grid decarbonisation would result in reduced building operation costs per consumed kWh of electricity without any retrofit action or energy demand reduction efforts. The stranding risk based on a building's carbon footprint would equally be reduced. Based on historic experience, this situation might finally result in far less emission savings than expected and even an increase in consumed energy.

However, the likelihood of the rebound effect may be mitigated by other factors:

Costs: The definition of the rebound effect is based on the theoretical assumption that the decarbonisation is not linked to a general increase of electricity costs. However, future projections of energy costs include increases of electricity costs. For example, the UK *Department for Energy and Climate Change* predicted in December 2017 that the cost of electricity for the services sector could increase between 6-20% from 2018 to 2035[134] assuming several price and growth scenarios. The future costs of electricity will affect the extent to which the real estate sector will shift from fuels to electricity.

Energy demand: Reduced emission factors of electricity will require a larger number of renewable sources. To achieve a higher ratio of renewables, more power generation infrastructure will be required. Depending on future socio-economic circumstances, this infrastructure may not be available on time and therefore, targets to reduce the carbon

[131] GHG Protocol, 2015.

[132] European Environment Agency, 2017.

[133] European Commission, 2012.

[134] Department for Business, Energy and Industrial Strategy (UK), 2018a.

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footprint of the real estate sector may be complemented by targets to reduce the electricity demand, which will require further measures like retrofit actions or on-site electricity generation.

Restrictions to fuel shift: Similarly, the achievement of carbon reduction targets may be bound to limitations in the proportion of emissions that can be achieved by fuel shift from fossil fuels to a low carbon electricity. Uncontrolled shift would lead to a rebound effect: electricity demand will increase proportionally to the reduction of fossil fuels. However, the capacity to finance and construct new infrastructure to produce electricity from renewable or low carbon sources is restricted and the success of the electricity grid decarbonisation will depend on the reduction of the global electricity demand. CRREM project expects future policies to not only limit carbon emissions, but also energy demand, particularly low carbon electricity. CRREM project also expects that exceeding demand reduction targets may have economic implications, like higher taxes or energy costs.

The authors apply current trends of grid decarbonisation considering data from energy models developed by the *European Commission* on the future evolution of the emissions factors of electricity and steam production for each member state available until 2050.[135] These scenarios imply decreasing Scope 2 emissions per unit of consumed electricity, contributing to achieve the sectoral decarbonisation targets. Presuming no significant differences in the share of electricity in total energy consumption for buildings from the same property type, it must be borne in mind, that this 'positive external effect' applies to the whole sector and results in **no improvement of a building's relative competitive position**.

Scope 3 – Other Indirect emissions, embodied carbon.

According to *ISO 14064-1:2018* Scope 3 emissions can be defined as '*other indirect greenhouse gas emission, other than purchased energy-related GHG emissions, which is a consequence of an organisation's activities, but arises from greenhouse gas sources that are owned or controlled by other organisations*. The boundary of Scope 3 carbon emissions can be defined very broadly depending on many carbon reporting objectives. Besides embodied carbon, other type of emissions could be indirectly related to the built environment through activities such as commuting, consumables, and lifestyle choices of occupants. The most widely accepted industry standard for calculating Scope 3 emissions associated with companies is the ***GHG Protocol Corporate Value Chain Standard***[136]. The related ***Product Life Cycle Accounting and Reporting Standard*** looks into the carbon accounting of lifecycle emissions related to individual products[137].

The *GHG Protocol*, divides Scope 3 emissions into two different categories:

- **Emissions from activities in the value chain** of the entities included in the company's organisational boundary (embodied carbon of retrofits);
- **Emissions from leased assets**, investments, and franchises that are excluded from the company's organisational boundary but which the company partially or wholly owns or controls (tenant associated emissions).

One major source of Scope 3 carbon emissions in buildings is **embodied carbon**, emitted by the energy consumed during product manufacture, construction, in-use (including repair, maintenance, etc) and end-of-life. For the existing building stock, the **embodied carbon related to construction work in the past** can be regarded like **'sunk costs'**. The amount is not relevant for future decision making. However, **embodied carbon of retrofit measures** must be taken into consideration if retrofitting shall have an objective positive effect on climate change. Currently, this aspect is not covered in the GHG reporting of companies and retrofit measures are evaluated by their reduction of annual emissions only. **From the landlord/investor perspective, tenant-procured and tenant-sub-metered energy consumption and related carbon emissions are regarded as Scope 3 emissions as well.**

[135] E3M-Lab et al, 2016.

[136] GHG Protocol, 2011a.

[137] GHG Protocol, 2011b.

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STAKEHOLDERS: ALLOCATION OF CARBON REDUCTION RESPONSIBILITIES

Investors shall focus on the carbon risk of real estate on the property – and portfolio – level as well as on company level. This requires the quantification and assessment of all carbon emissions released from buildings irrespective of who has the capacity to control these emissions.

Considering *all* emissions on the property level, one of the main challenges of accounting and reporting carbon emissions in the real estate sector is **the allocation of emissions to the appropriate entity or stakeholder at the various stages in the buildings life cycle. The total carbon emissions need to be fairly and completely distributed** amongst carbon emitting stakeholders, so that each stakeholder can contribute to reduce their share of emissions and achieve the overall target for the asset. This requires the definition of **reporting boundaries**, since the allocation of emissions to Scope 1, 2 or 3 differs fundamentally between investors, asset or property managers and tenants. In this context the definition developed by *EPRA's Sustainability Best Practices Recommendations* is very appropriate*:* '***Boundaries determine the extent of reporting according to assets or organisational activities owned or controlled by the reporting company'***.[138]

One major question in this context is how emissions in investment properties which are leased to third parties should be allocated between investors and tenants. This distribution needs to include all energy consumption and carbon emissions released within the building boundaries, as described in Figure D-13, regardless of who owns those emissions.

Regarding their significance for climate change, it makes no difference whether any part of carbon emissions related to building operation is allocated to Scope 1, 2 or 3 from a tenant or landlord perspective. **The focus of carbon accounting in the built environment should always be the assessment of ALL emissions, no matter which and how stakeholders finally reports them.** Except in the case of owner-occupied buildings, there will be always to some degree shared responsibilities regarding necessary efforts to reduce carbon emissions, either on a behavioural or technical level. **Carbon emissions from tenant energy consumption might be Scope 3 from a landlord's perspective, but it is under his responsibility to take major retrofit measures regarding envelope, HVAC etc**. The carbon risk of a specific building results from its carbon performance in relation to regulatory requirements and market expectations, no matter of how electricity is sub-metered within the building and who therefore allocates the respective emissions as Scope 2 or 3. Off course, an investor owning only a limited share of a certain building doesn't bear the full carbon risk, but in order to assess his specific risk it will be necessary to look at the total emissions from that building in a first step. Consequently, the authors are convinced that **any approach addressing the assessment of carbon risk in the commercial real estate sector has to consider emissions from the entire building**, anyhow, offering users to specify and calculate their individual responsibilities regarding Scope allocation and setting organisational boundaries.

Nevertheless, a separated assessment of different building parts and associated emissions can be advantageous to receive comparable figures on a buildings carbon performance. If, for example, tenant-obtained electricity is unknown to the manager of a shopping centre, carbon intensity figures should reflect this data gap. **The restricted data coverage of a building's total floor area is a very common challenge of carbon assessment.** An additional challenge with regard to the assessment of reliable figures on carbon performance results from vacant spaces. If a certain share of the building's total floor area is vacant and the assessed amount of energy consumption and carbon emissions includes only a limited share of the occupied area, calculations on energy and carbon intensity figures must apply only the covered occupied area as denominator.

A transparent allocation of emissions to the Scopes of individual stakeholders is crucial for all institutions that report carbon emissions independently. Generally, each stakeholder involved in construction, operation and maintenance of a building has its very own possibilities to influence carbon emissions.

[138] EPRA, 2017, p. 41.

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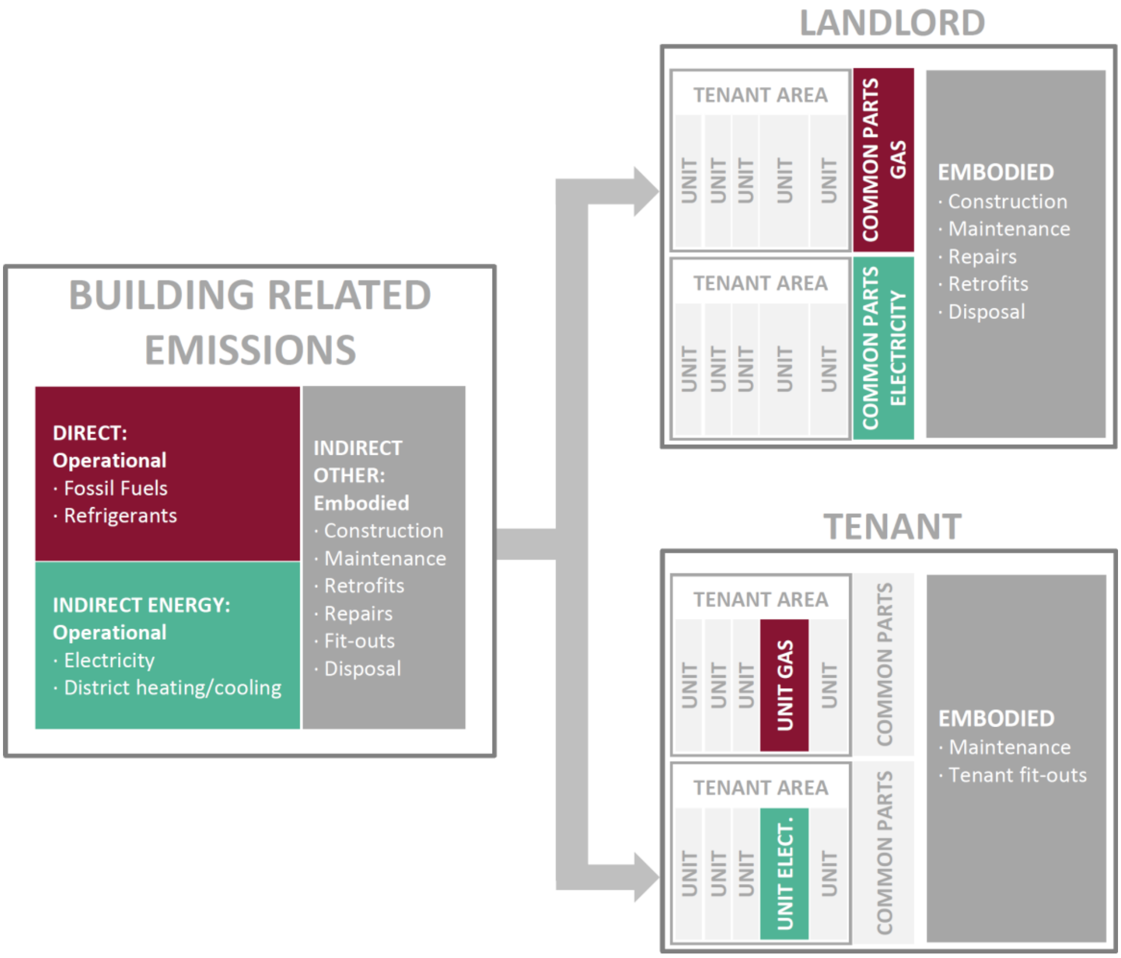
If available, present and expected future **data on the occupancy of buildings** should be combined with the carbon intensity values to account for vacancies. This approach enables the normalisation of current values to the buildings' intrinsic GHG performance[139].

The *GHG Protocol* Corporate *Standard* offers some more flexibility in this regard: if total floor area of a portfolio or building is not available, companies can calculate an average intensity value per asset.[140] However, this procedure should only be an exception.

An operational challenge is the **lack of a standardised European floor area measurement system**. Even a slight difference in the methodology of calculating floor area will change the denominator intensity value, in turn impacting carbon assessment. A widely adopted floor area measurement standard is the ***'International Property Measurement Standards (IPMS)'***. Amongst others, this standard is adopted or recommended by ***RICS*** **(*Royal Institution of Chartered Surveyors)***, and the ***National Australian Built Environment Rating System (NABERS)*** building rating system, as well as *GRESB*. However, global adaptation of the standard is regarded as slow, and there is limited control on whether the standard is implemented correctly. *RICS* offers a free online *IPMS* standard conversion tool[141].

Figure D-13: Allocation of carbon responsibilities to stakeholders



Source: CRREM

[139] UNEP, 2009.

[140] GHG Protocol, 2011a, p. 181.

[141] RICS, 2018.

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Landlord/investors are commonly responsible for the operational **carbon emissions of the common areas of a building**, which mainly entail operational emissions from lighting and space conditioning (if any), shared services such as building heating, as well as the embodied carbon emissions from repairs, maintenance and retrofits. These emissions are often managed by asset and property managers. Still, depending on the type of lease, tenants may take responsibility of the emissions of the common parts, or landlords may also be partially responsible of the energy consumption of units, for example during void periods or if they pay the tenant's bills. There are also agreements where the owner pays the bill for energy and then claims the amount from the tenant. In that case the limits between tenant and owner are not clearly defined and should be agreed to avoid gaps or double counting.

Tenants/occupants are responsible of all unregulated operational carbon emissions. They are also responsible for regulated carbon emissions within the tenant space, as the actual emissions (as opposed to the emissions predicted during the design stage) of the building systems largely depend on behavioural decisions: opening windows, operating hours, temperature set points. They are also fully responsible of the embodied carbon emitted through fit-outs and – depending on the lease type – maintenance works.

Regarding the classification of any emission to **Scope 1, 2 or 3**, it is crucial to differentiate whether the allocation takes places from the **investor or tenant perspective**. Tenant-obtained and tenant-sub-metered energy and related carbon emissions form part of a landlord's Scope 3 emissions. Energy consumed in landlord-controlled areas (like common areas in rented buildings) contributes to the landlord's Scope 1 and Scope 2 emissions. The allocation of individual emissions to Scopes and the typical share of Scope 1, 2 or 3 in a company's total emissions largely depends on the specific business model of the reporting company. Figure D-14 summarises the Scope allocation of multinational shopping centre operator *ECE* (Scope 2 emissions > 90%) and Germany based REIT *alstria* (Scope 3 > 80%). Whereas *alstria* reports all tenant related emissions under Scope 3, *ECE* includes also emissions from leased space under Scope 1 and 2 since *ECE* has direct control of these areas. Both ways of allocation do not infringe the rather general rules of the *GHG protocol* or *EPRA*. *ECE* reports all emissions emerging from district heating under Scope 2 even if this heat is consumed by tenants to a large degree. This example underlines the importance of focussing on all emissions that emerge from a building. In order to reduce emissions and meet climate targets – either by retrofitting, behavioural changes or other measures (see Section D.3) – urgent action is necessary and commitments must be made irrespective of scopes and reporting commitments.

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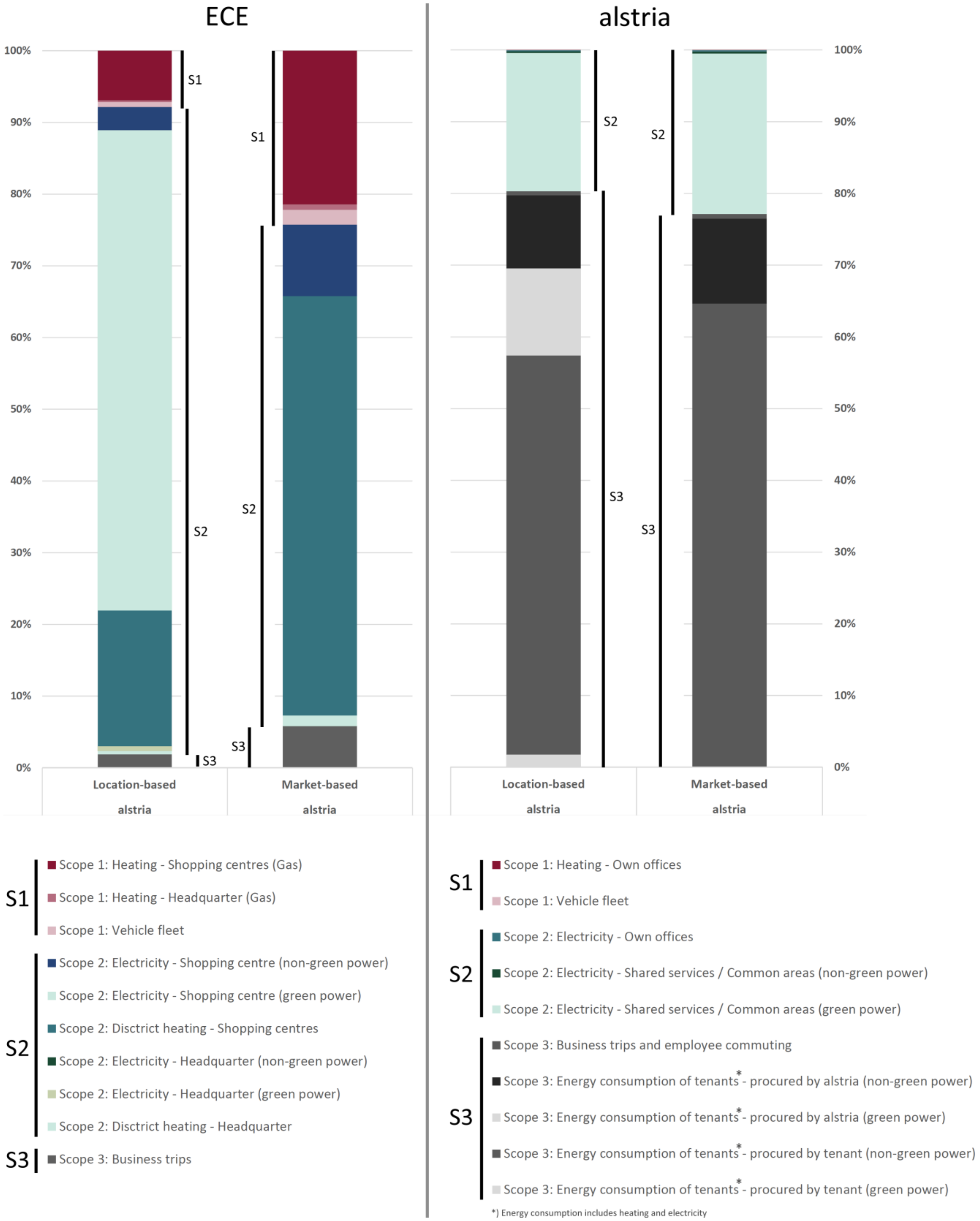
Figure D-14: Allocation of emissions to Scope 1, 2 or 3 - Shopping centre operator (ECE) vs. REIT investing in office space (alstria)



Source: alstria, 2018; ECE, 2018.

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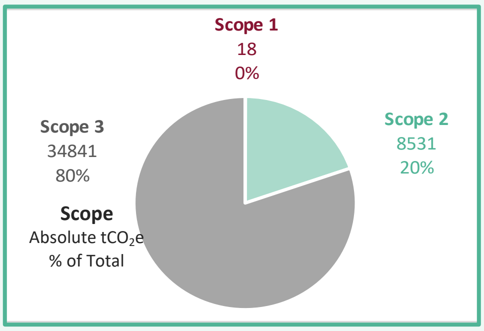
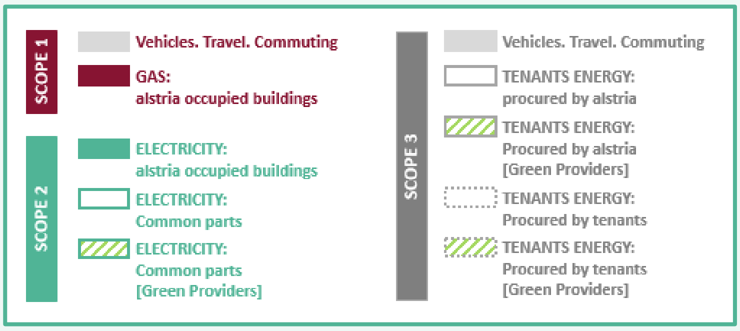
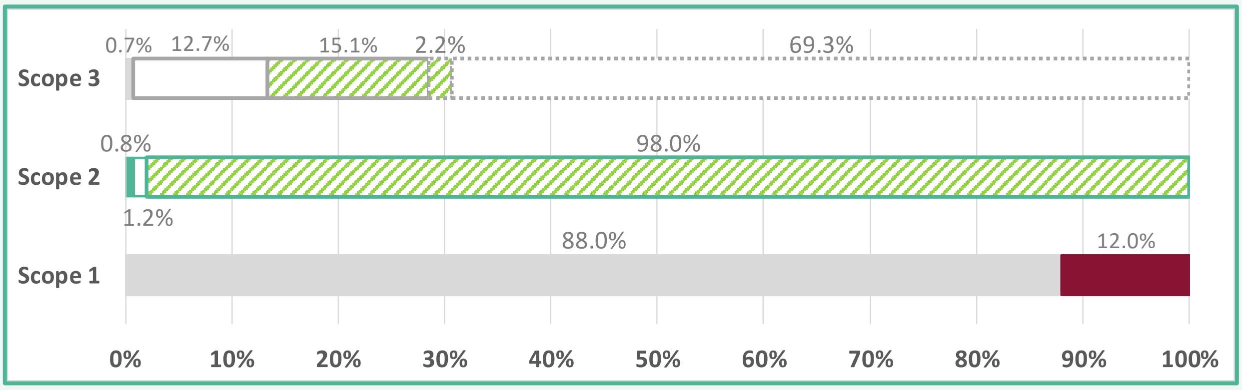
CARBON OWNERSHIP CASE STUDY: *alstria*

alstria is a Germany based Real Estate Investment Trust (REIT) that owns and manages commercial real estate which is leased to third parties. *alstria* applies the *GHG Protocol* scope definitions to account and report their corporate carbon emissions. As is often the case for real estate companies, most of their emissions belong to Scope 3 carbon emissions since the vast amount of operational emissions result from tenant space.

However, this distribution of reported emissions needs to be re-allocated to ensure that their portfolio complies with *EU* reduction commitments:







Scope 1: Only 12% of *alstria's* Scope 1 emissions are emitted by buildings occupied by *alstria* itself.

Scope 2: All *alstria*'s Scope 2 emissions are released by buildings, mostly from electricity consumption in common parts. These emissions are under *alstria's* full control and subsequently, *alstria* has succeeded in procuring most of this energy from green suppliers.

Scope 3: 99.3% of *alstria's* Scope 3 emissions, from both electricity and gas consumption, are released by buildings owned by the company but rented by various occupiers/tenants. Nevertheless, all these emissions need to be addressed by the owner when setting carbon reduction targets. Energy procured by *alstria* to its tenants comprises 28.8% of these emissions. This control ensures that around half of this energy (mostly electricity consumption) is already procured from green suppliers. Tenant engagement programs further contribute to increase the share of green energy procured directly by the tenants, resulting in a lower carbon footprint of the buildings and reduced Scope 3 emissions.

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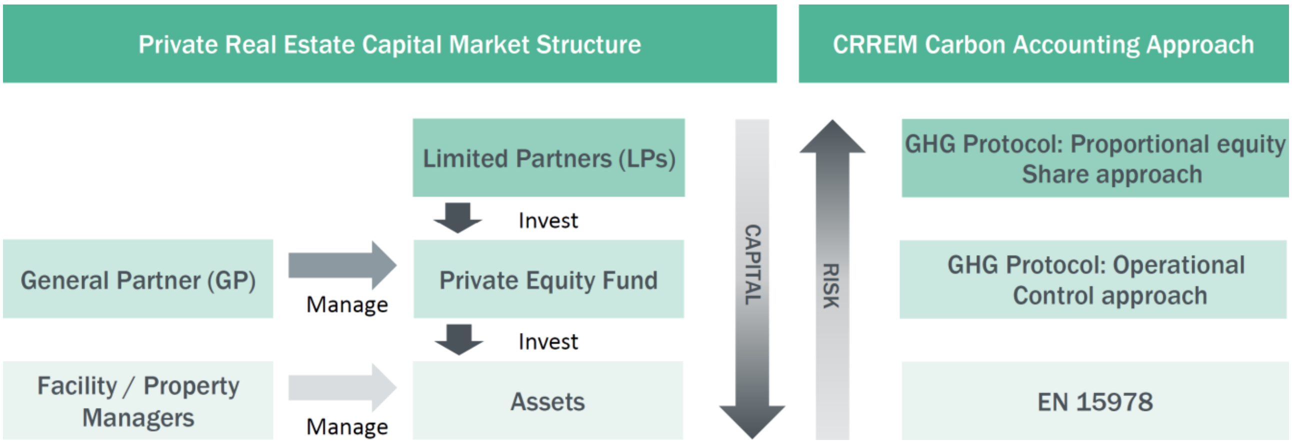
The engagement between **tenant and owner** involves a **shared interest**, as the risk of obsolescence may affect both of them. On the one hand, owners and investors want to assess and control the risks and guarantee that all assets comply with current and future regulation and ensure that the value of their portfolio is not affected. To achieve this, they **need to collaborate** with their tenants to gather energy data, set up improvement plans and encourage the use of efficient equipment, green energy supply and implement behaviour changes to reduce energy consumption and emissions. On the other hand, tenants strive to outperform their own GHG reporting commitments, also aim to reduce their running costs (energy bills) and improve their units' internal conditions to increase productivity. Tenants will only be able to achieve this by occupying buildings that allow them to plan, implement and control their own energy reduction strategies. Therefore, they will turn towards their landlords asking for the building improvements required to reduce their carbon footprint. Alternatively, they will seek to move into low emitting or carbon neutral assets that guarantee the carbon reductions they are targeting.

Figure D-15: Capital flow and risk assessment within private real estate capital market structures



Source: CRREM.

Real estate capital markets can be characterised by a complex fiduciary system involving several intermediate parties, each having different responsibilities and interest. These different responsibilities impact each party's operational control over the assets they manage and consequently the question whether emissions should be classified as Scope 1 and 2, or Scope 3.

A schematic overview of how an institutional investor might invest in private real estate and how they should account carbon emissions and carbon risk, can be found in Figure D-15. A similar approach should be applied for listed real estate companies, Limited partners, funds, Exchange-Traded Funds (ETFs), or other (listed) securities.

The **boundaries between these responsibilities can substantially vary** depending on contractual and management relationships: A tenant may be responsible for the maintenance of part of the building he occupies, while a landlord may decide to include green clauses within leasing conditions. HVAC systems' lifespan is substantially shorter than a building's lifespan and therefore, a landlord will need to substitute HVAC and lighting systems, demonstrating the theoretical influence of landlords on the carbon emissions of the building.

As depicted in Table D-2, the classification of emissions to Scope 1, 2 or 3 depends on the applied reporting approach. *EPRA* refers to the *GHG Protocol* and allows companies to report using the following reporting boundary approaches:

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Table D-2: GHG Protocol Reporting boundaries

EQUITY SHARE APPROACH
Scope 1 and Scope 2 emissions are reported according to **its share of equity invested in an asset**. The equity share approach reflects economic interest of the reporting asset. In the case of a Joint Venture (JV) asset, the entity will account for the emissions by weighing the emissions using the percentage of ownership in the asset. Since most real estate assets are also leveraged, it is important to mention that in case of one single owner, 100% of the asset is relevant for his reporting regardless of the loans provided.
OPERATIONAL CONTROL APPROACH
An entity accounts for 100 percent of the Scope 1 and Scope 2 GHG emissions from operations over which it has **'operational control'**. Operational control is defined as the investor/owner having ‚the full authority to introduce and implement its operating policies at the operation '. This approach does not account for GHG emissions from investments over which the entity has no control. In the case of a Joint Venture (JV) asset, the entity would fully account for the GHG emissions if it holds (joint) control.
FINANCIAL CONTROL APPROACH
Financial control is determined if the entity has the ability to direct the financial and operating policies of the asset to gain economic benefits from its activities. Usually, this happens if the entity controls the majority of the shares but conveys this to another organisation.

Source: Adapted from GHG Protocol, 2014.

According to the *GHG Protocol*, organisations that use the equity share approach include emissions from equity investments in Scope 1 and Scope 2. Organisations that use the operational or financial control approach only account for investments that are under the company's control in Scope 1 and Scope 2[142]. If the emissions associated with investments are not included in either Scope 1 or Scope 2 emission inventories, they should be reported under Scope 3.

When using an equity share approach, investors should allocate emissions proportionally based upon the invested capital in their portfolio companies. Table D-3 provides an overview of how companies can account for both equity or fixed income / debt investments.

[142] GHG Protocol, 2011a, p. 51.

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Table D-3: Equity and Debt Investment reporting according to the GHG Protocol

EQUITY INVESTMENTS
Proportional emissions from equity investments should be allocated to the investor based on the investor's proportional share of equity in the investee. Emissions are allocated to Scope 3, if they have not been categorised in Scope 1 or 2.
DEBT INVESTMENTS
Proportional emissions from project finance and debt investments that can be directly linked to carbon emissions should be allocated to the investor based on the investor's proportional share of total equity plus debt (enterprise value).

Source: GHG Protocol, 2011a, p. 52-53.

Greenhouse Gas protocol for real estate

The *GHG Protocol* is a carbon reporting standard that can be used in all sectors of the economy. Therefore, it cannot include guidelines for specific sectors like real estate. To fill this gap, since 2011 the *European Real Estate Association (EPRA)* regularly publishes their Sustainability Best Practices Recommendation guidelines[143] which define critical scope performance measures and indicators to cover not only carbon, but wider sustainability, social and governance impact on the real estate sector. These guidelines based on the *Global Reporting Initiative's (GRI)* standards[144], an initiative to promote best practice for reporting publicly on a range of economic, environmental and social impacts, which can also be used in all sectors of the economy. Both *GHG* and *GRI* standards are developed based on the same principles of relevance, completeness, consistency, transparency an accuracy. Figure D-16 provides a summary of the relation between the scope of both *GRI* and *GHG* reporting standards, the *EPRA* guidelines and *CRREM* project.

[143] European Public Real estate Association, 2017.

[144] Global Reporting Initiative, 2019.

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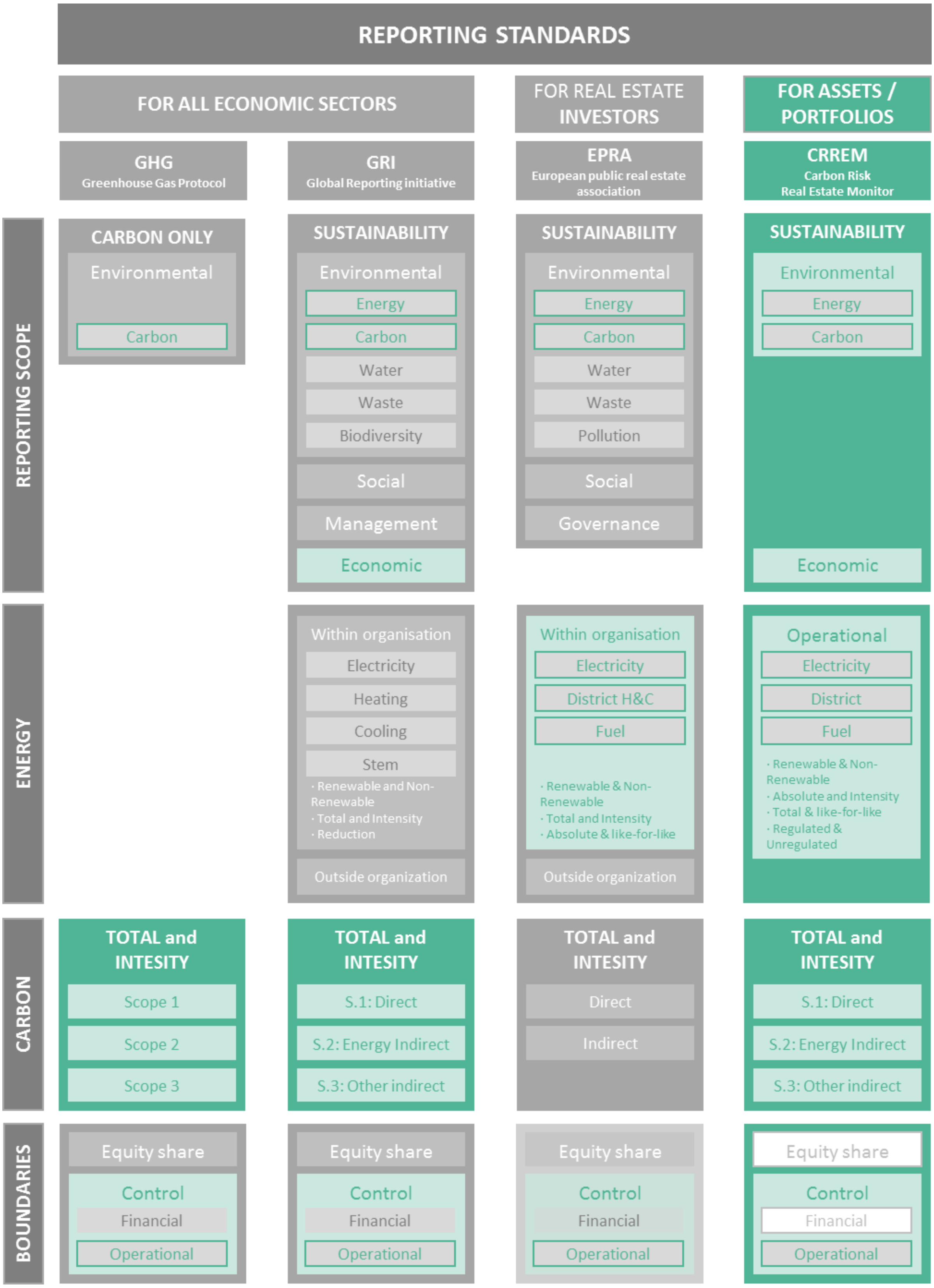
Figure D-16: Comparison of GHG, GRI and EPRA standards with CRREM scope



Source: CRREM.

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The green colour in Figure D-16 indicates alignment with the *CRREM* project, which is explained in the following paragraphs together with the most relevant differences between standards:

REPORTING FOCUS: *GHG, GRI* and *EPRA* all define guidelines from the perspective of organisations, investors or businesses, which is the right approach for corporate reporting. However, *CRREM* focuses on assets and portfolios instead of organizations and will reconcile both approaches in the project's outputs to avoid double counting and reporting gaps amongst corporate stakeholders.

REPORTING SCOPE: *GRI* reporting scope aims to control a wide range of sustainability parameters that include environmental, social, management and economic indicators. This is reflected by *EPRA* guidelines, which also encourages their members to report on wider sustainability and environmental areas, including water, waste and pollution. Even though the *GHG Protocol* focuses on carbon emissions only, *GRI* acknowledges the *GHG protocol*´s strength and consistency in carbon accounting and reporting by referring to and adopting the same scopes in their carbon performance measuring. *EPRA* guidelines adopts GHG's Scopes 1 and 2 only. The scope for stranded risk assessment proposed by *CRREM* includes not only the mitigation of carbon emissions, but also the control of energy demand, together with the economic impact of the mitigation and adaptation measures.

ENERGY: As previously mentioned in this section, *CRREM* expects future policies to not only cap carbon emissions, but also energy demand, particularly of a decarbonised electricity grid. This aims to avoid the rebound effect of fuel shift from fossil fuels to electricity. Therefore, CRREM links carbon risk not only to emissions but also to the operational energy demand of assets and adopts *EPRA's* indicators – more suitable for real estate assets.

CARBON: The *GHG protocol* is the strongest standard to measure and report carbon emissions and it has been adopted by most reporting initiatives, including the *GRI* standard, *EPRA* guidelines, *GRESB* the *CRREM* project to account carbon. However, as *CRREM* focus on assets, instead of organisations, stakeholders will need to collect more and more detailed data, mainly on the relation between landlord-tenant, tenant consumption and embodied carbon. Current guidelines for reporting organisations from *EPRA* and *GRI* on indirect carbon emissions and energy demand do not require the collection of enough information to assess carbon risk from the asset perspective. Further efforts on this will be required to minimise assumptions.

REPORTING BOUNDARIES: *GRI* and *EPRA* guidelines adopt the *GHG Protocol*'s three approaches described earlier in this section to select reporting boundaries: equity share, financial control and operational control. EPRA acknowledges that in the real estate sector the operational control approach is most widely used because decisions aiming to energy or carbon assessment are usually directed by buildings characteristics and performance. However, they do not encourage their members to use one approach over the others. *CRREM's* assessment of carbon risk requires the collection of information from buildings, so *CRREM* encourages the operational control approach. However, as previously mentioned the equity share approach could also be considered when accounting for the emissions associated with the investments of Limited Partners (LPs) or Real Estate Investment Trust (REITs).

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FUTURE IMPACT OF CLIMATE CHANGE ON REAL ESTATE GHG EMISSIONS

There is a **wide range of climatic regions in Europe, coming with very different demands to buildings' thermal quality**. Some *EU* member states show a great intra-country variability of climate zones, whereas others have rather homogeneous climatic conditions. Information on average heating- and cooling-related weather and climate conditions at a certain location are important for the assessment of buildings' carbon performance in two ways: (**1) Normalising weather conditions in the year of assessment and (2) estimating the effect of climate change on future heating and cooling demand**. Meaningful decisions regarding the necessary decarbonisation efforts of individual buildings have to rely on these two effects, since the weather conditions in one single year might not correctly reflect the building's inherent qualities and since climate change will have a very different effect on heating and cooling related energy demand and carbon emissions within Europe.

A common way of operationalising heating and cooling demand of buildings is the use of so-called Heating and Cooling Degree Days (HDD/CDD) [145]. The variables are calculated by comparing the temperatures of a certain day with a specific base temperature, below (HDD) or above (CDD) which the building will need to be heated or cooled. Finally, these daily differences are summed up over the whole year. This method is more reliable in estimating actual energy demand than other approaches that are for example based on the mean outdoor temperature only.[146] For reasons of legibility, the following sections rely on heating only, but the general principles apply to cooling in a comparable way. Since heating demand is directly proportional to the indoor-to-outdoor temperature difference and a building's over heat loss coefficient (depending on building fabric and air infiltration), there is also a **directly proportional relation between heating demand and HDD, as the latter reflect these temperature differences.**[147]

Weather normalising of energy and carbon assessments

The first area of application of HDD and CDD is the **normalisation of energy demand** and GHG emissions based on actual consumption data for a certain year. In particular if owners intend to monitor the GHG performance of one building through the years it might be interesting to subtract the effect of weather variability. If the measured values originate from a year with rather mild winter months, a low actual heating demand will not reflect the real thermal quality of the building. Local 30-year average HDD and CDD values can be derived for example from ***ERA-Interim*** **weather reanalysis data** and can be compared with those values in the year of energy demand.

Climate change impact on energy demand and GHG emissions

Climate change will have significant impact on the future heating and cooling energy demand. HDD and CDD values can also be used to consider this effect when estimating a building's future GHG emissions. The most recent and comprehensive data set of future projection of HDD and CDD was developed by *Spinoni et al. (2018)* providing *EU*-wide data for the period between 1981 and 2100 (Figure D-17).

The future degree-day data can be based on different climate scenarios (for example *RCP4.5*). Since HDD and CDD affect the demand of space heating and cooling, but not of lighting, water heating and appliances, the climate impact of degree-day changes must not be applied to the total energy consumption of buildings. Estimations of use type specific shares of heating and cooling of total energy consumption can be derived among others from the ***Building Energy Efficiency Survey (BEES)*** [148] which was promoted by the *United Kingdom's Department for Business, Energy & Industrial Action (BEIS)*.

[145] Petri et al, 2015, p. 10.

[146] Day, 2006.

[147] Day, 2006.

[148] Department for Business, Energy and Industrial Strategy (UK), 2016b.

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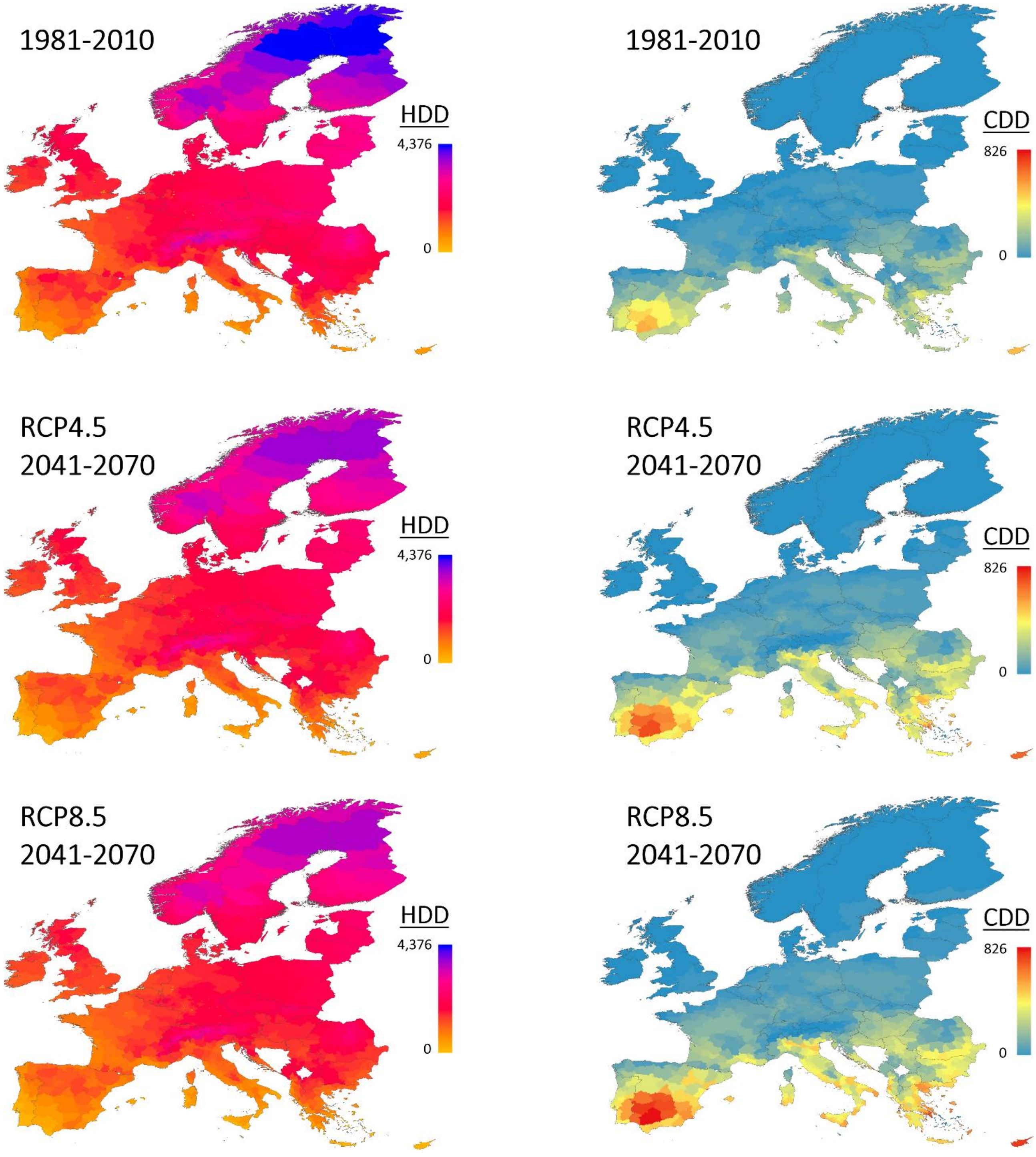
Figure D-17: Future development of HDD and CDD under RCP4.5 and RCP8.5



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

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D.3 RISK MITIGATION: CARBON REDUCTION MEASURES

Once investors have assessed their portfolio's exposure to carbon and stranding risk, the next step is to decide what is the right approach for the organisation to manage the risk. The *Task Force on Climate-related Financial Disclosures* (*TCFD*, see Section A.1) recommends companies to report upon their planned response for dealing with climate risks by stating whether they plan to 'mitigate', 'transfer', 'accept', or 'control' climate risks. The application of these carbon risk management options applicable for real estate investment companies is defined below, while also offering an 'avoid' and 'exploit' risk management alternative:

- **Mitigating** carbon risks involves taking steps to reduce the probability of the risks. From a real estate investment perspective this could involve implementing a retrofit project to reduce energy consumption.
- **Transferring** carbon risks centres on transferring the risk to another party. Typically, this involves insurance contracts. However, in real estate one could also think about transferring the retrofit risk to the tenant, by ensuring the tenant is responsible for capital expenditures (this typically is the case in NNN or FRI leases). Alternatively, investors could place assets in a fund which they still manage but not own.
- **Accepting** carbon risks occurs when a real estate company acknowledges the risk but does not warrant spending money or effort efficient enough to avoid or control the risk. This is also known as 'risk retention', acknowledging that non-catastrophic or smaller risks can be dealt with when they arise. However, considering the certainty of global warming, this approach would normally delay mitigation action.
- **Controlling** carbon risks includes controlling the impact of the risk if this occurs. This can be done through a contingency plan. An example of controlling carbon risks is to diversify the assets that are at risk of becoming stranded due to regulatory changes, across Member states, thus limiting the impacts of a portfolio wide market correction or policy response.
- **Avoiding** carbon risks could entail not investing in inefficient properties that need retrofitting, or even disposing of inefficient assets. Many so-called 'Core' real estate investment strategies follow this approach (perhaps inadvertently) frequently disposing off assets before any before any significant capital expenditures are required, as to achieve a bond-like cash-flow payment structure.
- **Exploiting** carbon risks turns a risk into an opportunity. A market correction of office buildings that cannot be let due to regulatory requirements, might lead to cheaply priced assets that can be retrofitted, and thus offer benefits for a 'value add' real estate investment strategy.

This section outlines landlord-strategies for reducing the operational carbon emissions of commercial real estate portfolios. The cost effectiveness of energetic retrofits depends on different factors, including the tenancy cycles, current and future building codes, and expected lifespan of building components. Energetic retrofit measures trigger one-off Scope 3 GHG emissions defined as embodied carbon. Consequently, there is always a **trade-off between reduced Scope 1 and 2 emissions and coincidently induced Scope 3 emissions (see Section D.2).**

According to *IEA*[149], the real estate industry is 'on track' regarding carbon reduction strategies that tend to be cheap, easy to implement, have short payback periods and effective abatement costs. However, **improvements of building envelopes and heating systems are usually more expensive or more difficult to implement and thus imply higher direct and indirect costs (longer void periods)**. As national carbon reduction targets become more stringent due to *EU* commitments for 2050, low-cost strategies such as LED-lighting will not be sufficient and investors will need to consider more capital-intensive carbon reduction actions.

Long-term planning of energetic retrofits for assets is crucial to ensure cost-effectiveness as the implementation of retrofit actions impacts future capital requirements. For example, installing high quality building insulation will not only

[149] IEA, 2017a.

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result in immediate energy savings, but might also ensure that the building is 'future-proof' regarding upcoming stricter regulatory requirements. Correct planning will thus reduce unexpected costs and control budgets. The *CRREM* tool will provide landlords with a long-term perspective of their buildings' carbon performance enabling the **integration of energetic and GHG-related measures into the existing renovation cycle ('anyway costs').**

STRATEGY: DATA, CARBON-COST ASSESSMENT AND ENGAGEMENT OF STAKEHOLDERS

Companies can pursue diverse measures to enhance the energy efficiency or reduce the carbon footprint of their portfolios. The carbon reduction strategy needs to be flexible and easy to be updated, as the **best opportunities to reduce carbon emissions change constantly**, especially with the proliferation of **new green technologies**. In many instances, installing energy efficiency improvement measures, has economic benefits for both the landlord and the tenant. Management strategies to reduce carbon can focus on promoting behavioural changes, equipment calibration, and **physical measures such as retrofits**. In many instances **high capital expenditures are not per definition a requirement to improve the energy efficiency of a real estate portfolio**.

Carbon reduction strategies frequently start with assigning responsibilities over carbon reduction, or sustainability in general. One of the most widely used overarching frameworks for reducing environmental impacts of organisations, and thus carbon emissions is the **establishment of an Environmental Management System**. The most widely used framework for this is ***ISO 14001***. Next to establishing a leadership, policy, and responsibilities framework, *ISO 14001* follows the so-called **'Plan-Do-Check-Act'** improvement cycle, in which the outcomes of environmental improvement measures are reviewed, monitored, and adjusted.

The *European EMAS* (*EU Eco-Management and Audit Scheme*) framework, builds on the *ISO 14001* framework by adding several additional requirements, which amongst others relate to corporate communications and employee involvement[150].

Data collection mechanisms

Operational energy data collection

Finding carbon reduction opportunities in a standing investment portfolio typically starts with **energy consumption data collection to identify inefficient assets**. Data can come from multiple sources:

- Automatic meter readings
- Invoices
- Manual–visual readings
- Tenants

The Commercial Real Estate Industry is increasingly able to collect **and aggregate energy consumption data**. In 2012, the 443 property companies, funds and REITs that participated in the annual *GRESB Real Estate Assessment*, were able to provide energy consumption data for an average 24% of its portfolio by floor area. In 2017, the 903 participants, reported energy consumption for on average of 64.3% floor area (showing significant differences in terms of property types and region), including both landlord and tenant-controlled data. This strong rise in the abilities of real estate managers to collect operational energy data is largely due to the rise in **smart meters** and innovations in data management systems that cover energy and carbon.

[150] EMAS, 2018.

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SMART METERS

The reduction in **cost of sensors** along with the **internet of things**, has led to the rapid proliferation of smart building meters, focussed on both gas and electricity readings. Smart meters frequently provide insights into energy consumption reduction opportunities, through collecting energy consumption data within short intervals (every 10 seconds). **Algorithms can subsequently provide insights in how energy consumption and carbon emissions can be reduced**. The EU aims to replace at least 80% of electricity meters with smart meters by 2020. This policy is supported by the strong decrease in the pricing of smart building meters (costs, including installation, range between EUR 200 and EUR 250). In fact, in Q1 2018 alone, 1,240,500 new smart meters were installed by large energy providers in homes and businesses in the UK, representing an increase of more than 10% of the total smart meter stock.

The trend in the rising use of smart meters, aligns well with the data requirements of carbon risk assessments. Smart meters will enable more accurate, timely, and affordable calculations of operational energy efficiency ratings.

Technical Buildings Assessments

Another method of collecting information and identifying the best carbon reduction opportunities, is by technical building assessments. A technical building assessment can be defined as **a formal documented assessment of a building undertaken by a person with technical expertise**, such as building engineers, building surveyors and architects, identifying carbon reduction or energy efficiency opportunities. Technical buildings assessments and related checks are often conducted during the due diligence process, before the acquisition of a new property.

Related to technical building assessments are in-use **Green Building certification schemes such as *BREEAM/In Use, LEED/Building Operations + Maintenance,* or *GPR Gebouw***. These building certification schemes rate existing buildings based upon their green attributes and identify carbon reduction opportunities in the process. Green Building Certifications can combine elements of a technical building assessment with a data management system, but often do so in a pre-defined format, such as a scorecard or check-list[151].

[151] USGBC, 2018.

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SMART READINESS INDICATOR

The **2018 *EPBD* Recast** includes the so-called ***Smart Readiness Indicator (SRI)***, referring to the technical development of buildings and the use of advanced information and communication technologies. Smart buildings can be defined as **'[…] *the ability of a building or its system to sense, interpret, communicate and actively respond in an efficient manner to changing conditions in relation to the operation of technical building systems or the external environment (including energy grids) and to demands from building occupants*.'** The terms 'automated' or 'intelligent buildings' are commonly used as well.

The presence of smart facilities can essentially foster climate protection by a **reduced energy demand and lower carbon emissions.** Based on well-defined criteria, *SRI* can **assess if and to what extent, a building is 'smart ready'.** It can be implemented as a voluntarily scheme for rating the smart readiness of buildings, just like energy performance certificates do for energy efficiency and other criteria. The *SRI* is under ongoing development, continuously improving to meet the demands of potential stakeholders.

The *EU* supported 'Smart Readiness Indicator' project defines a field of eight impact criteria:
energy, flexibility of the grid, self-generation of energy on site, comfort, convenience, wellbeing and health, maintenance and fault prediction as well as the provision of information to occupants.

These impact criteria are broken down into ten domains:
heating, cooling, domestic hot water, mechanical ventilation, lighting dynamic building envelope, on-site renewable energy generation, demand side management, electric vehicle charging as well as monitoring and control.

In an on-site assessment, preferably by a 3rd party, each sub-category can then achieve points according to its smart-readiness based on a checklist approach. In that way, a weighted percentage score showing the smart readiness of the rated building is created. The higher the score, the better the performance.

The ***European Commission*** intends to make the **added value of smart buildings** more visible. The Smart Readiness Indicator shall highlight increased health and comfort as well as energy savings and a reduced carbon impact. Moreover, the **integration of smart buildings into the energy grid** offers the potential to a more flexible demand management.

Carbon-Cost assessment

Improvement opportunities do not need to be expensive. Instead, the following types of efficiency measures are already identified by *ENERGY STAR*[152] as usually cost effective:

- Operational – such as eliminating unnecessary use of existing equipment.
- Small capital projects – such as lighting upgrades.
- Procurement – such as renegotiating utility supply contracts.
- Behaviour, other non-cost-intensive measures, retrofit measures

Unibail-Rodamco-Westfield, Europe's largest real estate company in terms of market capitalisation, emphasises the importance of an 'energy efficiency attitude' that shall apply to the daily optimisation of technical equipment and routine business activities, minor refurbishment measures, mid-term technical improvements and, finally, large works resulting in major improvements of intrinsic building performance (see Figure D-18).

[152] ENERGY STAR, 2014.

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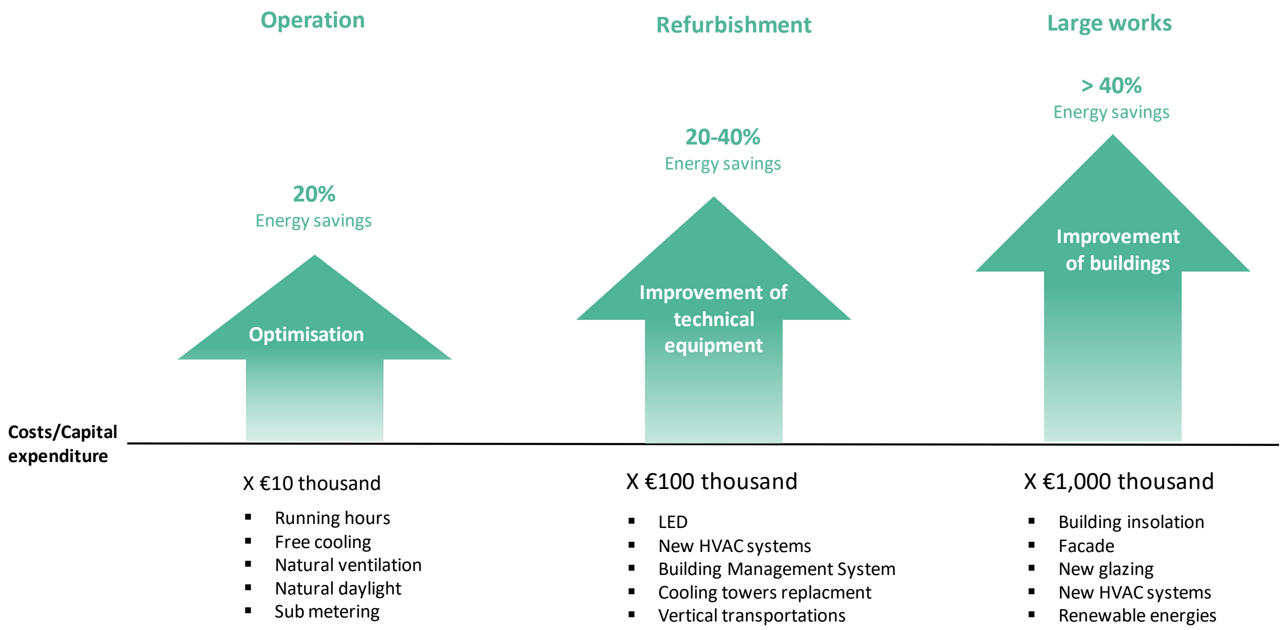
Figure D-18: Gradual approach to energy savings according to Unibail-Rodamco-Westfield



Source: Unibail-Rodamco, 2017.

Capital expenditures often determine investment decisions in energy efficiency measures. Prudent investors make decisions based on tools that enable a cost-benefit analysis of different options. Calculating the payback period of any investment through savings in energy bills seems simple with such tools. In reality, potential pitfalls like the **user/investor dilemma** require a considerably more complex approach, since investors have to bear the costs of efficiency measures whereas tenants profit from reduced operating costs. A more ambitious calculation involves ***Marginal Abatement Cost (MAC) Curves***, which help define the life-cycle cost efficiency of different strategies, provided that the capital cost and potential savings (economic and in carbon) are known (Figure D-19). Each bloc represents a carbon reduction strategy. The horizontal axis (width) represent the absolute energy or carbon savings of that strategy or the aggregation of several strategies. The vertical axis (height) represents the **marginal cost: life-cycle cost of each unit of carbon or energy saved**. The strategies are then sorted depending on their cost-impact efficiency. The strategies under the horizontal axis are cheaper than 'business as usual', so they define the main areas of opportunity to address in the first place. The strategies above the axis will require investment, so a careful analysis of absolute cost (area of the block), relative cost (cost of each energy or carbon unit saved - height) and absolute savings (width of the block) is required.

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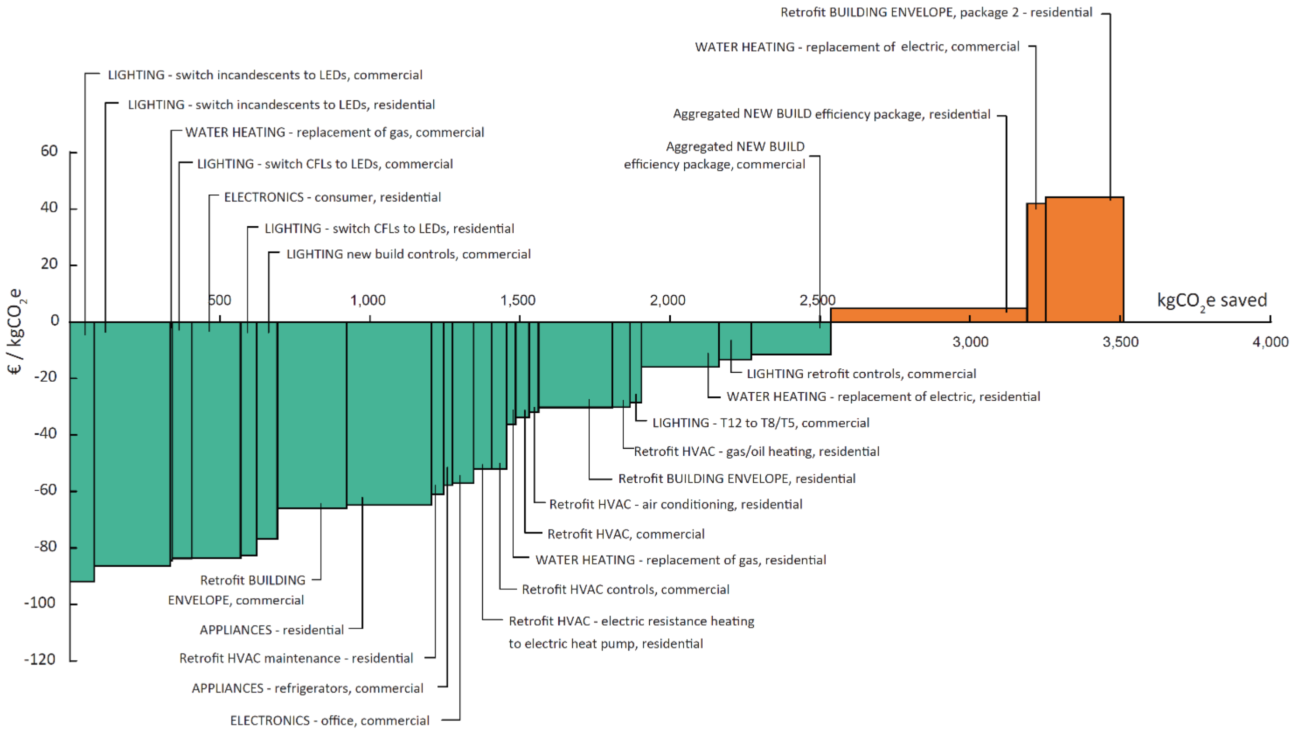
Figure D-19: Example of Marginal Abatement Cost Curve applied to building services



Source: Adapted from McKinsey & Company, 2009.

Information and stakeholder engagement

Many carbon reduction strategies need to involve **different stakeholders**. This section highlights some key strategies real estate managers and REITs can pursue to leverage stakeholders to reduce carbon risks.

Employees

Employees are key stakeholders in any business. Involving employees in sustainability and carbon reduction efforts can boost employee engagement, recruitment, and retention. Methods to improve the sustainability involvement of employees are varied. Typical strategies pursued are the establishment of committees, including sustainability or carbon related metrics in performance targets, or organizing training sessions. However, more creative strategies can be pursued as well. *Kilroy*, an American REIT, claimed to have significantly reduced energy efficiency, by creating 'engineer baseball cards', highlighting their energy efficiency credentials, thereby improving their motivation to find carbon reduction solutions[153].

Suppliers

Suppliers are a key stakeholder for reducing embodied carbon of retrofits and other Scope 3 emissions. Common strategies focus on the **establishment of procurement requirements**, often involving ***Environmental Product Declarations (EPD)***, which analyse and quantify the impacts a single product would produce during its whole carbon life cycle. Respective data can be gathered from suppliers and in accordance with ***ISO 21930:2017 or EN 15804*** (for products used in construction works), enabling investors to conduct a reliable analysis of GHG emissions related to retrofits.

[153] ENERGY STAR, 2016.

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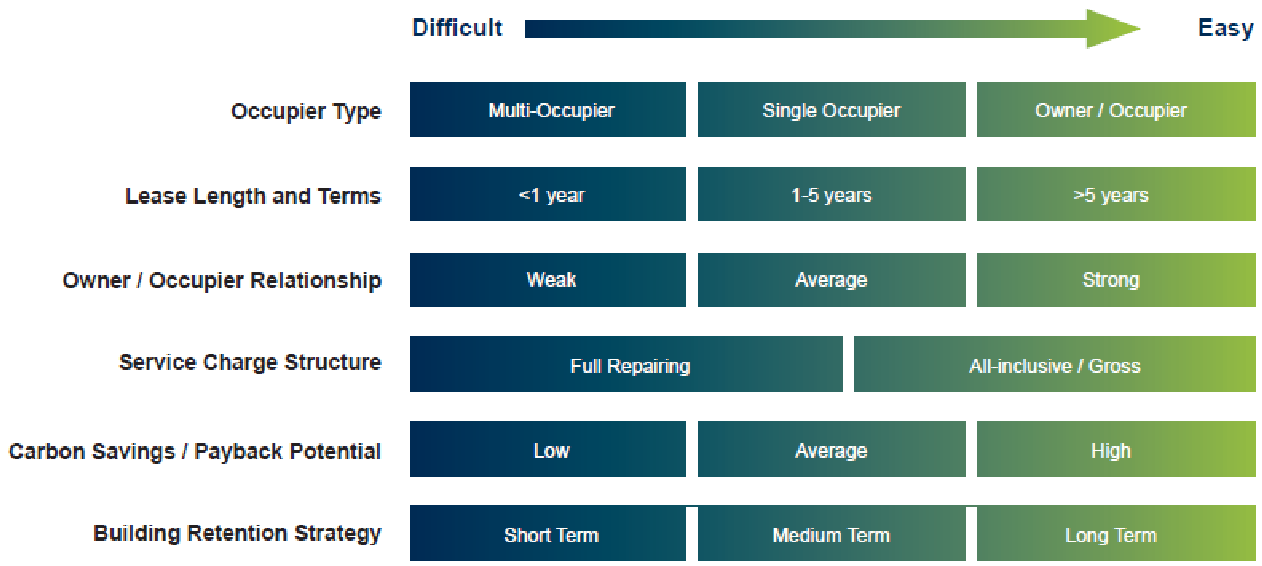
Property/Asset managers

Real estate investors often make use of third-party property or asset managers. Property/asset managers commonly take on some or all the landlord's asset management functions, many of which relate to managing carbon emissions. In order to ensure that property/asset managers pursue the same carbon reduction objectives, an appropriate incentive structure might be needed, along with a mechanism for evaluating carbon reduction efforts. Further information on legal issues and best practices for reducing a building's impact on the environment can be found in the *Sustainable Property Management Guide* published by UK-based *Capita Real Estate and Infrastructure.*[154]

Tenants

Tenants are a key stakeholder for reducing the operation carbon footprint of a real estate portfolio. The ability to implement retrofit measures is often dependent on the type of **contractual agreement between tenant and landlord**. Figure D-20 presents examples on how different type of profiles and contractual relationships are to impact asset retrofit actions.

Figure D-20: Prioritisation model for retrofit measures



Source: Better Building Partnership BBP, 2010.

The **leasing structure** of a property often defines how much influence a landlord can exert on a property and indirectly a tenant's emissions. In situations in which the tenant has significant control over the property, in for example, the case of a **full repairing and insurance (FRI) lease, or NNN-lease**, efficiency improvements fall under the discretion of the tenant. The tenant, instead of the landlord, might as such also face building-related regulatory carbon risks.

The primary method through which a landlord can exercise control on tenant-controlled energy efficiency measures is through the inclusions of a **'sustainability lease clause'** in the leasing contract (**'green lease'**). Without such a clause, it might even be impossible for the landlord to acquire energy consumption data, and through that establishing a baseline energy consumption figure. Several institutions published comprehensive guidelines providing general and country specific assistance to tenants and landlords willing to address sustainability issues, including carbon, in their

[154] Capita Real Estate and Infrastructure, 2016.

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lease contract. Most recent guidelines were published by the *Building Owners and Managers Association International*[155] and *ZIA German Property Federation*[156].

Next to sustainability leasing clauses, a key method to reduce tenant related carbon emissions includes **providing training to tenants**, setting up a **tenant engagement programme**, educating tenants about sustainable alternatives (waste recycling), providing tenants with utility feedback reports or dashboards, offering sustainability related fit-out guidance, or setting minimal fit-out standards. In addition, feedback surveys can improve the flow of information between tenants and landlords regarding undiscovered carbon reduction opportunities.

In situations in which the landlord has significant control over the property, sometimes tenant engagement can be crucial if a landlord intends to **anticipate upcoming regulation**. It is common practice that when improvements are required to comply with already adopted building codes/policies, regulation provides the necessary instruments to facilitate an agreement between tenants and landlords. However, when the landlord plans to target improvements ahead of policy changes, it can be difficult to convince tenants to undertake disruptive retrofit or improvement works. A communication strategy that focusses on tenant-related benefits such as lower energy bills or improved wellbeing commonly helps in reaching an agreement.

In **assets rented under shorter leases**, the landlord/owner is often able to plan and improve the property during the void periods between leases. However, this can be problematic in the implementation of works that affect a whole building under multiple leases (for façade replacement or insulation). As leases normally do not end at the same point of time, there will not be a single void period to implement the works. Possible solutions to this include (1) a staged implementation of works, which is not always technically or economically feasible, (2) negotiation with tenants, which may include compensations to undertake works while the units are still occupied (but not always possible if the works are too disruptive for the tenant activity), or (3) avoid leasing the empty units until all the whole building is unoccupied. All options, particularly not leasing out empty units, can have a significant impact on the asset's expected Return on Investment (ROI).

Behavioural incentives

Behavioural incentives offer a variety of possible strategies, that can help to reduce operational energy consumption and carbon emissions:

Setpoints: Thermostats and timers can be progressively adjusted to collectively reduce the energy consumption, engaging both occupants (so that they control their surrounding space) and landlords, for example reducing the heating temperature in common areas where in winter users would normally walk with their coats on.

Engagement: Occupants need to be engaged and educated on the type of systems installed and how to adjust their environment, which may include operating ventilation (simple window opening agreements) as well as active HVAC systems. This is particularly challenging in public and shared spaces, such as an open plan office, as many employees will not dare or will not know how to adjust their environment. Corporate policies or engagement programs are normally required (see previous section for further information).

Corporate culture: Corporate policies need to endorse energy efficiency. For example, clothing codes should vary with changing seasons. Similarly, office room lighting should be off or drastically reduced outside working hours, with personal lighting made available for employees required out of normal working hours.

Cost of energy and carbon: Higher energy costs drive behavioural change. Energy taxation is one of the tools that administrations can use to reduce unregulated energy consumption from occupants, particularly in the domestic sector.

[155] BOMA, 2018.

[156] ZIA, 2018.

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The *EU Emissions Trading System* (*EU-ETS*)[157] aims to reduce carbon emissions with a 'cap and trade' system and emission allowances for companies. Allowances are auctioned and can be traded in an international carbon market endorsed by Art. 6 of the Paris Agreement[158]. Companies who exceed their allowances can be heavily fined. Therefore, the *EU-ETS* can price (or tax) carbon emissions which is driving corporate behaviour towards engagement in carbon emissions reduction (see Section B.1).

MEASURES TO REDUCE CARBON EMISSIONS OF BUILDINGS

The 'fabric first' approach

One strategic approach providing guidance for a structured way of addressing carbon emission reductions is labelled **'fabric first'**. According to the 'fabric first' approach, energy efficiency measures retrofit measures to mitigate the carbon emission of buildings and ensure their adaptation to their new climatic conditions should be implemented according to the following hierarchy:

I. REDUCE ENERGY DEMAND

Fabric improvement with passive (not energy consuming) measures to reduce the need of heat or air conditioning

- Wall/roof insulation
- Window replacements
- Air tightness

II. MEETING THE DEMAND EFFICIENTLY

Efficient equipment and systems that control and optimise energy use

- Installation of high-efficiency equipment and appliances
- Building automation system upgrades/replacements
- Building energy management systems upgrades/replacements

III. SUPPLY ENERGY FROM RENEWABLE SOURCES

Ensuring minimum carbon impact of consumed energy in the building

- Installation of on-site renewable energy
- Purchase of off-site generated renewable energy

[157] European Environment Agency, 2018b.
[158] UNFCCC, 2015.

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The following table provides a general, non-exhaustive lists of the most common areas where retrofit action can be planned to reduce energy demand and to meet the demand efficiently:

BUILDING ENVELOPE: REDUCING DEMAND

INSULATION	Roof, external walls and floors, doors; special focus on reducing thermal bridges.
GLAZING	Double glazing, triple glazing, secondary glazing, low-e glass, solar control glass.
AIR TIGHTNESS	Reduce infiltration to ensure all ventilation is controlled.
SOLAR SHADING TO REDUCE SOLAR GAINS	Internal or external, fixed or movable, manual or automatic.
GREEN SPACES	Green roofs and appropriate planting contribute to better insulation, shading, and promote biodiversity

MEETING THE DEMAND EFFICIENTLY

HEATING AND HOT WATER	Efficient boilers, air heat pumps (air to air, air to water), ground heat pumps (water to water).
VENTILATION	Natural ventilation (particularly enabling cross ventilation), mechanical ventilation or mechanical ventilation with heat recovery (MVHR) should be considered to mitigate the risk of overheating before the installation of any active cooling system. Automatic controls (e.g. automatic night ventilation) can significantly improve the performance of systems.
COOLING	Heat pumps, passive cooling (evaporative).
LIGHTING	Energy efficient luminaires (e.g. LED, CFL).
CONTROLS	Manual (TRVs, timers, thermostats) or automatic (Building Management Systems – BMS). System controls, together with the capacity of occupiers to override them, are crucial in reducing regulated carbon emissions. Engagement of occupants on how to properly use them and good design of HVAC zoning reduces discomfort, performance gap and energy consumption.

Decisions that meet the same operational carbon reductions with the lowest embodied carbon impact should always be preferred. The 'fabric first' approach is widely endorsed by institutions like the *Energy Savings Trust*[159], the *UK's National House Building Council (NHBC)*[160] and it is also adopted by administrations such as the *London Plan 'be lean, be clean and be green'* approach to minimise building's carbon emissions[161]. The **operational carbon reduction** of the same retrofit actions can significantly vary depending on the building characteristics. The same amount of insulation will entail different carbon reduction depending on factors such as the existing building shape and layout, air tightness. Further, the **embodied carbon impact** of all retrofit measures needs to be considered. The consensus is that the life-cycle impact of a 'fabric first'-approach will be beneficial (except for very energy efficient buildings).[162]

[159] Energy Saving Trust, 2010.

[160] NHBC Foundation, 2013.

[161] Greater London Authority, 2016, Policy 5.2.

[162] Only when the carbon footprint of a building is closer to zero, the embodied carbon impact of the energetic retrofit may be higher than the operational carbon benefit.

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Energy from renewables and offsetting

The real estate sector can implement a large range of on-site renewable energy generation technologies that can replace the procurement of fuels, electricity or heat. Companies have to report on the indirect GHG emissions 'resulting from the offsite generation of purchased electricity, heat or steam'.[163] According to the mandatory **location-based approach of the *GHG Protocol Corporate Standard*** for reporting indirect carbon emissions, standardised emission factors have to be applied when converting the amount of energy consumption to carbon emissions. There is no final consensus across the different green building certification and carbon reporting schemes as to whether certain types of off-site generated renewable energy can be used to offset emissions. A classification can be based on the ownership of used installations, the location of generation and the connection with the electricity grid. A comprehensive discussion of this issue was published by the *Green Building Council of Australia*, comparing the rules for offsetting in different systems including *RE100* and the Australian systems *NABERS* and *greenstar.*[164]

Figure D-21 displays a hierarchy of different boundaries originating from the discussion on *Nearly Zero Energy Buildings (NZEB)*[165] and although there has been no general hierarchy agreed on, the presentation enables a vivid depiction of the main types of renewable energy supply. The five mentioned supply options are ordered with respect to the location of the energy supply.

The notion of 'renewable energy generation within the built environment' normally refers to the categories I, II and III (see Figure D-21). **Categories IV and V do not involve any efforts to reduce actual energy consumption by retrofit measures or behavioural changes.** Efforts in the built environment should focus on improving buildings' intrinsic properties that result in a reduced energy demand and carbon emissions. An investment in off-site renewable energy generation might improve the investor's total carbon balance, but the building's potentially poor energy and carbon performance is unsolved.

[163] EPRA, 2017.

[164] GBCA, 2018.

[165] Hermelink et al, 2016.

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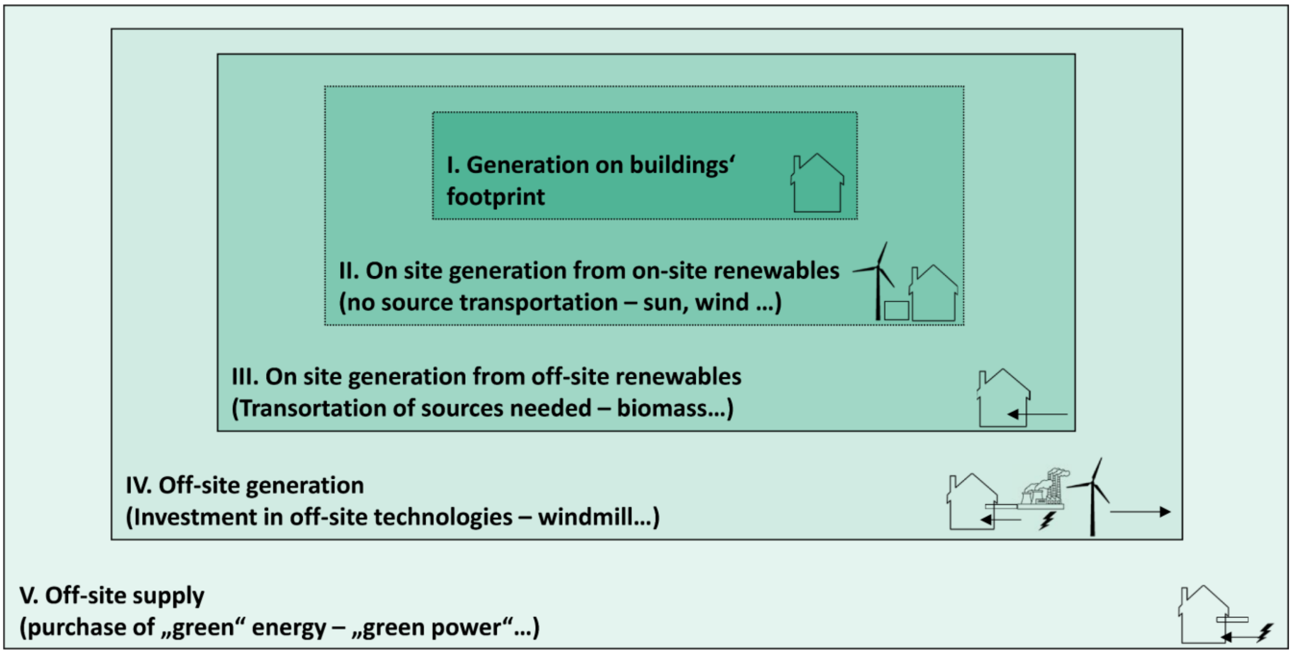
Figure D-21: System boundaries of on-site and off-site energy generation from renewable sources



Source: Ecofys, 2013.

I. GENERATION ON BUILDINGS' FOOTPRINT

Use renewable energy sources available within the building footprint and connected to its electricity grid or hot water systems.

II. ON-SITE GENERATION FROM ON-SITE RENEWABLES

Use of renewable energy sources available on-site but not directly on the building's footprint.

III. ON-SITE GENERATION FROM OFF-SITE RENEWABLES

These technologies use available off-site resources that need to be transported to the building to generate energy (biomass). Some of the carbon benefits are lost in transportation and processing.

IV. OFF-SITE GENERATION

Investment from the building owner in renewable energy generation plants located outside the project site. Depending on the on-site available renewable resources, the generation of renewable energy off-site can be more efficient, both financially and in generation-demand patterns.

V. OFF-SITE SUPPLY

Purchase of green energy from the grid.

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FIGURES

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TABLES

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ANNEX 1: ACRONYMS AND ABBREVIATIONS

2DS	2°C consistent climate scenario of the International Energy Agency IEA
AR4	Fourth Assessment Report (IPCC)
AR5	Fifth Assessment Report (IPCC)
BAU	Business-as-usual
BBP	Better Building Partnership
BEES	Building Energy Efficiency Survey
BEIS	Department for Business, Energy & Industrial Strategy
BMS	Building management system
BOMA	Building Owners and Managers Association
BPR	Best Practice Recommendations
BSO	Building Stock Observatory
CDD	Cooling Degree Day
CEN	European Committee for Standardization
CEN/TC	CEN Technical Committee
C-FACT	Corporate Finance Approach to Climate-stabilizing Targets
CFL	Compact Fluorescent Light
CH_4	Methane
CHP	Combined heat and power
CO_2	Carbon dioxide
$CO_2e(q)$	Carbon dioxide equivalent. The unit is used to make the *Global Warming Potential* (*GWP)* of *Green House Gases (GHG)* comparable to the *GWP* of *CO_2*.
COP	Conference of the Parties der UNFCCC
CRE	Commercial Real Estate
CRREM	Carbon Risk Real Estate Monitor
CSI	Climate Stabilization Intensity Targets
CSO	Context-based Carbon Metric
CTI	Carbon Transparency Initiative
DHW	Domestic Hot Water
EC	European Commission
ECIU	The European Consortium of Innovative Universities

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ECMWF	European Centre for Medium-Range Weather Forecasts
EEA	European Environment Agency
EIC	European Investor Committee
EMAS	Eco-Management and Audit Scheme
EN	European Norm / European Standard
ENTRANZE	Policies to Enforce the Transition to Nearly Zero Energy buildings in the EU-27
EPBD	Energy Performance of Buildings Directive
EPA	United States Environmental Protection Agency
EPC	Energy Performance Certificate
EPD	Environmental Product Declaration
EPRA	European Public Real Estate Association
ERA	ECMWF Re-Analysis
ESD	Effort Sharing Decision
ESG	Environmental, Social and Governance
ETF	Exchange-Traded Fund
ETS	Emission Trading System
EU	European Union
EUA	European Union Allowance (CO_2 emissions)
EU-ETS	European Union Emission Trading System
EUR	Euros
EUREF16	EU Reference Scenario 2016
FRI	Full Repairing and Insuring
GBC	Green Building Council
GDP	Gross Domestic Product
GEVA	Green House Gas Emissions per Value Added
GHG	Greenhouse gas
GMST	Global mean surface air temperature
GP	General Partner (in private equity)
GRESB	Global Real Estate Sustainability Benchmark
GRI	Global Reporting Initiative
Gt	Gigaton

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GWP	Global Warming Potential. *GWP* is used to measure the extent to which a certain *Green House Gas (GHG)* contributes to the heating of Earth's atmosphere in comparison with CO_2.
HDD	Heating Degree Day
HFC	Hydrofluorocarbons
HVAC	Heating, Ventilation and Air Conditioning
IEA	International Energy Agency
IIASA	International Institute for Applied Systems Analysis
IIÖ/IIO	Institut für Immobilienökonomie / Institute for Real Estate Economics
INDC	Intended Nationally Determined Contribution
INREV	European Investors in Non-Listed Real Estate
IPCC	Intergovernmental Panel on Climate Change
IPE	Investment & Pensions Europe
IPMS	International Property Measurement Standards
ISO	International Organization for Standardization
IT	Information Technology
JV	Joint Venture
kWh	Kilowatt hour
LCA	Life Cycle Assessment
LED	Light-emitting diode
LEED	Leadership in Energy and Environmental Design
LP	Limited Partner (in private equity)
LSE	London School of Economics
LULUCF	Land Use, Land-Use Change and Forestry
MAC	Marginal Abatement Cost
MSR	Market Stability Reserve
N_2O	Nitrous oxide
NABERS	National Australian Built Environment Rating System
NDC	Nationally Determined Contributions
NF_3	Nitrogen trifluoride
NHBC	National House Building Council
NNN	Net taxes, net property insurance and net common area maintenance
NOAA	National Oceanic and Atmospheric Administration (US)

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NZEB	Nearly Zero Energy Building
NZZ	Neue Zürcher Zeitung
OCI	Oil Change International
OPEC	Organization of the Petroleum Exporting Countries
PBL	Planbureau voor de Leefomgeving - Netherlands Environmental Assessment Agency
PFCs	Perfluorocarbons
RCP	Representative Concentration Pathways
REIT	Real Estate Investment Trust
RICS	Royal Institution of Chartered Surveyors
ROI	Return of Investment
sBPR	Sustainability Best Practice Recommendations
SBT	Science Based Targets
SBTi	Science Based Targets initiative
SDA	Sectoral Decarbonisation Approach
SDS	Sustainable Development Scenario
SF_6	Sulfur hexafluoride
SRI	Smart Readiness Indicator
TCFD	Task Force on Climate-related Financial Disclosures
TRV	Thermostatic Radiator Valve
TU	Tilburg University
UA	University of Alicante
UK	United Kingdom
ULI	Urban Land Institute
UN	United Nations
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNGC	United Nations Global Compact
US	United States
USD	US dollar
USGBC	United States Green Building Council
UU	University of Ulster
WBCSD	World Business Council for Sustainable Development

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WLC	Whole-Life Carbon
WRI	World Resources Institute
WWF	World Wildlife Fund
ZEBRA	Nearly Zero-Energy Building Strategy

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ANNEX 2: GLOBAL WARMING POTENTIAL OF GREEN HOUSE GASES: CO_2e

What are greenhouse gases?

Greenhouse gases absorb and emit thermal infrared radiation, in turn causing the so-called **Greenhouse gas effect** in which the gases trap heat within the 'surface-troposphere system'[166]. GHGs occur in the Earth's atmosphere naturally, and serve an important purpose keeping the earth habitable. Due to ongoing anthropogenic emissions and land-use change, the concentration of GHG in the atmosphere keeps rising. According to *IPCC's* fifth assessment report, it is extremely likely (95% confidence) that human activities are the dominant cause of global warming from 1951 to 2010.[167]

Definition of GHG according to IPCC's 15th special report 2018:
'*Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of terrestrial radiation emitted by the earth's surface, the atmosphere itself, and by clouds. This property causes the greenhouse effect.*'

The most abundant greenhouse gas is water vapour. Direct human impact on climate change through the release water vapour is limited, as it circulates through the atmosphere rather quickly. However, climate models predict **that increases in man-made GHG emissions will increase water vapour due to global warming, in turn resulting in a positive feedback loop**, strengthening the impact of man-made emissions. The importance of this feedback loop on climate change is regarded as a key model uncertainty[168]. In turn, GHGs play a delicate balance in the Earth's climate system – having too little GHGs will decrease temperature to uninhabitable levels (without GHGs, temperatures would drop to minus 18°C[169]), while increasing GHGs are correlated with rising temperatures resulting in detrimental consequences for man and nature.

The Kyoto Protocol gases and addition of Nitrogen Trifluoride

Due to a growing scientific consensus that human activities are increasing the levels of GHGs in the atmosphere, the *Kyoto Protocol* was established in 1997, identifying a group of six greenhouse gases whose man-induced emissions were to be limited with binding targets for industrialised economies. These six types of GHG emissions are Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs) and Sulfur Hexafluoride (SF_6). These six GHG were also originally included in carbon accounting frameworks, such as the *GHG Protocol Corporate Standard*.

A seventh GHG, Nitrogen Trifluoride (NF_3), was added to national inventories under *the United Nations Framework Convention on Climate Change* (*UNFCCC*) in 2013, as scientific research revealed that there were much higher atmospheric concentrations of NF_3 than previously expected, while at the same time industrial production rates had increased 40-fold between 1992 and 2007[170].

Global Warming Potential, CO_2e and the IPCC Assessment Reports

The impact GHGs have on our atmosphere is dependent on the amount of heat they absorb ('radiative efficiency') as well as the period of time that they remain in our atmosphere ('lifetime'). In order to compare the impact of GHGs, the

166 IPCC, 2007.
167 IPCC, 2014.
168 NOAA, 2018a.
169 Energy Education, 2018.
170 Russel, 2013.

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Intergovernmental Panel on Climate Change **(*IPCC*)** calculates so-called **'Global Warming Potential' (GWPs)** values for the different types of GHG, indicating the amount of warming a gas causes over a given period of time (typically 100 years) in relation to CO_2.

The reason for **the negligence of other GHGs in emission inventories** can often be found in the absence of reliable information on these GHGs. '*IPCC emission categories provide numbers to different sources of emission but do not systematically attribute these to sectors*'[171]. However, non-CO_2 GHG have GWP-weighted share of global GHG emissions of 12%/27%/48% (500/100/20-year time horizon)[172].

The GWP is calculated as an index, with CO_2 having the index value of 1, while the GWP for other emissions reflects the impact these emissions have as a multiple to CO_2. For example, Methane (CH4) is estimated to have a GWP of 28–36 over 100 years. The GWP value reflects that CH_4 does not have a lifetime as long as CO_2 (about a decade on average) but does absorb much more energy than CO_2, and as such has a higher GWP value. Additionally, the GWP accounts for indirect effects, as CH_4 is a precursor to ozone, which in turn is an GHG[173]. An overview of GWP values for some GHGs can be found in the following table.

Table Annex 2-1: Global Warming Potential values relative to CO_2

Industrial designation or common name	Chemical formula	GWP values for 100-year time horizon		
		Second Assessment Report (SAR) 1995	Fourth Assessment Report (AR4) 2007	Fifth Assessment Report (AR5) 2014
Carbon dioxide	CO_2	1	1	1
Methane	CH_4	21	25	28
Nitrous oxide	N_2O	310	298	265
Sulfur hexafluoride	SF6	23,900	22,800	23,500
Nitrogen trifluoride	NF_3	N/A	17,200	16,100

Source: IPCC, 2014, p. 124.

Multiplying the amount of GHG by its GWP leads to a so-called **'carbon dioxide equivalent' (CO_2e)**. Within the industry, carbon emissions frequently do not refer to just the emissions of the chemical compound, but rather to CO_2e. In fact, it is estimated that **non-CO_2 greenhouse gases have jointly contributed up to around 40 percent of overall human induced global warming**[174]. The extremely high GWP values of non-carbon GHGs underpin this relevance.

As can be seen in the table above, the estimated **GWP values have changed over the years** with the release of keystone *IPCC* Reports. This highlights the fact that **as scientific knowledge on the impact of GHGs advances, carbon accounting reporting standards must be revised**. This results in limitations to the comparability of reported emissions over time, especially if investors need to make use of static reports. Companies or carbon accounting systems might be slow to adopt these new insights, resulting in **difficulties for investors to compare the emissions between different real estate portfolios they are invested in**.

[171] IPCC, 2014.

[172] IPCC, 2014.

[173] EPA, 2018.

[174] Rao / Riahi, 2006.

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ANNEX 3: EFFECTS OF CLIMATE CHANGE ON PROPERTY VALUES

Climate Aspect	Commercial and Residential real estate	Forestry	Agriculture	Infrastructure
Rise in temperature	Reduced ground rent (lower potential revenue, in the case of regional population changes; also, increased need for cooling, and thus higher operating costs)	Reduced ground rent (in the case of increase in forest fires, pest infestation, extinction of species)	Reduced ground rent (in the case of increasing drought, pest infestation)	Increased wear on installations; unstable ground
Water scarcity	Decline in attractiveness of a region/decline in ground rent; higher costs for water supply and treatment	Reduced revenues from forestry/increased danger of forest fires	Reduced harvests; increased costs for irrigation	Decline in bearing capacity of soil
Rising sea level	Reduced settlement area in coastal regions		Reduced agricultural land area/loss of potential revenues	Danger to port facilities
Increase in extreme weather events	1. Direct loss (e.g., hail damage to buildings) 2. Indirect loss (e.g., through gaps in production or rent after hurricanes) 3. Consequential loss (e.g., declining number of tourists in flood areas, rising insurance premiums)	1. Direct loss 2. Consequential loss 3. Depreciation of natural capital (permanent damage to ecosystems, extinction of species)	1. Direct loss 2. Consequential loss 3. Depreciation of natural capital	1. Direct loss 2. Indirect loss (infrastructure damages due to extremes in temperature, precipitation/ flooding/ overload of urban drainage systems/storm surges, which can lead to damage to roads, rail, airports, and ports; electricity transmission infrastructure is also vulnerable)
Increased regulation	Higher construction costs and running costs; higher costs, particularly in the case of carbon taxation			Higher construction costs and running costs
Increased adaptation costs due to climate change	Higher adaptation costs to protect properties and to make buildings energy - and resource efficient	Higher adaptation costs	Higher adaptation costs	Higher adaptation costs

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ANNEX 4: OVERVIEW OF NORMS RELATED TO SUSTAINABILITY, GHG AND RISK

Norm	Title	Content
EN 15978	Sustainability of construction works - Assessment of environmental performance of buildings - Calculation method	LCA, Embodied Carbon, reporting.
EN 15804	Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products	Product category rules (PCR) for environmental declarations. Assessment and reporting. Comparison of construction products based on EPD.
EN 15643-5	Sustainability of construction works - Sustainability assessment of buildings and civil engineering works - Part 5: Framework on specific principles and requirement for civil engineering works	Assessment of environmental performance over the whole life cycle.
CEN/TC 350	Sustainability of construction works	Assessment of sustainability aspects of new and existing buildings. Environmental product declaration of construction products. LCA.
ISO 12655	Energy performance of buildings - Presentation of measured energy use of buildings	Classification and metering of energy use by purpose, categories of energy use by boundaries.
ISO 14001: 2015	Environmental management systems - Requirements with guidance for use	Enhancement of environmental performance, fulfilment of regulation and achievement of objectives.
ISO 14040	Environmental management - Life cycle assessment - Principles and framework	LCA, Life Cycle Impact Analysis (LCIA)
ISO 14044: 2006	Environmental management - Life cycle assessment - Requirements and guidelines	LCA, Life Cycle Impact Analysis (LCIA)
ISO 14064-1	Greenhouse gases - Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals	Assessment and reporting of GHG emissions and removals.
ISO 16745-1	Sustainability in buildings and civil engineering works - Carbon metric of an existing building during use stage -Part 1: Calculation, reporting and communication	Measurement, reporting and communication of three different carbon metrics in the use stage of a building.
ISO 21929-1: 2011	Sustainability in building construction -- Sustainability indicators -- Part 1: Framework for the development of indicators and a core set of indicators for buildings	Sustainability indicators for new and existing buildings over the whole life cycle.
ISO 21930: 2017	Sustainability in buildings and civil engineering works -- Core rules for environmental product declarations of construction products and services	Environmental product declaration (EPD) for the construction sector.
ISO 21931-1: 2010	Sustainability in building construction -- Framework for methods of assessment of the environmental performance of construction works -- Part 1: Buildings	Assessment of environmental performance of new and existing buildings.
ISO 31000: 2018	Risk management - Guidelines	General principles, framework and a process for managing risk for any organization regardless of its size, activity or sector.
ISO 52000-1	Energy performance of buildings -- Overarching EPB assessment -- Part 1: General framework and procedures	Assessment of the energy performance of new and existing buildings.

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ANNEX 5: DEFINITION OF TERMS RELATING TO THE DECARBONISATION OF THE PROPERTY INDUSTRY

Decarbonisation

The term '**decarbonisation'** has been regularly used in literature and in the appellation of initiatives concerned with the reduction of greenhouse gases. The concept determines prosses to reduce the necessary CO_2 emissions. The process of decarbonisation requires the substitution of inefficient and emission-intensive technologies by efficient and low-emission technologies with at least the same (energetic) capacity.[175] The entire spectrum of options is based on four pillars[176]:

- Energy production (here, the usage of fossil fuels needs to be systematically replaced by renewable energy sources in order to gradually achieve a greenhouse gas reduction),
- a shift towards sustainable combustibles in the sectors of transportation, heating and industry,
- an increase in efficiency,
- the preservation and extension of carbon sinks.

Carbon-neutral

Carbon-neutral as well as the interchangeable term **CO_2-neutral** elucidates a condition where no gross contribution to global CO_2 emissions takes place due to activities of an individual, organisation, city or state.[177] This prerequisite is met when activities themselves do not emit CO_2. For most of the processes CO_2-neutral alternatives cannot be implemented with the technology available yet. Instead the CO_2-neutrality is reached by offsetting respectively creating compensation alternatives within or outside the system.[178] This can be achieved due to permanently bind positive emissions with energy production from renewable sources or carbon storage. The concept 'climate neutrality' exclusively refers to carbon dioxide. To include further GHGs the terms '**climate neutrality**' or 'greenhouse gas neutrality' is used. Similar to the concept of 'CO_2-neutrality' the terms also refer to the implementation for compensational activities which also includes the reduction of other GHGs due to compensation activities ((natural) carbon sinks or negative emissions in other sectors or countries). **Emission-free** consequently describes a condition in which no GHGs are emitted anymore.[179]

CO_2-free

CO_2-free, also referred to as Zero-CO_2, signifies that no CO_2 is emitted outside a given system. As a consequence, compensations and offsets are only possible within system boundaries (if required for the prevention of a positive net contribution outside a given system).[180] When this definition is applied on a building, CO_2-free implies that its management does not exhibit any CO_2 emissions, while the emissions of a CO_2-neutral building are equalised through offset mechanisms. Notwithstanding according to this definition, emissions may well be accrued, yet would have to be compensated within the building (particularly in the event of utilising electric energy emanating from renewable energy sources). However, in practice it is impossible that these occur without emissions, especially when indirect emissions are included in the analysis. By integrating Scope 3 emissions, achieving a CO_2-free condition is practically impossible.

175 IAA, 2018, p. 4.
176 World Bank Group, 2015, p. 28.
177 Rovers et al., 2008, p. 11.
178 Gössling, 2009, p. 3.
179 Bienert et al., 2017 p. 28-34.
180 Rovers et al., 2008, p. 11.

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While the procurement of a wind power station could have led to a CO_2-free state, this is from a 'Scope 3'- perspective not possible anymore due to the emissions caused by producing the facility.[181]

Nearly zero energy building nZEB

With regard to real estate, the concepts of net or nearly zero energy are frequently used. Based on the definition of a **'nearly zero energy building'** by the *EU* within the scope of the ***Energy Performance of Buildings Directive (EPBD)***. In article 2.2 of the *EPBD,* a 'nearly zero-energy building' is defined as a building exhibiting a very high overall energy performance. The house's energy consumption must be very low and should be covered to the highest extent possible with renewable sources produced on-site or nearby. Furthermore, the *EU* provides guidelines for the cost optimality for the energy performance of new buildings, existing buildings undergoing major renovation, and retrofitted or replaced elements that form parts of the building envelop. By 31 December 2020, *all* new buildings and after 31 December 2018, new buildings occupied and owned by public authorities have to be built according to the nZEB standard.[182]

[181] Bienert et al., 2017 p. 30-31.

[182] Ecofys, 2013.

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ANNEX 6: INDEX

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