Carbon Risk Real Estate Monitor

CRREM Retrofit Harmonisation Roadmap

A Guide to Policy Formulation in the European Commercial Real Estate Industry

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EXECUTIVE SUMMARY

Material and insights gained within the *CRREM* project enable the identification of strategies for European policy makers to move towards a more harmonised commercial property retrofit support system, thus encouraging an uptake of actions from the industry. ***CRREM* research to date has shown** that the real estate sector has in the main exhibited willingness and determination to embrace its environmental responsibilities. Nonetheless, transitional mobility and levels of intervention and adaptation vary considerably across the sector. Moreover, **knowledge and understanding of the implications and transitional risks posed by policy evolution needs to be more powerfully reinforced**. Further to supporting the implications and outcomes of policy change there is a pertinent need to transpose national and international goals depicted within the **Paris Agreement into meaningful "hard targets" and corresponding timelines for the real estate industry**. *CRREM* has devised a series of decarbonisation pathways for the real estate sector predicated +1.5°C to +2°C scenarios. This report synthesises and analyses existing policy initiatives in order to devise a **set of policy recommendations for altering, developing and introducing energy efficiency policies for European regulation** which support the upscaling of retrofit actions and seek to mobilise more proactive interventions – particularly targeting the mitigation of carbon intensive assets.

The Paris Agreement put in place a global collaborative framework to mitigate the impacts of climate change by limiting global warming to well below 2°C and pursuing efforts to limit it to 1.5°C. As at the end of March 2020 a total of 189 of the initial 197 signatories had formally endorsed their commitments to the 2015 Paris Agreement. Following on from the Paris Accord, the United Nations published their Sustainable Development Goals (SDG) in 2016. These two initiatives have radically transformed the landscape for commercial property owners and investors prompting reform of business operations and transformation in organisational cultures. Conventional **asset management frameworks have been reviewed and revised whilst risks models have been overhauled to account for physical and policy risks attributable to climatic change.** The commercial real estate sector is undergoing the most radical process of adaptation witnessed in the lifetime of many of the stakeholders and industry leaders tasked with overseeing and conceptualising the necessitated change.

Based on a **science-based methodology, the CRREM pathways** take account of property location and asset class/use-type in order to create meaningful assessment and evaluation of stranding risks and devise optimal retrofit intervention points in the asset lifecycle from an economic and ecological perspective. The visualisation and analytical evaluation afforded by the CRREM tool serves to deepen the understanding of stranding risk and of the need for immediate and impactful intervention strategies across the real estate sector if the targets laid down in the Paris Agreement are to be attained[1]. The economic business case supporting the decarbonisation of the commercial real estate sector is very strong in terms of impact relative to money spend and shows to be more favourable than other key industry sectors [2].

Optimising the real estate decarbonisation opportunity is nonetheless fraught with a series of barriers and challenges. Technical competence and resource capacity feature prominently as barriers to decarbonisation. However, the quality and robustness of data on energy performance and carbon intensity of buildings as well as inconsistencies in embodied carbon capture methodologies are the most persistently cited barriers. The lack of robust and credible data prevents evidence-based decision making, detracts from meaningful performance assessment all of which combines to compromise the business case for the upscaling of green retrofitting.

Given the magnitude of emissions, the decarbonisation of buildings and the commercial real estate sector has been identified as a key contributor to the realisation of aspirations laid out in the Paris Agreement.[3] In this context however a lot of obvious questions are still (partially) unanswered: To what extent does the commercial real estate sector or even a specific property need to reduce its prevailing carbon emissions to conform with the 1.5°C and 2°C scenarios and still be "aligned" in 2050? In financial and economic terms what does this mean with respect to direct and indirect

[1] The CRREM Tool is a free-to-use tool allowing policy makers to "plug in" their own data to inform and evidence policy development.

[2] BBP, 2020.

[3] United Nations, 2015.

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investment within the value chain and with regard to expected (energetic) retrofitting costs vs. potential carbon pricing expenditures? How can policy makers and other stakeholders best facilitate and enable this transition towards a decarbonised European real estate sector?

Central questions in the development of the "right" regulatory framework and policies in connection with the achievement of the climate targets of the commercial real estate industry are:

- How high is the CO_2 strain on the real estate sector at present?
- How can the efficiency of existing regulatory instruments be assessed in relation to achieving the 2020/2030/2050 targets?
- What gap is there in relation to target achievement?
- How can the goals be achieved through "smart" and market-oriented regulation?
- How are the instruments used to ensure static efficiency, accuracy of target achievement and dynamic efficiency (as a further incentive to innovate)?
- How can tenants and landlords in particular be incentivised to work on this common goal?
- What are potential pitfalls to achieve efficiency targets and what are on that basis well-defined policy recommendations?

Our resulting policy recommendations are summarised and cross-referenced in the next chapter as "Key recommendations". A more detailed narrative and contextual appreciation of the recommendations can be found within the corresponding section of the main text.

The report is divided into three main sections that are built on one another in terms of content and each provide input in regards to the following topics:

SECTION A DECARBONISATION OF THE EUROPEAN REAL ESTATE SECTOR – TARGETS VS. STATUS QUO

This section provides the introduction to the report and includes insight on the European climate targets, the current forecasts and the status quo. The analysis leads to number of fundamental recommendations. Further, the fundamental challenges for the real estate sector are explained: the energy efficiency investment gap and general market failures. Key barriers are highlighted with exploration of why these barriers either individually or in combination serve to inhibit the upscaling and roll-out of deep retrofitting within the commercial real estate sector. Lastly, the role of *CRREM* in helping to bridge the energy efficiency gap is highlighted.

SECTION B ACCELERATING DECARBONISATION WITHIN THE COMMERCIAL REAL ESTATE SECTOR

Section B investigates the role and potential contribution of real estate and construction, placing a focus on existing buildings as an impactful and cost-efficient strategy for attaining decarbonisation targets. At the core of this chapter are a multitude of policy recommendations and wider discussion on how decarbonisation can be accelerated for the sector in order to re-establish momentum and progress consistent with the Paris goals. Cross-references to these policies will appear in other chapters and are referred to as "Policy Advice / PA".

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SECTION C THE *CRREM* DECARBONISATION POLICY ROADMAP

This section begins with restating the challenge, succeeding with the starting point – the CRREM Policy Analysis Matrix. The *CRREM Policy Analysis Matrix*, which is designed to facilitate an analysis of how policies with different attributes will be responded to by organisations with different attributes. Resulting in a new proposal that is sectored into a three-phase approach. Concluding, the section explains how the roadmap can be tailored to different market segments. Whereas section B is stating policy recommendations, the CRREM Roadmap offers a programme for engagement by policy makers to address market participants with contrasting motivations and capacities as a basis for mobilising prompt, actionable, outcomes consistent with decarbonisation and climatic targets.

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KEY RECOMMENDATIONS

Policymakers can help accelerate a reduction of emissions by **setting a clear, long-term direction that builds confidence**, which is critical to driving action across the private sector. In addition, providing the right incentives will help to reach long-term milestones.

The following policy recommendations (short: PR) are addressed to European stakeholders but could in most cases also be relevant for policy makers outside the European Union. The portfolio of knowledge assembled within the *CRREM* roadmap provides r**obust, objective supporting evidence to inform and guide policy development on the upscaling of green retrofitting.** Our objective is to optimise the "impact potential" of efforts targeting the decarbonisation of existing buildings relative to Paris Agreement goals. **Upscaling deep retrofitting through investment and building supply chain capacity** will take time but the report's recommendations provide practical steps for the creation of an enabling and supportive policy landscape. The key emphasis needs to be widening mobilisation across the sector and to reiterate the **translation of headline environmental goals into meaningful time-defined targets** in to order to prompt immediate and impactful actions. There is a lack of a holistic decarbonisation policy frameworks within the built environment. Policy initiatives aimed at reducing carbon intensity within the built environment are scattered into different areas, with multiple roles and governance responsibilities. Section A.2 outlines general recommendations to the sector, including:

- Policy recommendation 1:
  - A) Translation of climate pledges into "hard" meaningful pathways for real estate
  - B) Effective communication of "hard targets" and Paris-conformant pathways
  - C) Promote city-scale decarbonisation roadmaps

Incorporating a CO_2 pricing scheme also for the real estate sector might be a decisive and indispensable factor in achieving the aspired emission reductions.

- Policy recommendation 2: CO_2 pricing model for the real estate sector

THE ROLE OF REAL ESTATE AND CONSTRUCTION – FOCUS ON EXISTING BUILDINGS

See section B.1 for recommendations:

- Policy recommendation 3: Prioritisation of "smart" decarbonising the existing building stock
- Policy recommendation 4: Establishment of meaningful milestones directly linked to the real estate sector
- Policy recommendation 5: Harmonising policy frameworks and stakeholder responsibilities

TARGET SETTING AND PROGRESS MAPPING – ENHANCE CONTROLLING CAPACITY

See section B.2 for policy recommendations regarding data and controlling:

- Policy recommendation 6:
  - A) Improve standardisation for future data collection and methodological consistency
  - B) Enhance third-party audits and high-quality benchmarks
- Policy recommendation 7: Foster data collection on carbon intensity of assets and "stranding risk" benchmarks following a "whole building approach"
- Policy recommendation 8: Consistent building codes that promote green and sustainable construction
- Policy recommendation 9: Promote data sharing across the value chain and address behavioural changes
- Policy recommendation 10: Promote more (smart) controlling, enhance measurement infrastructure, ensure standardisation and reduce reliance on purely modelled data

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BEYOND OPERATIONAL CARBON - DEFICIENCIES IN EMBODIED CARBON DATA UNDERMINE THE RETROFIT BUSINESS

Accounting for embodied carbon is critical to ensure that operational carbon savings achieved by retrofit works do not imply larger carbon emissions elsewhere. However, current policy frameworks do not require the reporting and reduction of these emissions and therefore, investors and owners seldom gather data. For key recommendations see section B.3.

- Policy recommendation 11: Include emissions from construction activities in climate policies – enhance the focus on "embodied carbon"

REVEAL THE UP- AND DOWNSIDES – PROMOTE EVIDENCE ON ALL RETROFIT VALUE ELEMENTS AND STRANDING RISK

Retrofits do not just affect energy costs, but also property values. The extent to which this is adequately captured and translated in asset valuations is an ongoing source of debate with a requirement for more robust data to improve transparency and better inform the business case for retrofits. See section B.4 and B.5 for key recommendations.

- Policy recommendation 12: Support valuation professionals' understanding of deep retrofitting solutions and prospective "value impacts"
- Policy recommendation 13: Include analysis of effects caused by superior or poor energy efficiency in regulation for property valuations
- Policy recommendation 14: Gradual ban on renting and selling of the least energy-efficient properties
- Policy recommendation 15: Implications of stranding risk need to be evidenced

NEED FOR CAPACITY BUILDING - UNDERINVESTMENT IN TECHNICAL AND CORPORATE INNOVATION TO SUPPORT TRANSITION

- Policy recommendation 16: Upscaling green retrofit capacity
- Policy recommendation 17: Local authorities to initiate portfolio-based approaches to support green retrofitting upscaling

HOW "GREY" IS THE BUIDLING STOCK? - LACK OF DATA REPORTING FROM MEMBER STATES ON BUILDING CHARACTERISTICS AND ENERGY PERFORMANCE

Section B.6 provides a recommendation how to support evidence-based decision making:

- Policy recommendation 18: Augment the building stock observatory to support evidence-based decision making and to include embodied carbon data

FUNDING NEEDED - LACK OF FINANCIAL RESOURCE CAPACITY AMONGST INVESTORS

There is an urgent requirement to find a more appropriate balance between regulatory enforcement (e.g. building energy codes or financial non-compliance penalties) and incentives while further work is needed on the conceptualisation of financing tools which enable the decarbonisation pathways to be initiated and advanced. See chapter B.7 for the PA:

- Policy Recommendation 19: Exploration of new and innovative funding models

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CRREM REAL ESTATE DECARBONISATION PATHWAYS

See Section B.8 for recommendations regarding:

- Policy recommendation 20: Translation of national and international decarbonisation targets into real estate benchmarks
- Policy recommendation 21: Combine direct and indirect emissions
- Policy recommendation 22: Harness industry leadership through "active partnering"
- Policy recommendation 23: Align and enhance data governance frameworks to support decarbonisation targets

TAILORING THE CRREM POLICY ROADMAP FOR MARKET SEGMENTS

In section C.4 a focus is placed on market participants. Policy recommendations are directed to mitigating the reluctant sectors and the recognition of greened buildings. Key recommendations are:

- Policy recommendation 24: Mitigation of reluctant industry sectors
- Policy recommendation 25: Recognition of "greened" buildings

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DECARBONISATION OF THE EUROPEAN REAL ESTATE SECTOR – TARGETS VS. STATUS QUO

SECTION A DECARBONISATION OF THE EUROPEAN REAL ESTATE SECTOR – TARGETS VS. STATUS QUO

The adoption of the Paris Climate Change Agreement is considered a watershed moment for tackling climate change and prompted a meaningful "step change" in the climate policy landscape and negotiations centred on collaboration and innovative interventions aimed at curtailing global warning[4].

Indeed, the signing of the Paris accord symbolises a global commitment towards reducing carbon emissions to 2°C and below[5].

A.1 INTRODUCTION

Through a series of policy initiations, guidance frameworks and proposed decarbonisation pathways, The *European Union (EU)* has demonstrated a proactive commitment to limiting global temperature increase to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C. Indeed, a series of policy initiations, guidance frameworks and proposed decarbonisation pathways underpin the *EU* aspiration to become the world's first climate-neutral economy. **Sustaining momentum relative to the 2030 target and ultimately the 2050 vison depicted in the Paris Agreement will necessitate transformational change** from a societal standpoint but also in terms of how businesses function and govern their environmental responsibilities. The **real estate sector has up to this point lagged other sectors of industry** with respect to the initiation and development of decarbonisation pathways and roadmaps. Historically, decarbonisation was viewed as a potential cost burden by many within the real estate sector, increasingly however **decarbonisation is perceived as an opportunity to add value, a premise for innovation and a basis for sustainable portfolio construction** leading to enhanced environmental and financial performance[6].

At technical and operational levels, the **real estate sector can make an impactful contribution** to the decarbonisation agenda. Real estate is a major source of Greenhouse Gas (GHG) emissions and as such affords significant scope in terms of achieving national and international decarbonisation targets consistent with the Paris Agreement[7,8]. The Paris Agreement did not stipulate or specify targets for the real estate sector. Nonetheless, the real estate sector offers unique challenges as well as opportunities. Buildings and construction related activity transcend key sectors of industry with businesses occupying space either as owner occupiers or as tenants. As such, the decarbonisation of properties has the dual impact of reducing carbon emissions within the real estate sector in its own right but also presents a key

[4] Bodansky, 2016.
[5] UNFCCC, 2015.
[6] UKGBC, 2019.
[7] BBP, 2020.
[8] WGBC, 2018.

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opportunity for cost effective and impactful change across the wider economic value chain. The decarbonisation of the sector affords significant impact potential within the confines of the decarbonisation agenda.

In spite of the increased momentum and "willingness" to pro-actively initiate change within the real estate sector the **translation of national environmental and decarbonisation targets into meaningful pathways, regulation and policies for change at asset and portfolio levels remains particularly challenging**. In this report we examine the nature and implications of those challenges and proffer recommendations which could serve to overcome barriers to decarbonisation within the real estate sector. From a policy viewpoint there is also an obvious need to better understand the levers and strategies which most effectively support adaptation across the real estate sector and to examine new strategies and funding vehicles which facilitate and encourage investment and innovation.

The purpose of the ***CRREM Decarbonisation Roadmap*** is thus twofold. Firstly, the roadmap depicts the project outcomes to date conveying a **robust, credible series of science-based targets and clearly defined pathways to "guide" likewise policy makers and investors** in the design and implementation of their climate strategies pertaining to the built environment more generally and the commercial real estate sector in particular consistent with the 1.5°C and 2°C targets. More specifically, **the roadmap synthesises key learning outcomes from the *CRREM* project** and transposes these into a **series of policy recommendations**. The intention is to address the identified barriers and gaps to decarbonisation of the existing commercial real estate stock based on the *CRREM* learning outcomes to date. The roadmap will serve to inform and guide policy formulation with robust, objective evidence which supports (deep) energetic retrofit and innovative investment strategies designed to facilitate and enable "local" actionable outcomes pertaining to the decarbonisation of the commercial real estate sector. Secondly, the roadmap affords real estate owners and managers more engrained **understanding of the impacts and implications of policy and proposed policy change on their investment portfolios**. The policy advice and recommendations depicted within this roadmap showcase viable decarbonisation pathways which permit early detection of "at risk" assets and inform intervention measures to mitigate the identified transitional risks in order to ensure long-term decarbonisation for their investment portfolios.

A.2 EUROPEAN CLIMATE TARGETS VS. CURRENT FORECASTS

In order to meet the carbon reduction targets, there have been numerous strategic approaches and policy commitments and implementations adopted at the national level and across participating governments. As at the end of March 2020, 189 of the 197 countries who signed up to the **Paris Agreement** had formally endorsed their commitments. Notably, the US initiated the procedure to withdraw from the Paris Accord in 2019 and will formally leave on 4th November 2020. Despite concerted policy initiatives and increased collaborative effort across a number of key sectors of industry a **sizeable gap remains between long-term climatic goals of +1.5°C to +2°C and the estimated aggregate effect of recent commitments of 2.8°C**[9]. Indeed, scientific research has demonstrated that current global pledges are not enough to meet the 2°C target. Furthermore, scientists claim that there is yet another gap between the pledges (already lagging behind) and existing national regulation that is not yet meeting in a lot of cases the requirements set out in the pledges[10]. Even if there are uncertainties in forecasts, it is clear that ambitious objectives and goals are necessary to avert serious effects on society, the environment and the economy[11].

[9] Climate Action Tracker, 2019.

[10] Climate Action Tracker, 2019.

[11] IPCC, 2019.

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Already in 2015, the EU submitted the INDCs for its member states, committing to a binding target of at least 40% domestic reduction in CO_2 emissions by 2030. This reduction is the pledge of the EU to comply with the Paris Agreement to ensure that global warming is kept well below 2°C[12].

The EU has established step-wise climate protection targets by 2050, the pathways of which are now included within National Determined Contributions (NDCs), revealing **planned reductions in CO_2 emissions of 20% (2020),**[13] **40% (2030)**[14] **and 80% (2050) premised on 1990 emission levels**[15,16,17].

The EU emission reduction targets for 2020 and 2050 place stringent requirements upon member states to transition to a low carbon economy[18]. Following other carbon reduction schemes, core policies have been introduced such as the *EU Emissions Trading System (EU ETS)* and the ***Effort Sharing Decision (ESD)*** setting binding targets for each member state[19]. **In May 2018, *EU* member states adopted a binding annual GHG emission target for 2021-2030** for those sectors of the economy that fall outside the scope of the *EU ETS.* The sectors **comprised buildings**, transport, agriculture, waste and non-*ETS* industry which when combined account for almost 60% of total domestic *EU* emissions[20]. The binding targets within the *Effort Sharing Regulation (ESR)* depict the annual GHG targets for each member state for the periods 2013-2020 and 2021–2030. Objectives consider different economic growth expectations and investment capacities across *EU* member states, ranging from 0% to -40% reduction by 2030 compared to 2005 levels[21]. In general, detailed **sector-specific targets within the non-EU ETS sectors were not determined by the EU directly** (rather the allocation is left to the respective member countries). The EU Commission plans to announce stricter climate targets for 2030 in September 2020. As recently announced, the panel is continuing to work on these stricter targets, even during the current challenges that the corona pandemic poses and will continue to pose for the European economy[22].

The participants of the COP21 already point out that the construction and real estate industry must make a significant contribution to mitigation measures. However, the Paris Agreement itself, as well as the EU's non-ETS targets, do not contain any specific reduction targets for the real estate industry. Due to the high share of the sector in global GHG emissions of around 9,8 Gigatons of CO_2[23] (or approximately 27% of all CO_2 emissions), ambitious national targets are essential in order to achieve a decarbonisation of the economy in line with the Paris Agreement. **Due to the low rates of new building construction in the EU, it is clear that in addition to the construction of energy-efficient new buildings, extensive measures for energy-efficient renovation of existing buildings is necessary.**

The primary legislation pertaining to the **decarbonisation of the real estate sector is still the *Energy Performance of Buildings Directive (EPBD)***. Since 2018, the *EPBD* has required each member state to present a long-term renovation strategy that will result in a **complete decarbonisation of its building by 2050**[24]. The *directive also* defines requirements towards energy performance of new buildings and major renovations. Under the *EPBD*, all new buildings within *EU* member states will be required to achieve the **"nearly zero-energy building" standard from 2021 onwards**. For new public buildings, the nearly zero-energy standard has been in place since 2019. According to the *EPBD*, it is up to the

[12] European Union, Intended Nationally Determined Contribution (INDC), 2015.
[13] European Commission, 2019a.
[14] European Commission, 2019b.
[15] European Commission, 2008; European Commission, 2012; European Commission, 2013.
[16] Ivanova et al., 2017.
[17] European Union, 2013.
[18] Strachan et al., 2015.
[19] European Union, Regulation 2018/842.
[20] European Union, May 2018.
[21] European Union, May 2018.
[22] Reuters, 2020.
[23] WRI World Resources Institute, 2020.
[24] Cf. EU Regulation 2018/844 Article 2a „Long-term renovation strategy".

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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[25]. However**, 35% of the existing buildings in the EU are currently over 50**[26] **years old and correspondingly, are in a poor energetic condition** with relative high consumption rates. Against this information, **a 5% increase in the annual renovation rate** in existing buildings would be required within the EU in order to align emissions from the building sector to the target of a maximum temperature increase of 1.5°C [27]. Further, the buildings, regardless of whether residential or commercial are getting more functions e.g. home office work place or charging stations for electric vehicles, leading to more energy consumption being shifted into the buildings. This leads to a considerable increase in energy consumption in regard to the building, and hence risks and energy consumption costs are being transferred. Many of these developments must still be considered and overcompensated.

Further, the **"European Green Deal" places a focus on an investment plan** to fight against climate change. With the ambitious plan, 485 billion EUR are made available and will come from the EU budget by 2030. Aids, among others, are aimed at coal regions in order to assist these during structural change. The *European Union Technical Expert Group on Sustainable Finance (TEG)* also states the **EU Action Plan on financing sustainable growth** and is a critical enable of transformative improvements for existing industries, and stating estimates from the OECD that over 6.35 trillion EUR will be required to meet the Paris goals as soon as 2030[28].

Current calculations not only show a global gap between objectives and status quo (see above), but also underpin that within the **EU, the achievement of the milestones in 2020, 2030 and 2050 is at risk despite all of the above-mentioned political initiatives and regulations**[29,30]. Without additional measures, many EU member states in the non-ETS under the ESD recommended savings are not likely to reach the targets by 2030. Germany as an example is required to reduce overall emissions by 38% compared to the year 2005 and it is still questionable if that goal will be reached[31]. The European Commission Roadmap scenarios for reaching net-zero emissions in the *EU* in 2050 estimate GHG emissions reductions of 55% to 65% until 2030. A further step-change is required to achieve the 2050 targets with annual reduction rates having to reach 5.3% (80% reduction) or even 11.7% (95% reduction) [32]. **Even if the long-term goal of decarbonising the economy by 2050 is clearly defined, individual sectors such as the real estate sector are evidently lacking clear sector-specific targets on which the respective business models and efforts of the individual companies to achieving the climate goals can be aligned.**

[25] European Commission, Energy Performance of Buildings Directive, 2018.
[26] Climate Action Tracker, 2019b.
[27] Cf. Ebenda, 2020.
[28] TEG, 2020.
[29] Centre for European Reform, 2019.
[30] C. Bals, 2013.
[31] BMU, 2018.
[32] European Commission Energy Roadmap 2050, 2019.

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POLICY RECOMMENDATION 1:

A.) TRANSLATION OF CLIMATE PLEDGES INTO "HARD" MEANINGFUL PATHWAYS FOR REAL ESTATE

In order to initiate these necessitated step-change, policy makers must start **focusing on scientifically translating climate pledges into meaningful carbon pathways for real estate owners and investors**. The *CRREM* carbon budget calculations show the pressing need for immediate and actionable outcomes by the sector. This includes moving beyond the "win-wins" of energy efficiency in order to attain actionable and meaningful impacts on direct and indirect emissions across the value chain. Previous research published by *CRREM* has highlighted the desire for "hard" meaningful targets amongst investors in order to guide and inform their mitigation measures and enable strategic planning of associated budgets and resources. Such targets are considered essential to the development of sectoral understanding of the scale of the challenge and the need for a proactive and engaged response to requisite risks and opportunities. In addition, targets help guide and inform mitigation measures and enable strategic planning of associated budgets and resources. Such pathways must be **(1) science-based/reliable**, enable **(2) long-term planning, (3) differentiate between countries,** sectors and use types and ultimately **(4) relate emissions on asset level to a "fair share"** derived from the remaining global carbon budget in order to meet Paris Pledges.

B.) EFFECTIVE COMMUNICATION OF "HARD TARGETS" AND PARIS CONFORMANT PATHWAYS

Translation of Paris Agreement Targets into Impactful Pathways for investors/owners. Real estate owners and investors need a clear roadmap with clearly **defined science-based "hard targets"** and time boundaries regarding potentially upcoming regulation. Only transparent meaningful targets will result in actions – particularly amongst those actors that are not already mobilised to initiate and embrace decarbonisation challenges. The *CRREM* tool provides hard targets for real estate investors and owners **transposing agreed Paris targets into meaningful pathways.** The tool is free-to-use and offers a credible and industry validated vehicle for effective communication and visualisation of the risks and opportunities that decarbonisation of the real estate sector affords.

C.) PROMOTE CITY-SCALE DECARBONISATION ROADMAPS

City-scale decarbonisation roadmaps are needed to transpose national and international targets into meaningful goals at "local level". **Local development plans, building control as well as the quality of existing and future infrastructure provision all impact upon the carbon intensity of a city.** Decarbonisation of the built environment needs to be fully immersed within future development plan and associated infrastructure provision. Creating meaningful "hard targets" and identifying key milestones are essential to initiating the necessitated promptness in response strategies that appear to be wavering amidst the 2030 and 2050 targets – yet attaining these "long-term" targets will only be realistic if "hard" incremental milestones are initiated and developed. Municipalities have a key role to play in creating an enabling landscape for decarbonisation, and positioning themselves as "exemplars of best practice" in order to attain a competitive edge in attracting business and investment.

The *CREEM* tool, through the development of "local" pathways could make a **valuable and insightful contribution to future development plans at city level** in order to ensure alignment with Paris Agreement Targets. This needs to be highlighted and enabled as a key strand of urban resilience policy and practice moving forward.

Local authorities should be empowered as key drivers for change. Local authorities need active support to initiate/widen the use of innovative procurement processes that stimulate innovation and share risk-taking in respect of decarbonisation of the built environment at city level. Local development and associated infrastructure investment

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frameworks need to be better integrated with the planning process and economic growth strategy, which need to contain robust and meaningful targets.

Going forward, **policy initiatives focused on the decarbonisation of buildings will invariably become tighter**, requiring long-term planning and budgeting of retrofit actions and adaptation measures. The rapidly evolving policy landscape will have pronounced ramifications for real estate owners and investors who need to consider the implications of changes to existing policy and regulation on their business operations, the value and lifecycle of their assets as well as trying to foresee the impacts resulting from forthcoming policies within their strategic management of carbon associated risks and opportunities.

Policy makers must set a clear and robust agenda of upcoming regulation to ensure that standards can be incorporated proactively into strategic planning of investors. Transition periods must reflect the nature and complexity of change to enable investors to effectively manage risks and budget for intervention measures necessary to ensure compliance. The urgent need for immediate action is not getting "heard" or acted upon sector-wide and non-financial incentives or the merely increased pressure may not suffice the required necessary emission reduction. More specifically there is a lack of focus on building construction and renovation requirements in order to comply with decarbonisation targets, with much of policy focus centered on improving operational energy efficiencies. Indeed, many countries, such as Germany, for example, still predominantly address the (primary) energy demand or consumption of buildings in their legislation[33]. **While operational efficiency is of fundamental importance, a stronger focus should be placed on the source of energy that is being consumed and the resulting carbon emissions. It is increasingly important therefore to balance the argument between "energy efficiency" and the "energy source" and the related emission factors ultimately leading to carbon emissions and climate change.**

The **central target must therefore be carbon or even better GHG-emissions and, in conjunction with this, a clear pricing of these emissions**. Thus, incorporating a **CO_2 pricing scheme also for the real estate sector** might be a decisive and indispensable factor in achieving the aspired emission reductions. To date real estate has not been part of the *EU ETS*. Implementation of the target goal in the non-ETS area has been most successful in those countries that have the highest energy (CO_2 tax) tax – validating the application of **a CO_2 pricing scheme**[34].

CO_2 pricing is often understood as a direct implementation of the polluter-pays principle. However, the question arises – **who is the polluter?** Tenants are not responsible for a bad energetic performance of a property, and the owner is not for the tenant's consumption behavior. Conversely, **CO_2 pricing should not further aggravate the tenant-owner dilemma**, but this can be the case if the CO_2 pricing puts pressure on the energetic refurbishment of existing properties without accompanying tax, tenancy or other financial incentives that are created.

[33] Cf. DGNB, 2020.

[34] EEA, 2018.

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POLICY RECOMMENDATION 2:

CO_2 PRICING MODEL FOR THE REAL ESTATE SECTOR

A **CO_2 pricing model** in the real estate sector can be implemented as an approach to reducing carbon emissions. The following points should be taken into consideration to enable implementation:

- **Pricing should be fair and representative** in order to allow a prompt enactment
- Pricing instruments must **ensure that the polluter pays** principle is considered. It must be fair and transparent for both tenants and landlords
- Create **no limit or threat to the competitiveness** of the industry
- Enable **simple implementation and minimal bureaucratic** costs
- **Support increased efficiency** and the use of renewable energy
- Pricing should **reflect the real costs of carbon emissions** per tonne
- Introduce **emission-trading in the building sector** and/or **ensure a cross-sector and cross-country approach for carbon pricing.**
- CO_2 pricing should be in **accordance with the life cycle** of a real estate project.

Benefits include improving the sector-wide and global harmonisation, enabling affordable housing as well as mitigating the tenant-landlord-dilemma - where tenants have a greater influence through their consumption behaviour with improved digitalisation and monitoring. Efficiency measures show to have a better pay-off in terms of amortisation and households may show higher net income for financing due to complete redistribution of the tax. Carbon pricing shows a lower administrative burden compared to other instruments and ensures high incentives for (energy) cost saving investments.
A further scenario for the use of a **potential carbon tax/carbon pricing** may be for **short holding periods**. Policy makers should be aware of low sustainability engagement of large private equity companies and thereby apply a **carbon tax.**

The implementation of a **CO_2-pricing policy** may have benefits and may act as an incentive for reduction. The user-owner dilemma can provide tax relief for the part of a renovation that the energetic performance of a building is improved, reduced. This would create incentives set for a higher renovation rate in the portfolio. The social acceptability of rents can either through direct reimbursements or through a CO_2 component of social benefits, such as housing allowance can be achieved. Countries such as Switzerland for example already have a direct submission per purchased ton, Belgium has a property tax reduction for energy savings in new construction based on the building energy efficiency certificate and France recently added the carbon pricing component to their energy consumption tax[35]. It is important that throughout policy makers support teaming up in order to avoid problems from tenant-investor or tenant-owner dilemmas. All policies should be enabling and strive towards cooperation between investors and tenants.
The **CRREM tool has already integrated a function to convert carbon excess emissions for properties** that are not compliant with Paris Proof carbon pathways into a present value in Euro by multiplying the emissions with a carbon price that can be selected or defined by the user[36].

[35] RICS, 2018.

[36] Hirsch et al., 2019.

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A.3 FUNDAMENTAL CHALLENGE: THE ENERGY EFFICIENCY INVESTMENT GAP AND MARKET FAILURES

Prior to divining into the detail of individual policy recommendations it is important to briefly illustrate some of the fundamental pitfalls the real estate industry is facing with regard to improving energy efficiency. Against this background, this chapter highlights the main challenges.

Energy efficiency in the real estate sector is vital in keeping energy demand under control and transitioning toward a low-carbon future[37]. As a contribution towards that goal, it is important to invest in measures that improve energy efficiency in the existing building stock. In spite of this, the actual take-up rates of such **investments are lagging behind.** An investment gap remains and 180 billion EUR will be needed to close the yearly investment gap in order to meet the EU's energy and climate targets by 2030.

Projections by *DG Clima* (funded by the *European Commission* 2011) estimated **that €4.25 trillion are needed for energy-efficiency investment across EU member states between 2011 and 2050 in order to meet an 80 percent EU greenhouse-gas reduction target.** *DG Clima's* analysis detailed the need for €759 billion to be invested in the retrofitting of existing buildings between 2011 and 2020 with a steady increase in investment assumed over the following decades to peak at €1.38 trillion between 2041 and 2050. Accurate evaluation and assessment of the progress towards attaining that target is problematic as EU member states have been permitted to interpret and define differently major renovations. As a result, the capacity to assess and evaluate retrofit actions relative to energy efficiency gains and reductions in carbon inventories is problematic and makes direct like-for-like comparison across countries extremely difficult.

Inconsistencies in policy adaptation across member states allied with inadequacies in data capture has undermined the business case for upscaling green retrofit actions. In 2011, the *Buildings Performance Institute Europe (BPIE)* noted that most estimates of renovation rates (other those relating to single energy saving measures) are between 0.5% and 2.5% of the building stock per year[38]. The authors assumed a renovation rate of 1%, considering that higher rates had reflected the activity of the previous few years which in some cases had been linked to special circumstances (e.g., the existence of a renovation programme). The findings were consistent with a prior study carried out for the European Commission by the Fraunhofer Institute, where refurbishment rates of 1.2%, 0.9% and 0.5% per year were found for North-Western Europe, Southern Europe and new Member States respectively[39].

The lack of an official European definition prompted the *ZEBRA2020* initiative to develop a "major renovation equivalent" indicator series comprising low, medium and deep renovation outcomes. The renovation activities for each of the levels are weighted relative to the individual country classifications and the achieved energy savings compared to the major renovation level. The results indicate that the annual share of the building stock representing an equivalent to major renovation is very low: it is below 0.5% in Spain, Poland or Belgium; around 1% in the Netherlands or Lithuania; above 1.5% in others like Germany, France or Austria[40].

Recent policy revisions [2018/844] will reaffirm the need for proactive commitment to the upscaling of retrofit actions across EU member states. *The Energy Performance of Buildings Directive (EPBD)* has put in place a clear direction for the full decarbonisation of the European building stock by 2050 with all Member States required to transpose it into national law by 10 March 2020[41].The revision processes introduced changes and updates to several key topics with the

[37] Ramos et al., 2015.

[38] BPIE, 2011.

[39] Fraunhofer Institute for Systems and Innovation Research, 2009.

[40] ZEBRA 2020, 2016.

[41] BPIE, 2019.

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requirement to produce national renovation strategies moving from the *EED* to the *EPBD* in order to ensure greater alignment with other aspects of energy performance of buildings. The most noteworthy revisions in terms of upscaling retrofit actions **include guidance on:**

- Long-term renovation strategies,
- Mobilising investment in renovation,
- EPCs and building renovation passports.

However even when simple net present value calculation shows investing in building efficiency to be profitable market participants might not carry out the investment. A vast body of research has elaborated on this apparent ***efficiency gap* between levels of investment that are thought to be cost-effective and the levels of investment being committed**[42].

Barriers to investment in energy efficiency measures within the real estate sector have been broadly classified into two groups**: i) market barriers and ii) behavioural barriers**.

In the former group, much of the theory has been developed from within a classical economic perspective, in which the markets for energy and energy-using technologies are theorised to be efficient, or in other words, where all costs, benefits and risks are fully taken into account by decision-makers[43]. Under this perspective, individuals are assumed to have stable and rational preferences such that the uptake of energy efficient technologies or the decision to forego them reflects a rational assessment of the relevant costs and benefits. This theoretical contention is, however, only meaningful if it can stand up to empirical scrutiny. Proponents of government interventions in markets often cite empirical analyses in which various factors are reported to prevent markets from operating efficiently.

These **market failures** include, among other factors, **environmental externalities, inefficient pricing, credit constraints, slow diffusion of energy-efficient technology, high transaction costs, hidden costs and low energy prices** [44, 45]. Elaborating on some of these market failures, prices for fossil fuels may not fully reflect the negative externalities of greenhouse gas emissions and air pollutant emissions. To the extent that such externalities remain unpriced, there is an economic efficiency-based policy justification to take prices to their correct level by, for example, imposing **a Pigovian tax or usage caps**[46]. Another often cited barrier to energy efficiency investments is the limited access to, or the excessive cost of, capital due to uncertainty issues or credit constraints. Regulatory measures such as building codes and standards are often combined with price instruments such as taxes and subsidies to overcome these apparent market failures. However, **price instruments such as energy taxes are limited by the low elasticity of energy demand, and furthermore, excessive use of subsidies** is likely to lead to other inefficiencies due to high fiscal cost and the free-riding effect[47].

The existence of market failures implies that the **core assumptions of perfect information and rational decision-making, as would characterise a free market, are unlikely to hold in practice**. For example, *CREEM* research has highlighted the **unavailability of data across the real estate value chain** as a key barrier to retrofit investment. Gaps in data provision detract from the comprehensiveness and robustness of the business case supporting retrofitting. The capacity to determine baselines and to benchmark the performance of retrofit solutions post adaptation ensures that the true extent of "savings" and "value added" is difficult to definitively ascertain. A series of previous studies in behavioural economics link imperfect information and behavioural failures to the energy efficiency gap [48,49].

[42] BPIE, 2011, 2016 / D'Agostino et al., 2017.
[43] European Commission, 2018.
[44] Allcott and Greenstone, 2012.
[45] De T'Serclaes, 2007.
[46] Gillingham and Sweeney, 2012.
[47] Ramos et al., 2015
[48] Allcott and Mullainathan, 2010.
[49] Shogren and Taylor, 2008.

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Several **behavioural failures that affect energy efficiency decisions** can be identified[50,51]. Among other factors, **bounded rationality, risk aversion, and presence bias** are behavioural factors cited to cause lower than expected energy efficiency investment in buildings[52]. The existence of **split incentives** between landlords and tenants is another significant behavioural factor. In most rental arrangements, the benefits of energy savings accrue to the tenant and thus there is no incentive for the landlord to make the upfront investments in building efficiency. The information and behaviour uncertainties discussed above are further amplified by the variability of future energy prices and changing regulatory environments, making it even harder to estimate the economic return of building efficiency investments.

Market failures and behavioural aspects are ultimately affecting stakeholders or the energetic refurbishment process itself: (i) investor, (ii) tenant, (iii) construction, (iv) refurbishment process and cycles, and (v) performance related barriers which either individually or in combination serve to inhibit the upscaling and roll-out of deep retrofitting within the commercial real estate sector.

Investor Related Barriers: Investor orientated barriers are the most prominent barrier type with the **inability of green value to be fully capitalised in property values routinely cited as an inhibitor to investment**. Probably one of the most important considerations, before investing in energy efficiency retrofits, is the **cost associated with the investment. Informational barriers** are characterised by the lack of understanding associated with the technologies locally available as well as the lack of market information; consequently, reducing the take-up of retrofit initiatives. Additionally**, limited access to financial support** further reduces the likelihood of energy efficiency take-up. Finally, there is a severe **lack of incentive** to undergo energy efficiency retrofits. This includes the fact that the primary incentive lies on the supply side of the market. In this regard, there is more financial utility to structure and sell a financial product to finance green initiatives, relative to the perceived utility it creates for the investor.

Tenant Related Barriers: Key in the tenant related barriers is the **split incentive**, which hampers property owners to invest their resources when (part) of the benefits are cashed by the tenant. In various markets and countries, rental law prohibits the mix of monthly rents and energy charges, and thereby reduces the potential of rent increases after retrofits at the expense of lowering energy charges. Moreover, in many cases tenants need to cooperate in retrofit activities. The outlook of a certain rent increase after a retrofit that temporarily reduces their comfort of use, needs to be compensated by a significant and reliable reduction in energy expenses in order to win the tenants cooperation.

Construction Related Barriers: Construction barriers to green investments are subjected to a lack of knowledge on both the supply and receiving end of such initiatives. The refurbishment process is perceived as complex and requires specialist knowledge to fully understand. Similarly, the lack of technological know-how on the limited supply of refurbishment initiatives available further dampens the incentive to undergo energy efficiency retrofits. The remaining two barriers, grouped under construction orientated barriers, relate to one another. Firstly, there exists a slow supply of construction materials and consequently a **lack of capacity in the construction industry**. Secondly, and in relation to limited supply, there is a **lack of competition between service providers** and therefore no incentive by suppliers to reduce prices of offering the service at affordable prices.

Refurbishment Process Barriers: Energy efficiency retrofits are commonly associated with a long and unattractive process, which increase transaction costs of the initiative. Similarly, the perceived cost of time and inconvenience further aggravates the negative perception of energy efficiency retrofits, as the only available time to undergo retrofits

[50] Allcott and Mullainathan, 2010.

[51] Gillingham et al., 2009.

[52] *Bounded rationality* is the idea that in decision-making, rationality of individuals is limited by the information they have, the cognitive limitations of their minds, and the finite amount of time they have to make a decision. The term *risk-averse* refers to investors who, when faced with two investments with a similar expected return, prefer the lower-risk option. Risk-averse can be contrasted with risk seeking. *Presence bias* relates to the tendency that decision makers have to overweight the importance of short-term payoff, thereby reducing the weight of longer-term benefits.

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are during holidays. In addition, the retrofit process creates reduced living quality and usually involves very costly compensation. The process also increases with complexity when multi-tenant property refurbishments are planned. In this regard there is the issue of mutual consent to be provided by all of the shared tenants before the process can start, from which disagreement causes significant delays.

Long renovation cycles: Long renovation cycles are linked to the landlord-tenant relationship and limited capacities in construction. Often energy measures are only worthwhile if parallel general renovations are intended and undertaken, however in asset technology and systems the life-span is often up to 30 years. The life-span for external components such as the roof is even up to and over 50 years.

Performance Barriers: The performance gap between estimated carbon emissions at design stages and actual energy consumption and subsequent emissions in completed buildings poses large uncertainty in the evaluation of the stranding risk of buildings and portfolios with no data on actual consumption post-occupation. The performance gap also undermines the evaluation of the potential impact of carbon reduction measures and plans aiming to reduce this risk[53].

A.4 ROLE OF CRREM IN HELPING TO BRIDGE THE ENERGY EFFICIENCY GAP

A lack of information, or difficulties of processing relevant information, can withhold owners and investors to invest in energy efficient retrofits, as future gains are uncertain. *CRREM* can help to alleviate some of these concerns and barriers, by simplifying the **supply of relevant considerations**, and by highlighting the most prominent **retrofit related gains and expenses** as well as potential **risks of inactivity: *stranding***.

The value capture element of energetic retrofit is important ex-ante, as this future indirect benefit is often missing in the payback period calculations that are often used when analysing energy efficiency investments. The *CRREM* framework and tool enables users to quantify and include the intended retrofit investments, and besides calculating the net carbon impact (plus energy cost savings, and stranding risk reduction) the framework can offer an estimation of the capitalisation rate of this investment on the property value as a result of the retrofit.

In short, *CRREM* can help to bridge the energy efficiency gap and break down some of the barriers for energy efficiency investments in commercial real estate by:

- Providing property owners with the relevant information regarding future policy pathways.
- Offering a reliable timeframe for the period until stranding asset risk will start building up.
- Helping to consider retrofits by comparing required costs and project savings.
- Including the most likely value effects of energy efficiency retrofits.

CRREM offers information, which is currently absent or hard to access for the decision makers in the property markets. Information that has, thus far, been at the heart of the energy efficiency gap. Further to this, *CRREM* has developed a series of real estate specific decarbonisation pathways to transpose climate goals into meaningful targets and associated milestones conformant with the Paris Agreement. A detailed overview of the *CRREM* pathways, methodological frameworks and calculations can be found in *CRREM* Report entitled *"Stranding Risk & Carbon: Decarbonising the EU commercial real estate sector based on science-based target"*[54].

The section that follows is an overview of the *CRREM* pathways and how they can be effectively utilised and adopted to inform future policy development. The pathways serve as an objective industry endorsed evidence base to

[53] Carbon Buzz, 2020.

[54] Hirsch et al., 2019.

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communicate and initiate viable mitigation strategies and impactful changes across the real estate sector. Enabling and supporting the rollout of the *CRREM* tool – a free to use tool – will offer a key data repository to support strategic investment into green retrofit, enable better performance evaluation and dispel uncertainties pertaining to climate related stranding risk.

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CRREM

ACCELERATING DECARBONISATION WITHIN THE COMMERCIAL REAL ESTATE SECTOR

SECTION B ACCELERATING DECARBONISATION WITHIN THE COMMERCIAL REAL ESTATE SECTOR

Assuming that few properties will be fit for 2050 without any modification, upscaling deep retrofitting will be essential to ensure the alignment of real estate assets with the stringent GHG standards of the future.

Retrofitting will directly affect the energy consumption (and carbon emissions) of an asset and also change the overall operation costs and **reduce exposure to stranding risks.**

In this section we focus on various learning outcomes and insights identified within the CRREM project which might be subject to policy advice for altering, developing and introducing energy efficiency policies to improve the speed and scale of uptake of energetic refurbishment in order to achieve Paris aligned decarbonisation targets within the European commercial real estate sector.

Despite a strong narrative to support both the ecological and economic business case for green retrofits, uptake levels have been paltry – ensuring that the impact potential remains largely untapped. When it comes to both the willingness and capacity of owners and investors to embrace green retrofit solutions, the diverse and fragmented nature of the real estate sector value chain and contrasting inception points means it is impossible to devise a "uniform" decarbonisation roadmap for the commercial real estate sector. As such we proffer a series of recommendations based on our research to date which serve to guide and inform policy development and initiation. Our ***CRREM* Roadmap** appreciates that not all EU member countries will start at the same point of origin in respect to decarbonisation of the commercial real estate markets – nor will they necessarily all follow the same intervention and mitigation pathways. Thus, our suite of recommendations serves as a roadmap to the creation of an enabling policy environment consistent with the *CRREM* decarbonisation pathways which constitute a series of "hard targets" for investors and property owners aligned to the Paris Agreement Targets.

CRREM research has persistently highlighted the need to initiate a step-change in the capture of both operational and embodied carbon performance data within the commercial real estate sector. The **disjointed nature of the real estate value chain as well as complexities over data ownership** have all been highlighted in previous *CRREM* research as barriers to performance assessment and to evidencing the business case in respect of green retrofitting. The specific aspects of the data challenge and their implications for the decarbonisation of the European commercial real estate sector are listed below, along with a series of associated policy recommendations.

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B.1 THE ROLE OF REAL ESTATE AND CONSTRUCTION – FOCUS ON EXISTING BUILDINGS

Despite their prominence as carbon emitters, buildings represent a key area of opportunity for climate change mitigation. A recent *IEA Global Status Report* estimates that buildings and construction combined represent circa 36% of global energy use and 39% of energy-related carbon dioxide (CO_2) emissions[55]. As such, **deep retrofitting of existing building stock has significant scope to make a meaningful contribution** towards the attainment of global warming targets. For example, it has been calculated that innovative energy saving measures in UK non-domestic buildings could save 86 $MtCO_2$ by 2050, depending upon the rate at which the measures can be deployed[56]. The decarbonisation of building stock is particularly important: since commercial properties tend to turn over only every 30 to 50 years, getting it wrong will lock in emissions, and potential costs, for decades. In contrast, focused acceleration in this action area can close 20% to 55% of the gap between current emissions trends and 2030 abatement targets, depending on the local climate and population growth of the city, at an average cost of $20 to $100 per tCO_2e[57]. Adding to this argument also insights from other countries stress that the energetic potential a new building is largely exhausted due to the high requirements based on the EPBD (in Germany, for example, incorporated in the so-called EnEV). The focus for achieving the climate targets must therefore be increasingly placed on the existing building stock and its energetic optimization. Looking at Germany as an example, 62% of living space was built before 1979 and is therefore energetically in poor condition[58]. **Around 60% of our existing buildings will form part of the building stock in 2050 and thus afford the greatest opportunity for delivering impact at scale due to their higher carbon intensity profiles**[59]**.** Across the real estate and construction sector, concerted efforts have been made to improve the energy efficiency and carbon profile of new buildings – including a more delineated analysis and understanding of the embodied carbon profile across the asset lifecycle. However, the meaningful step changes necessary to attain the climatic targets contained within the Paris Agreement will only be realised through intensive upscaling of green retrofitting as a means of tackling emissions within the existing building stock[60].

If we assume that **new buildings will constitute 10% of the building stock, and that New Build can approach zero carbon to a greater extent than existing stock (say 95% efficient new build to 65% efficient existing), then a staggering 87% of improved performance will need to come from existing buildings**.

Despite the laudable efforts to combat the existing carbon footprint of the real estate and construction sectors, a magnitude of studies emphasis that whilst progress is advancing, there remains a growing urgency to address energy demand and emissions from existing buildings and construction processes as **improvements are not keeping pace with the rising demand for energy services and increases in global floor area**[61]. Due to strong floor space and population expansion, final energy usage by buildings globally grew from 119 Exajoules (EJ) in 2010 to 125 EJ in 2018 and 9.7 gigatons of CO_2 emissions[62]. Pertinently, the relative share of fossil fuel use in buildings remained almost constant since 2010 at roughly 45 EJ[63]. **The energy intensity per square metre (m^2) of the global buildings sector needs to improve on average by 30% by 2030 (compared to 2015) to be on track to meet global climate ambitions set out in the Paris**

[55] IEA, 2019.

[56] Strachan et al., 2015.

[57] McKinsey and Company, 2017.

[58] Cf. Deutsche Energie-Agentur GmbH, 2018, page. 16.

[59] Carbon Trust, 2014.

[60] BMWi, 2015.

[61] IEA, 2017.

[62] Global Alliance for Buildings and Construction, International Energy Agency and the United Nations Environment Programme, 2019.

[63] UN Environment and International Energy Agency, 2017.

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Agreement[64]. According to the UN Emissions Gap Report, over **15 $GtCO_2e$ need to be reduced** in order to stay on track until 2030[65]. Reports highlight that current policies and investment fall short of what is needed, and moreover, what is realisable and achievable[66]. Also, within the EU there is still a discrepancy between the target achievement and the defined interim targets based on the current forecasts.[67] The climate protection plan has already confirmed goals for the years 2030 onwards with the goal of being GHG neutral by 2050. **Goals are also defined and set goals beyond the overall economic level and for all individual sectors**[68].

POLICY RECOMMENDATION 3:

PRIORITISATION OF "SMART" DECARBONISING THE EXISTING BUILDING STOCK

Policy makers should foster the most cost-effectiveness decarbonisation actions and prioritise retrofit actions in the **(1) existing building stock.** The upscaling of energetic retrofit measures will require close collaboration with property managers and investors. "Smart" decarbonisation means that not only a narrowed focus on simply reducing the operational carbon emissions is relevant. Landlords need more guidance on how deep energetic retrofit might **(2) match best with normal refurbishment cycles** (and the property life-cycle) in order to ensure cost-effective measures with favourable pay-back periods. It must also be noted that the **(3) energy-efficient refurbishment** itself also has embodied carbon effects and that the necessary construction measures themselves also reduce the remaining carbon budget. An overall positive effect must be ensured when planning and implementing measures. An **(4) enforcement of environmental declarations** of the construction products used, increased transparency and ultimately a more perceived **(5) responsibility across the entire value chain** are of great importance. It is also essential **(6) to avoid so-called "lock-in" effects,** i.e. whereby mis-informed retrofits actions do not generate impactful outcomes resulting in a buildings carbon intensity being prolonged between renovation cycles and also the result of stranded assets due to the absence of proactive climate policy.

CRREM follows these global projections of the *IEA* and further calculates the decarbonisation efforts of the *EU* commercial real estate sector by downscaling global carbon budgets and its associated decarbonisation pathways. *CRREM* further downscales each country's carbon budget and carbon intensity pathway (emissions per square meter) to commercial real estate subsectors. This downscaling considers country and subsector specific stock size, expected growth and current carbon emission intensity in each country and subsector. ***CRREM* calculated that the maximum amount of carbon that the *EU* commercial real estate sector can emit from 2020 until 2050 is 6.6 $GtCO_2e$ for a 2°C warming scenario. At the current rate of emissions this "carbon budget" would only last until 2036. In a 1.5°C warming scenario, the budget amounts to 4.9 $GtCO_2e$ which will be depleted by 2032.**

Most EU member states, like e.g. Germany already started to work on more granular interim goals to achieving the 2050 target[69]. In addition to a mere achievement monitoring, these interim goals must also include a cost-benefit analysis in order to initiate further or different measures. These also do not only have to take place at an aggregate level, but also have to be converted into sector-specific requirements and measures. In this context, regular monitoring and progress reports on an annual basis are desirable. In the UK, *the Committee on Climate Change (CCC)* produced carbon budgets by sector through to 2050 under different global heating scenarios. Their report detailed that emissions from buildings

[64] UN Environment and International Energy Agency, 2017.

[65] UNEP, 2019.

[66] Climate Action Tracker, 2019.

[67] European Commission, Reference Scenario, 2016, p. 84.

[68] BMU, 2017.

[69] cf. KSP 2050, 2016.

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in the UK had fallen by 13% since 2013 and are around 20% below 1990 levels[70]. While acknowledging the progress the *CCC* recommendations cited the need for an immediate overhaul of low-carbon heating and energy efficiency in respect of non-residential buildings if the governments vision of full decarbonisation of non-residential buildings by 2050 is to be attained.

POLICY RECOMMENDATION 4:

ESTABLISHMENT OF MEANINGFUL MILESTONES DIRECTLY LINKED TO THE REAL ESTATE SECTOR

The CRREM calculations bring into sharp focus the scale of the task still ahead and reiterate to policy makers the need for prompt and immediate actions. **Long-term** targets for 2030, 2040 and 2050 need to be preceded with meaningful "hard" and enforceable milestones if the ultimate end goal is to be realised. *CRREM* enables stakeholders to prepare regular monitoring and progress reports that can **continuously assess target achievement at the level of sector-specific requirements/conditions.** These are underpinned by consumption (in kWh/m^2/a) and GHG emissions and can therefore also be extrapolated in order to question nationwide target progress and achievement.

Behavioural nudges to enhance energy savings after retrofit - large fractions of energy (and CO_2) savings projected get lost due to **rebound effects** of users. Include a set of behavioural nudges (feedback loops) to reduce rebound effects. **Milestones can help to track progress and provide feedback in order to reduce the rebound effects.**

L**ong-term thinking** should also be **promoted by policy makers and long-term sustainable strategies** should be the base of each recommendation. With reliability, transparency and specific goals **long-term planning** for companies can be enabled. Meaningful milestones that are reached **provide a form of progress measurement and motivation in the short as well as in the longer term.** Considering rapid decarbonisation in the real estate sector and in the establishment of milestones, a further important factor is **risk awareness.** Policy can highlight the importance of **risk awareness and strategically improve** sensitivity towards this subject.

There is a lack of **a holistic decarbonisation policy framework** within the built environment. Policy initiatives aimed at reducing carbon intensity within the built environment are scattered into different areas, with multiple roles and governance responsibilities. For example, building regulations try to **control "regulated" emissions**, but really only come in to play for new buildings and large refurbishments. Planning authorities have limited power to push the requirement further, because they cannot implement or control results after planning is granted, whilst *EPCs* only affect the assets actively in the market, not the whole stock.

Policy makers should place a focus on harmonising stakeholder responsibilities, align different frameworks and promote local development plans.

[70] Committee on Climate Change, 2019.

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POLICY RECOMMENDATION 5:

HARMONISING POLICY FRAMEWORKS AND STAKEHOLDER RESPONSIBILITIES

There is a pertinent need for the development of an integrated and joined up framework aligning decarbonisation policy objectives for the real estate sector into meaningful goals and targets and to ensure that stakeholders on the governance side work collaboratively, to promote and initiate change and support transition. The policy landscape for the decarbonisation of existing buildings is fragmented and often contradictory to attaining the targets depicted within the Paris Agreement. At present, the attainments of the sector have come about more as a result of "self" governance and regulation and on the back of actions by investors and owners, who have actively embraced their environmental responsibilities**. A more "joined-up" approach is needed**, given the location specific nature of property and the need to target those assets with the highest levels of carbon intensity – reliance on market forces alone is not going to initiate change at the pace necessary to conform with the 2030 targets contained within the Paris Agreement.

B.2 TARGET SETTING AND PROGRESS MAPPING – THE CONTROLLING CHALLENGE

Following on from the Paris Accord, the United Nations published their Sustainable Development Goals (SDG) in 2016. One of the SDG goals is to combat climate change and its impacts. These two initiatives have radically transformed the landscape for commercial property owners and investors prompting reform of business operations and transformation in organisational cultures. As highlighted in the recent *Global Real Estate Sustainability Benchmark* (*GRESB)* 2019 survey, existing guidance published by the *UN* to support the implementation of the *Sustainable Development Goals (SDGs)* states that in order to limit global warming to 1.5°C, GHG emissions in 2050 must be 40-70% lower than 2010 levels[71]. *SDG 7.3* aspires to double energy efficiency improvement rates by 2030[72]. To achieve this target, global energy efficiency has to improve by a 2.6% compounded rate between 2010 and 2030. The *actual* like-for-like energy consumption for real estate reported by *GRESB* in 2019 showed participants *falling behind* the *SDG* target. This was somewhat alarming given that *GRESB* participants can be regarded as the best-in-class market participants highlighting the magnitude of the task in hand given that overall results across the entire sector will require even more ambitious improvements than achieved so far. **Ensuring a high level of data quality and property-related reporting will therefore continue to pose a major challenge for professional real estate investors**.

The work of the TEG is a valuable, progressive step getting the taxonomy and definitions right as **missing operational carbon emissions and energy consumption data often leads to false impressions** of low stranding risk. This usually involves: periodic data gaps due to a new acquisition, a lack of information on energy consumed and paid for by tenants, no data on "unregulated carbon emissions", or inaccurate normalisation if occupation/use rates of buildings are incorrectly reported etc. Missing critical data or data that was not analysed and evaluated correctly can erroneously give the appearance of an efficient building if not appropriately reported.

In detailed checks of input data from property holders at asset level, CRREM still regularly revealed problems missing data points, the choice of different reference sizes for areas, the use of different area units, a high degree of uncertainty

[71] GRESB, 2019.

[72] United Nations, 2015.

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in the determination of emissions due to leaks in refrigeration units or just incorrect data entries resulting in obviously unrealistic figures. Also, the reporting of carbon emissions only based on low market-based emission factors prevents a comprehensive comparison and benchmarking of buildings' actual carbon performance.

POLICY RECOMMENDATION 6:

A.) IMPROVE STANDARDISATION FOR FUTURE DATA COLLECTION AND METHODOLOGICAL CONSISTENCY

Enhanced governance and data standardisation are needed to provide robust and credible evidence of carbon intensities and transitional risks attributable to decarbonisation.

Data collection can be improved by generating more standardisation. E.g. *CRREM* encourages the usage of *IPMS (International Property Measurement Standards)* to measure floor area. **Creating data standardisation by setting floor measurement standards to convert energy into carbon,** such as the use of use of *IPMS,* the most widely adopted floor area measurement standard, would enable consistent benchmarking and make results comparable.

CRREM has identified two main areas of uncertainty related to measures and conversions for the estimation of climatic risk: the different methodologies to survey floor areas and the selection of present and future carbon factors to calculate the carbon footprint of energy consumed. Furthermore, changing the maturity level of data collection such as ensuring smart data collection improves security while enabling interoperability of different systems and technologies within a smart grid environment.

Future data collection methodologies 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 the embodied carbon of new buildings and major retrofit works. Policy makers must strive to improve data capture pertaining to embodied carbon emissions and initiate consistent and robust methodologies to allow for meaningful impactful analysis over the asset lifecycle.

CRREM has adopted carbon factors from *EU* sources covering all member states which follow the methodological recommendations by the *IPCC*. The *CRREM* methodologies are valid for their geographical context, and can be adjusted to account for sectoral disparities. Boundaries and data collection efforts should be aligned to the requirements of the *CRREM* project.

B.) ENHANCE THIRD-PARTY AUDITS AND HIGH-QUALITY BENCHMARKS

Similar to financial data, **third-party carbon auditing processes** can provide investors with additional certainty that the data gathered and the assumptions adopted are correct. This would **improve transparency, evidence the business case for retrofitting and enhance comparable performance and payback modelling.** Further, third-party audit standards should engage in ESG reporting and disclosure frameworks aligned with the *TCFD* recommendations to lead to coherent and comparable data. Also, policy makers should further support already existing industry benchmarks like *GRESB* that can play an important role improving data quality within the sector.

Heightened awareness of the impacts of decarbonisation has been evident within the real estate investment community over the course of the last decade. The Paris Agreement has nonetheless catalysed a momentum shift in terms of expectations. All sectors have experienced heightened expectations in regards to cutting emissions. The real estate sector will hardly be able to nor should it be held accountable for target shortfalls in other sectors such as the automotive industry. Still, institutional investors such as pension funds, state funds, insurance companies, banks and

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sovereign wealth funds are under **increasing pressure to divest from carbon-intensive companies and assets,** and to engage with policymakers and stakeholders on sustainability issues[73]. Furthermore, owners and asset managers are expected to demonstrate **a heightened disclosure of carbon performance and the risk posed by climate change** to their assets[74]. Previous *CRREM* research entitled *"Stranding Risk and Carbon:* Decarbonising the EU *commercial real estate sector based on science-based targets"* highlighted that assets that do not conform to expected energy performance and emissions standards risk low demand and suppressed values (stranding). The current **recommendations of the *TEG* (Report on Climate-related Disclosures, 2019) in alignment with the Task Force on Climate-related Financial Disclosure initiative propose various benchmarks**, measures to increase transparency and improve low-carbon investment strategies. Guidance to improve corporate disclosure of climate-related information is placed as a focus. Proposal towards an EU Action Plan is also positive in this regard and should be implemented. From the point of view of multi-asset investors, pension funds and other forms of investment that invest directly or indirectly in real estate, it will be more important in the future to **be able to compare the conformity of the respective investment with the requirements of the EU Sustainable Finance Taxonomy and to generally to meet the ESG criteria for the investment to be able to display transparently**. In particular, carbon intensity will play a central role. **The transposition of *NDC*s applied to the built environment will therefore need to target *all* energy consumed by and within the asset**, regardless whether or not they are "regulated".

CRREM research has highlighted that many investors have placed their initial emphasis in the confines of the decarbonisation challenge on improving the energy efficiency of buildings and increasing levels of clean energy provision. Given that also indirect emissions (lighting and other tenant related electricity use) are also dominant source of building emissions it is also clear that much of the proffered progress within the real estate sector must pertain to **initiatives to decarbonise grid networks and enhanced clean energy provision**. Pertinently, direct emissions from buildings have remained comparatively stable at around 2.8 $GtCO_2$[75]. *CRREM* suggests a "**whole-building approach" focussing on direct and indirect emissions**.

In addition to the expansion of the efficient controlling infrastructure per se, it is also important to emphasize that due to the EPBD and generally the previous industry standards, information on the climate impact of buildings focused strongly on energy consumption ($kWh/m^2/a$). It seems important to note that, in the light of reaching climate targets, it is not ultimately consumption alone, but also the associated GHG emissions that are of vital importance. If high energy consumption is covered on-site by non-fossil fuels with minimal emission factors (EF), the CO_2 intensity may even be lower than that of a very well-insulated new building whose fuels are still based on fossil fuels.

[73] Urban Land Institute, 2019.

[74] Urban Land Institute, 2016. / TEG, 2020.

[75] IEA, 2017.

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POLICY RECOMMENDATION 7:

FOSTER DATA COLLECTION ON CARBON INTENSITY OF ASSETS AND "STRANDING RISK" BENCHMARKS - "WHOLE BUILDING APPROACH"

Policies should even further enforce the collection of carbon emission data based on the building boundary ("**whole building approach**") instead of focussing on the reporting organisations or only consumption data. This approach would foster collecting data on emissions related to the tenant and landlord areas, also enabling an improved assessment of stranding risks on asset level.

Policy makers must focus on both **1. Final energy use (measured in kWh/m²/a) and 2. Carbon intensity (measured in kgCO_2e/m²/a).** Focussing on energy use only might result in the neglect of low-carbon energy sources. Carbon intensity target must reflect that grid decarbonisation might lead to reduced emission factors and lower carbon footprint of properties whereas consumption might be moving in a different direction leading to higher demand. Therefore, this creates a false sense of "achievement" and prevents meaningful intervention on the part of the owner/investor as the "cleaning of the grid" means they can claim to be moving towards a more decarbonised business model whilst effectively doing nothing. The *CRREM* tool explicitly includes the effect of grid decarbonisation on a property's future carbon performance, clearly demonstrating the significant gap between grid-related emission reductions and the actual requirements emerging from the Paris Agreement. *CRREM* showcases the risks of resistance to change as well as the need for moving mitigation measures beyond energy efficiency in order to determine true carbon intensity profiling at asset level.

The calculation of intensities will also require more local data on emission factors.

The significance is brought into sharp focus upon exploration of the future development pipeline. **By 2060, building sector floor area is projected to double, adding more than 230 billion m² to the planet in new buildings construction.** Those additions are equivalent to building the current floor area of Japan every single year from now until 2060. In the UK, total non-domestic floor area is expected to increase by 35.5% by 2050, while 60% of existing buildings will still be in use – emphasising the need for a more holistic and balanced approach to decarbonisation pathways which encompass both new build provision as well as the deep retrofitting of existing assets[76].

According to the projections of the *CTI 2050 Roadmap Tool* applied in the *CRREM* decarbonisation pathways, the total growth of the *EU* buildings sector under a net-zero scenario is significantly below global growth rates and regarding the non-domestic sector there is even a slight decrease of floor area[77]. Correspondingly, the **required improvements of the EU building stock's overall carbon intensity are primarily reached by an increase of retrofit activities instead of new construction – whereas on a global scale "green" and decarbonized new construction will be crucial in order to meet climate targets**. An approach that simultaneously reduces the amount of embodied carbon inevitably connected to constructing new buildings. Figure 1 shows the growth expectations derived from *CTI 2050* for the non-residential sector in eight selected *EU* member states.

In terms of the future development pipeline, globally half of new buildings expected to be in existence in 2060 will be constructed over the next 20 years heightening the need for prompt and immediate action[78]. There is an obvious **urgency to address energy and emissions from new building construction** if ambitions for a 2°C world (or below) are

[76] Strachan et al., 2015.

[77] CTI, 2019.

[78] World Green Building Council, 2017.

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to be achieved. Pertinently however, globally **two-thirds of the proposed growth in new build properties are expected to occur in countries that do not currently have mandatory building energy codes in place**[79].

POLICY RECOMMENDATION 8:

CONSISTENT BUILDING CODES THAT PROMOTE GREEN AND SUSTAINABLE CONSTRUCTION

Getting robust and consistent building codes and green construction policy - besides EPBD - in place and taking on board best practice lessons from markets that have achieved significant strides in decarbonisation of the construction sector is critical. **Embodied carbon across the buildings lifecycle is not adequately captured resulting in high intensity construction processes** which offset the energy efficiency attainment of new buildings. Inadequacy of coding or lack of ambition results in high intensity emitting assets being constructed and operated over a 25-30-year cycle. Some aspects that would **encourage more sustainable** and especially **"decarbonized"** buildings would be to:

- Ensure Building codes that only permit net zero for new construction and deep retrofits
- Prohibit energy systems that use fossil fuels for replacement and new construction likewise
- Support district heating and in general more district focused planning
- Give incentives (like e.g. higher density) for plus properties
- Promotion of neighbourhood/ district approaches
- Promotion of renovation roadmaps
- Provide incentives for sustainable building materials
- Support for sector collaboration
- Improve the financial and investment landscape to enable upscaling of investment
- Assembly of public authority assets into portfolios of scale to attract private investment

For investors acting in developed countries (e.g. *OECD)* the challenge is more about attaining the appropriate balance between new asset development and the decarbonisation of the existing buildings. **With circa 65% of the total expected building stock in 2060 already built within *OECD* countries the impactful gains will be realised through the scaling up and intensification of policy actions on green retrofitting in tandem with facilitating behavioural change within society and across the corporate sector**[80].

[79] Global Alliance for Buildings and Construction, International Energy Agency and the United Nations Environment Programme, 2019; IEA, 2017.

[80] World Green Building Council, 2017.

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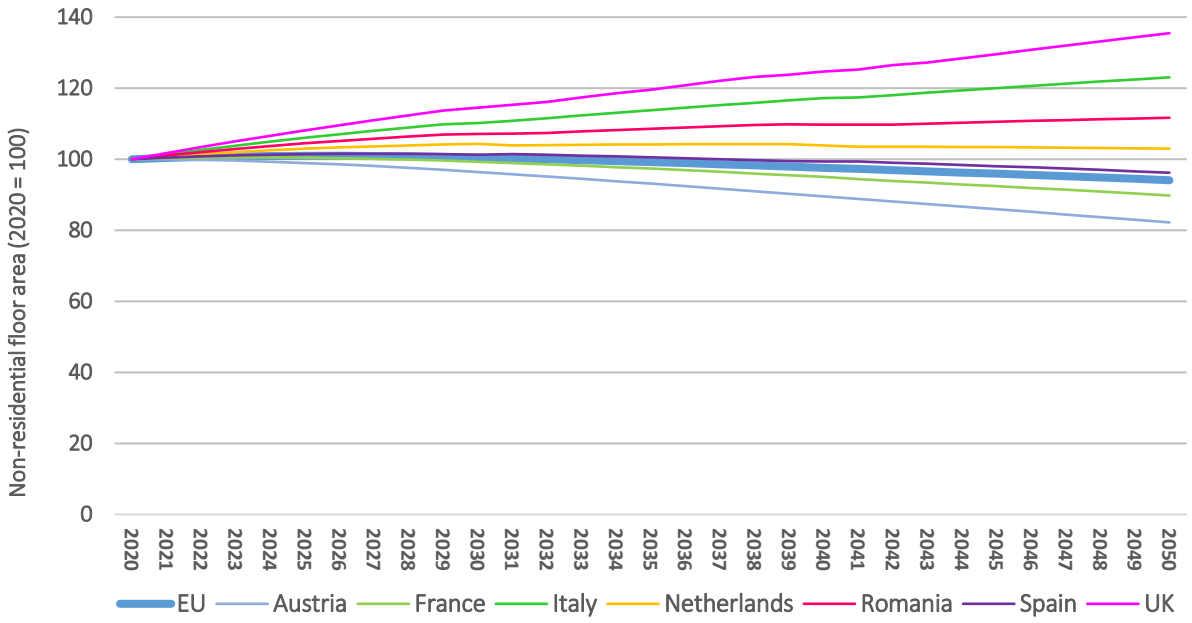
Figure 1: Non-residential floor area in selected EU member states (2020 = 100; Shared Effort Scenario)



Source: CTI, 2050 Roadmap.

Furthermore, the so-called **performance gap is still a challenge for market participants**. In the built environment performance gap usually refers to the difference between the estimated energy and carbon performance of a building or project during the design stage and the actual energy consumption after the building or project is completed and occupied. Estimation methodologies often rely on building models instead of actual data. Initiatives like *Carbon Buzz* demonstrate that buildings do *not* perform as well when they are completed as it was anticipated when they were being designed[81]. Behavioural aspects like this and data sharing therefore play another important role that needs to be addressed by policy makers.

[81] Carbon Buzz, 2020.

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POLICY RECOMMENDATION 9:

PROMOTE DATA SHARING ACROSS THE VALUE CHAIN AND ADDRESS BEHAVIOURAL CHANGES

Policy must place **stronger emphasis on behavioural changes**. E.g. when it comes to data sharing and collaborative partnering frameworks. Policy makers must facilitate these changes more intensively by improving the quality and robustness of data capture informing the business case for retrofitting and **removing barriers to data sharing** to enable investors and tenants to work collaboratively and act jointly in attaining decarbonisation targets in line with the Paris Agreement. Furthermore, policies regarding carbon data sharing between tenants and building owners should be developed and existing policies modified (e.g. *Energy Performance of Buildings Directive, General Data Protection Regulation)* to guarantee transparent and sufficient data transfer. This promotes the improvement of energy performance of existing building stock and the reduction of carbon emissions. In general, more **public campaigns** for behavioural changes must be accomplished alongside with **labelling initiatives in order to further increase transparency** regarding the energy use of appliances for consumers.

For some markets, property types, and leasing structures, acquiring **tenant data** is to date particularly difficult due to regulatory constraints. Tenants can easily decline their engagement into data sharing agreements and without data, the carbon inventory of real estate assets is incomplete. We recommend more **policies supporting the implementation of green leases** with binding clauses in relation to the sustainable operation of a building and provisions regarding sharing of data and co-operation on improving environmental performance. **Tenants must be encouraged to grant building owners access to energy consumption data** to take greater control over consumption, potential improvements, and energy supply contracts. Especially for commercial real estate there is much room for improvement regarding data sharing.

Most reporting, certification, benchmarking and disclosure initiatives **encourage the use of metered data or data from invoices, aiming to gather full data including unregulated carbon emissions**. To **ensure data sharing** permissions from tenants' meters and invoices to avoid gaps in the carbon inventory, **Green Leases** (or similar agreements between landlords and tenants) are the best available option. The calculation of occupancy rates based on actual number of occupants and operation hours is more accurate than using lease rates based on the amount of floor area leased.

When investors or asset managers cannot gather or access enough data to complete the whole carbon inventory of their portfolio (for example, data from their rented units), they should revert to alternative data sources available to them to at least partially complete the inventory. Some of these data sources may provide data modelled at design stage (e.g. regulated data modelled to comply with building regulations, *EPCs,* etc.) or even after occupation – if for example, other initiatives or projects have required the estimation of this data.

Measuring CO_2e within the real estate sector is a complex task. In order to reach defined targets, it is essential to have proper controlling infrastructure and measurement facilities in place. In addition to the inclusion of tenant data (see above), the areas of **smart metering, big data, data quality assurance and the ongoing monitoring of targets must be successively improved by expanding the IT-based controlling infrastructure**.

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POLICY RECOMMENDATION 10:

PROMOTE MORE (SMART) CONTROLLING, ENHANCE MEASUREMENT INFRASTRUCTURE, ENSURE STANDARDISATION AND REDUCE RELIANCE ON PURELY MODELLED DATA

Process mapping must be enhanced and supported in order to attain the potential benefits to be derived from technologies such as **smart metring** and senor enabled technologies in a consistent and comparable methodological process in order to improve the robustness of the data collation and performance evaluation at building level. Energy monitoring and supply companies like ISTA and others could more intensively bridge data gaps within the real estate value chain.

Policy makers must strive to improve data capture and initiate consistent and robust methodologies to allow for meaningful impactful analysis over the asset lifecycle. Furthermore, changing the maturity level of data collection such as ensuring smart data collection improves security while enabling interoperability of different systems and technologies within a smart grid environment.

Regulation should due to the so-called "performance gap" also **encourage more measured performance data instead of modelled data.**

B.3 BEYOND OPERATIONAL CARBON - EMBODIED CARBON DATA DEFICIENCIES UNDERMINE THE RETROFIT BUSINESS CASE

The accounting of embodied carbon is critical to ensure that operational carbon savings achieved by retrofit works do not imply larger carbon emissions elsewhere. However, current policy frameworks do not require the reporting and reduction of these emissions and therefore, investors and owners seldom gather data. *CRREM* research suggests that the ineffectiveness in embodied carbon capture generates a bias towards new development rather than the retrofit and decarbonisation of existing assets.

Further compounding the decarbonisation agenda within the construction and real estate sectors has been the **continued rapid expansion in new building development** in line with floor area growth, **new building replacement for properties that had reached the end of their economic life and emissions due to renovation/maintenance and refurbishment work – so-called "embodied carbon"**. Building construction emissions – those related to the manufacturing of building materials – amounted to a further 11 $GtCO_2$ in 2018, for a total of 39% of global energy-related emissions[82]. **Policy makers therefore need to address rising energy use and emissions resulting from standing investments but at the same time also focus more intensively on embodied carbon** emissions caused by new construction and measures carried out to ensure better energy efficiency for the existing property stock.

From a policy viewpoint, *EN 15978* is the standard most widely recognised by regulations and certification schemes across Europe as the reference standard to **quantify embodied carbon in buildings**. The *EN 15978* methodology is currently the best methodology available in the EU. Ensuring consistency of application and supporting best practice in embodied carbon capture through a "cradle to grave" is essential to one of biggest barriers to meaningful carbon performance evaluation and to moving sectoral focus beyond energy reduction interventions.

[82] United Nations Environment Programme, 2019.

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POLICY RECOMMENDATION 11:

INCLUDE EMISSIONS FROM CONSTRUCTION ACTIVITIES IN CLIMATE POLICIES – ENHANCE THE FOCUS ON "EMBODIED CARBON"

Construction of new energy efficient buildings and energetic refurbishment measures will inevitably cause resource use and (carbon) emissions. Policy makers must include these emissions more clearly in assessing their overall approach to tackle climate change. They must also ensure that **trade-offs between higher operational efficiency and emissions caused by construction and refurbishment measures are adequately and transparently taken into account**.

Future data collection methodologies 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 the embodied carbon of new buildings and major retrofit works. A positive environmental benefit of retrofit measures can only be ensured if embodied carbon, as well as savings at operational level, are accounted for.

The CRREM tools enables users to get back on track regarding too hight operational emissions by carrying out an energetic retrofit but at the same time also focus and balance the effect of embodied carbon that comes along with the retrofit.

B.4 PROMOTE TRANSPARENCY AND SUPPORT EVIDENCE GATHERING ON ALL RETROFIT VALUE ELEMENTS AND STRANDING RISK

Retrofits do not just affect energy costs, but also property values[83]. The extent to which this is adequately captured and translated in asset valuations is an ongoing source of debate with a requirement for more robust data to improve transparency and better inform the business case for retrofits. In theory both the energy cost savings and the associated value uplift attributable to retrofitting should be extensive, and thereby allow property owners to reap the proceeds of projected future energy savings – either as a one-off lump sum green sale premium or in the case of long term holdings to be accrued over the life time of the asset. The underlying mechanism, frameworks, and theoretical assumptions are due to a massive body of research already well known[84].

Many initiatives and researchers offer broad frameworks with which to capture any value effects of energetic retrofit. Such value effects go beyond the property level and can also affect the company at large. In this way, models capture both the A (energy saving) and B (indirect benefits).

[83] RentalCal, 2018. / RenoValue, 2016. / RICS, 2017.

[84] Deka, 2016.

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They can reveal how deep energy retrofits, which achieve superior energy savings over conventional retrofits, offer bottom-line benefits for business beyond energy cost savings alone. **Accounting for, articulating, and capturing that present-but-overlooked additional value can drive far greater investments in building energy efficiency while generating returns that directly benefit a business's balance sheet.** Such non-energy benefits of deep retrofits are not "soft" and intangible but in fact real opportunities for significant, quantifiable business value[85]. The aspects of deep retrofit value fall into nine discrete value elements. They serve as a menu of the potential types of value and costs a retrofit can create:

- **Retrofit Development Costs:** These costs are critical because they represent the initial capital investment against which future cost savings and other benefits are measured. Many retrofit projects have little "cost plus" if timed correctly with other capital improvement projects and if the project follows best practices.
- **Non-Energy Property Operating Costs:** Deep retrofits can reduce these costs (e.g., maintenance, water, insurance, and occupant churn rate) and can add more occupied space in a building through equipment downsizing and better occupant use of space.
- **Retrofit Risk Mitigation:** Deep retrofits are often subject to the standard and relatively high real estate risks of a "to-be-built" project where development costs and future operating cost savings are forecasts to determine return on investment. These risks can be compounded by additional risks like new products and systems, new specialised service providers, new contracts and design processes, complex financing requirements, and potential savings underperformance from building energy simulation models.
- **Health Costs:** The *World Green Building Council (WGBC)* provides evidence that intelligently retrofitted and operated buildings improve the health of building occupants and users, directly reducing health costs, for example through moisture and pollutant control, improved ventilation and access to outside air, access to the natural environment and daylighting, and temperature control[86].
- **Employee Costs:** According to a *US Green Building Council (USGBC)* survey, there is evidence that more sustainable buildings can help to reduce employee costs by lowering recruiting, retention, and employee compensation costs[87].
- **Promotions and Marketing Costs:** The substantial expenses associated with promotions and marketing— typically in the range of 10% of revenues—often do not include all the time spent by non-marketing staff in promotions and marketing activities. Deep retrofits can provide the content many companies are looking for in order to shape their branding story, offsetting money that would otherwise be spent developing other approaches to sustainability branding.
- **Customer Access and Sales:** Deep retrofits contribute to improved customer access and sales because customers of all types − consumers, businesses, and governments − are beginning to require demonstrated sustainability performance and leadership as part of their decision to purchase. Deep retrofits also increase sales potential since healthy, productive, and satisfied workers are more engaged and innovative.
- **Property-Derived Revenues:** Deep energy retrofits can provide additional company revenues from the enhanced demand for deep retrofit properties from potential tenants in the event a company must lease some of its space or from potential buyers of the property in the event a company must sell. Other revenues can come from purchase agreements, energy services agreements, renewable energy certificates, and government or utility tax credits, rebates, or other subsidies.
- **Enterprise Risk Management/Mitigation:** Deep retrofits can significantly contribute to mitigating some of the more pressing business risks facing companies today, primarily by contributing to an enterprise's performance as measured by sustainability reputation and leadership; individual occupant health, productivity, and satisfaction;

[85] RentalCal, 2018. / RenoValue, 2016. / RICS, 2017.

[86] WGBC, 2018.

[87] USGBC, 2018.

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and space flexibility. Also carrying our deep energetic retrofits will reduce the "stranding risk" of properties and investors likewise.

To **assess the value components of a deep retrofit project**, **a valuation professional must evaluate the outcomes of a deep energy retrofit** on a given value and/or cost element and then address how the outcomes effect property and/ or business value[88]. Projects **results from *RenoValue*, *RentalCal* or *NUWEL* as well as the *RICS* publications (Val. Information Papers etc.) can serve as a guidance for valuers** which data needs to be more intensively analysed in the light of energy efficiency and how that information must be processed in order to reveal the impact on the final valuation figure[89].

Premiums for efficient buildings and discounts for grey properties are a moving target but the overall impact is of increasing importance and often amounts to up to 10 % of the property values[90]. The degree to which tenants and occupiers of green retrofit buildings are willing to pay a price premium is often debated within the real estate investment community with results using a **wide array of methodologies and across different countries showing disparity and inconclusive evidence of a price premium** maximising the net present value (NPV). *Kumbaroglu* and *Madlner* evaluated the economically optimal retrofit investment options for energy savings[91]. The authors explicitly considered split incentives of building owners and users and addressed energy price uncertainty through *Monte Carlo simulation.* **The results indicate that energy price changes significantly affect the profitability of retrofit investments, and that increased price volatility creates a substantial misdirecting incentive of waiting**, making it more rational to postpone the investment. *Bienert and Cajias* state a found a positive linkage between a green agenda and a green performance, especially in terms of an increased ability to generate revenues and a decreased level of idiosyncratic stock volatility, illustrating the economic motivation behind green investments[92].

Likewise, other authors identified a willingness to pay a price premium, e.g. *Wiencke* found a **price premium for energy-oriented retrofitting** of 5.0%[93]. Also, *Geltner et al.* reported empirical evidence on green retrofits of commercial buildings. Using a new real estate price indexing methodology, they build statistically rigorous comparative price indexes of green retrofits, versus non-green, office buildings in the US, quarterly for the 2005-2014 period. They find **substantial value enhancement in green retrofit projects (between 10% and 20%) to non-retrofits, and they find evidence that retrofitted green buildings provide investors with lower asset price volatility.** But during and just after the financial crisis the premium dropped temporarily to near zero, suggesting that the demand for green property investment is income-elastic[94].

In stark contrast to green premia is brown discounting. **Existing, conventional buildings will become obsolete, and experience "brown discounts" if they do not adapt to the increasing demands of tenants and regulators regarding sustainability features**. Due to increasing stringency of regulatory requirements, properties that fall below standards become less attractive due to increasing level of necessary economic input for upgrading. A framework that illustrates this market development is illustrated in Figure 2 below[95].

[88] Rocky Mountain Institute, 2014.

[89] RentalCal, 2018. / RenoValue, 2016. / RICS, 2017.

[90] Deka, 2016.

[91] Kumbaroglu and Madlner, 2011.

[92] Bienert and Cajias, 2012.

[93] Wiencke, 2013. / Robinson et al., 2016. / Deka, 2016.

[94] Geltner et al., 2017.

[95] Green Energy Money blog, 2016.

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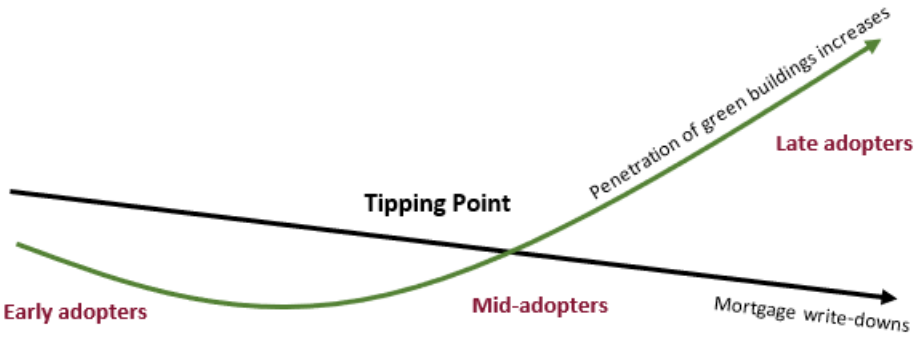
Figure 2: Potential trend of green buildings taking over the market (and non-sustainable buildings becoming obsolete)



Brown Discount & Green Premium Appraisal Valuation

Green Premium:
- **Demand for green**
- **Sufficient supply of green buildings**
- **High quality assets**
- **Premium value assignment**

Brown Discount:
- High deferred maintenance and energy operating costs
- Low quality assets
- Declining regional markets

Source: Own illustration based on Green Energy Money, 2016.

At first, the initial green buildings – representing a small early adopter community – will be rewarded with green premia for the distinct benefits that they offer their users and owners. Over time, however, mortgage write-downs will become more prominent and eventually, a larger fraction of the asset market will become "green" to avoid the negative value (and consequential mortgage write-downs) effects. Once, this tipping point is reached, brown discounts will become more apparent for the laggards in the market that failed to align with green building standards and will pay the stranded asset risk premia in the shape of brown discounts. Due to the increasing awareness of the investment community and transparency initiatives initiated by the EU Sustainable Finance Action Plan this development will be accelerated in the near future.

A series of EU funded projects have over the years to varying degrees contributed to the ongoing discussion pertaining to the most effective and transparent means of capturing the value uplift of green retrofitting. Projects such as *REVALUE, RenoValue, Immovalue, RentalCal, HEART, ENERFUND* and *DEEP* have been used as entitled *Retrofit Value Capture Instruments.* For the purposes of this report we have prepared a summation of the learning outcomes and project takeaways which serve as a basis for informing the *CRREM* Roadmap (see SECTION C). All in all, we learn from the aforementioned list of projects that energy efficiency investments require informational assistance in order to help owners and investors to **make investments through retrofits.** Several of the related *EU* projects have targeted stakeholders to provide this information and raise their awareness regarding energy efficiency within the built environment and the associated risks to asset values and exposure to policy-initiated transaction risks. Additionally, the *European Commission* concluded that the performance standards are the strongest measure to increase the rate of renovations, providing a clear signal to investors and stakeholders[96].

[96] European Commission, 2016.

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

POLICY RECOMMENDATION 12:

SUPPORT VALUATION PROFESSIONALS UNDERSTANDING OF DEEP RETROFITTING SOLUTIONS AND PROSPECTIVE "VALUE IMPACTS"

Appraisal professionals have a crucial role to play within the decarbonisation agenda. Valuation professionals are not "market makers" but in cases where value uplifts attributable to green retrofit are realised through capitalisation or rental yields this need to be consistently and accurately captured. Equally, the presence and pertinence of so-called "brown discounts" need to be accurately communicated as premise for enhancing market evidence. The lack of consistency in valuing and capitalising retrofit measures has contributed to the disparity in research findings on the added value attained via retrofit measures and has added to investor uncertainty. From a valuation viewpoint there needs to be much more transparency on the "grading" and nature of retrofit measures and their prospective impact on value.

POLICY RECOMMENDATION 13:

INCLUDE FOCUS AND ANALYSIS OF EFFECTS CAUSED BY SUPERIOR OR POOR ENERGY EFFICIENCY IN REGULATION FOR PROPERTY VALUATIONS

Policy makers must ensure that regulation related to the valuation of assets is addressing these aspects. Within the EU there exists besides the *European Valuation Standards* (EVS) also a vast amount of regulation regarding the derivation of market values and mortgage lending values. **Focussing on energy efficiency and energy intensity of assets must within those frameworks be an integral part that valuers must include in their work. This is not only essential for market value (MV) but also for mortgage lending value (MLV).** Here again the risk component of not being compliant in the future is essential. Poor properties will not only lose their value in the future but are also a "weak" collateral since PD (Probability of Default) and LGD (Loss given Default) are affected in a negative way.

In addition to incorporating these aspects into laws, regulations and other forms of regulation, it is also essential to sharpen the transparency of the "good" and "less good" objects in terms of energy. The current elaborations of *TEG* are a big step in the right course enabling investors to redirect capital flows in accordance with the requirements of the global climate targets. The EU *Taxonomy for sustainable activities* is intended to provide direction by clearly branding assets with a low carbon footprint. The *IEA* also found that building retrofit decisions are driven less by the price of energy/carbon and more by retrofit policies and building performance standards[97].

Nevertheless, in addition to the mere creation of transparency and the support of the evaluators in considering energy efficiency in the context of the evaluation, there are other targeted regulatory approaches that should be enforced. **New policy measures prohibiting leasing out properties that fail to meet minimum energy efficiency standards have been announced in the Netherlands and UK**. Obviously, the outlook of rental vacancies due to these regulations will depress property values in the future, and extenuate brown discounts. **Other countries in the EU should follow this procedure and should introduce similar regulations to gradually prohibit the sale and / or rental of properties with very poor energy standards.** Though prohibitions are generally not very "market economy orientated" policy instrument. In this case, however, the link is simple, since the energy certificates exist across Europe due to the *EPBD* and therefore easy implementation and visibility are given. It is essential that property owners are given sufficiently

[97] IEA, 2016, p.81.

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long transition periods by the legislators to be able to make non-compliant properties sufficiently energy-efficient within the normal maintenance cycles.

POLICY RECOMMENDATION 14:

GRADUAL BAN ON RENTING AND SELLING OF THE LEAST ENERGY-EFFICIENT PROPERTIES

Policy makers **should adopt the regulation that from the end of a certain transitional period, particularly carbon intensive properties have significantly less liquidity on the market (in letting and/or selling).** These measures must take into account the typical renovation cycles in the real estate industry and provide owners with appropriate support programs (in the form of subsidies and/or loans).

Prerequisites for the implementation of a ban for example may include:

- Enabling a fair transition period for different asset classes
- Definition of a regional scope to define the least energy efficient buildings
- Definition of geographical/regional coverage

CRREM can offer a valuable contribution to the retrofit value capture discussion, because we offer a broad scope on the direct and indirect costs and benefits of retrofits. The *CRREM* tool provides investors and owners of real estate with reliable and concrete warnings regarding their stranded asset risk exposure that is due **to science-based target policy** paths. Other projects have shown that large fraction of the public information regarding energy policy is not absorbed by investors and owners. By offering this information as a means of reducing risk, we believe that a larger audience will be interested, as behavioural economics has shown that we fear risks more than we cherish benefits of the same size. Instead of only stimulating energy efficiency, because it gains benefits, *CRREM* can do the same (and perhaps more efficiently) by warning for the risks of reluctance. Once, we are able to get the attention of investors and owners based on their risk exposure, we can then make them well aware of a wide range of benefits that can help them to financially assess the cost-benefits of energetic retrofits.

Besides potential upsides of more efficient buildings also the downsides of “doing nothing” and being left with a “grey” building that will eventually not meet market expectations anymore need to be clearly communicated. The term stranding risk has become increasingly commonplace within the commercial real estate literature in recent years but the levels of comprehension amongst the owner and investment community varies significantly, as the *CRREM* research to date has shown. One of the key challenges for the investment community has been the translation of policy and future policy direction into what that means from an operational viewpoint at both the individual and portfolio level. Further to the translation is the need to be able to communicate impactful intervention measures in order to **mitigate stranding risks and prospective value write-downs** of assets for investors. From a scientific viewpoint the *CRREM* tool affords investors the insight to make informed and proactive decisions regarding stranding risk exposures, but from a policy viewpoint a number of recommendations can be proffered to further this process.

Accordingly, the *CRREM* pathways serve as an evidence base to facilitate enhanced appreciation of stranding risks and of the need for the commercial real estate sector to significantly “up its game” if Paris Agreement Targets as to be realised. From a policy perspective greater effort is needed to implement strategic policies, market incentives and innovative long-term financing solutions to encourage broad uptake of energy saving and sustainable solutions and to bridge the **gap between climate ambitions and policy action** in buildings and construction. There remains a lack of more strategic policy guidance and frameworks for increasing carbon mitigation and an **evidence base for examining carbon assessments**, **downscaling carbon budgets** and **setting decarbonisation targets** in real estate.

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POLICY RECOMMENDATION 15:

IMPLICATIONS OF STRANDING RISK NEED TO BE EVIDENCED

Ambitious action is needed to communicate the implications of policy induced risk and the implications that non-action will have in respect of the marketability and value of real estate assets. The *CRREM* tool enables investors to "plug in" their own data into the risk assessment tool and to **visualise and audit their risk profile at both asset and portfolio level in order to gain more engrained understanding of the risks and opportunities afforded in respect of the transition to a decarbonised real estate sector.** The *CRREM* tool also offers a platform upon which policy makers can visualise and communicate existing and proposed policy changes to investors and owners "in a familiar platform" in order to promote proactive mitigation and intervention measures. This is particularly needed for **"laggers"** or those investors that have not yet embraced or lack understanding of decarbonisation risks and opportunities.

The assessment of stranding risk requires to focus data collecting efforts in the building instead of the reporting organisations. Data collection required to assess the stranding risk of buildings often differ from the reporting boundaries of many organisations, normally focused on their own activities. The assessment of the stranding risk of an asset requires data of all carbon emissions emitted within the building boundary. This includes emissions related to the tenant areas and landlord areas. For some markets, property types, and leasing structures, acquiring tenant data can be particularly difficult due to regulatory and /or behavioural constraints. Using the *CRREM* Risk Assessment tool real estate organisations have the opportunity to audit or evaluate the risk exposure of their assets relative to existing and future policy landscapes as well as market expectations. If stranding risk timelines and implications for asset values are fully comprehended, more effective capturing of building level performance will be enabled.

B.5 INVESTMENT IN TECHNICAL AND CORPORATE INOVATION TO SUPPORT TRANSITION AND CAPACITY BUILDING

There is an **obvious need for upscaling and capacity building** to support the commercial upscaling of green retrofitting and associated smart technology (technical and human competence) with respect to green retrofitting and to enhance interoperability and compatibility of "operating systems and data capture tools" through product innovation and development. The upscaling of the niche green retrofit sector represents a huge opportunity to develop successful business models that attract private-sector investments and allay concerns on security, data sharing, costs, maturity of the technology and its integration with existing systems. Framing it as "greening by activities", the upcoming EU *Taxonomy for sustainable activities* will have a strong focus on this aspect of a sustainable economy[98]. Best practice would be to use "smart" technology for data collection, the EU already aims to replace 80% of electricity meters with **smart meters.** They also work on how best to **deliver smart grids for the benefit of the energy system and its users**, including the interoperability of the most common systems and technologies within a smart grid environment. The program is funded with a total potential investment of €45 billion from the European Union.

[98] European Commission, 2020.

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POLICY RECOMMENDATION 16:

UPSCALING GREEN RETROFIT CAPACITY

The green retrofit space is predominantly characterised by small, innovative, entrepreneurial companies. **They lack the critical mass and capacity to upscale to the levels necessary to meet Paris Agreement Targets.** Given the scale of the decarbonisation challenge the growth and expansion of green retrofit companies/vehicles needs to be explored in order to transpose what is currently a ”niche” capital market opportunity into a larger investment proposition – clear communication of future policy directives and their impacts will be key drivers and determinants in the expansion and scalability of green retrofit expertise. This rings true whether investors assemble this expertise in-house or source it externally. **CRREM is advocating the establishment and support for specialist funds/vehicles that undertake green retrofit** – in particular policy should be targeting investors who do not have in-house expertise/capacity and in many instances, this should include the public sector. There is a large consultancy market offering advice and retrofit “solutions” but more needs to be done to upscale the companies doing the actual retrofit work.

POLICY RECOMMENDATION 17:

LOCAL AUTHORITIES TO INITIATE PORTFOLIO BASED APPROACHES TO SUPPORT GREEN RETROFITTING UPSCALING

Policy makers need to support the **upscaling of green retrofit solutions** through the assembly of public sector asset portfolios and the development of **long-term finance plans aligned to the Paris Agreement goals and timelines.** Enhancing investment in R&D and innovative retrofit solutions requires economies of scale and a pipeline of project opportunities. Municipalities also have a key role in exploring innovative ways to borrow and invest in deep retrofit projects alongside the private sector.

B.6 HOW “GREY” IS THE BUIDLING STOCK? - LACK OF DATA REPORTING FROM MEMBER STATES ON BUILDING CHARACTERISTICS AND ENERGY PERFORMANCE

The *Building Stock Observatory,* set up with *EU* funding as the main data repository to collect information on the *EU* building stock characteristics, energy efficiency and renovation rates contains significant data gaps. Members states have failed to update, report and record information in this repository. These data gaps affect the development of policies to set carbon reduction targets for the built environment, whilst collating from disparate sources (based on actual or modelled data) is not only time intensive, but it has to be carefully executed to ensure compatibilities of data and methodologies.

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POLICY RECOMMENDATION 18:

AUGMENT THE BUILDING STOCK OBSERVATORY TO SUPPORT EVIDENCE BASED DECISION MAKING AND TO INCLUDE EMBODIED CARBON DATA

Implement a quality and monitoring framework to ensure the **correct reporting from member states or delegated data partners.** In the intervening period the *CRREM* risk assessment tool can address some of these data gaps with the application of reasoned assumptions for both investors and policy makers, including sector and location specific data inferencing.

Expand the scope of data collection of the Building Stock Observatory to include embodied carbon impact of new buildings and major retrofit works. In order to meaningfully assess and evaluate both the ecological and economic break-even points for retrofit necessitates more engrained analysis of the operational and embodied carbon profile over the entire asset life cycle. Data gaps and limitations continue to inhibit the meaningful analysis needed to initiate the **"demolish and replace"** culture which pertains within the commercial real estate sector. The ideology that commercial real estate assets have **a 20-25-year life cycle** is premised solely on financial and economic methodologies and needs to be explored more deeply relative to the decarbonisation challenge, if commitments in the Paris Agreement are to be realised. The *EN 15978* standard is already in place as a base to quantify embodied carbon in buildings. The standard is also compliant with *ISO 14040:2006* and *ISO 14044:2006* international requirements and guidelines for life-cycle assessment, and it is the best practice and most adopted methodology currently available in the EU.

B.7 THE FUNDING GAP – DISPARITIES IN INVESTORS FINANCIAL RESOURCE CAPACITY

There is an urgent requirement to find a more appropriate balance between regulatory enforcement (e.g. building energy codes or financial non-compliance penalties) and **incentives and financing tools which enable** the decarbonisation pathways to be initiated and advanced.

Investors and owners with financial capacity are already embracing decarbonisation – however a large volume of real estate owners and investors (including government owned portfolios) do not have the financial wherewithal to decarbonise their assets – even if they are motivated to do so.

A "perpetual" point of criticism is the ratio of the full costs of a renovation measure and the share of the energy-related additional costs. Studies such as those of the IWU[99] and other research institutions show that parts of the energy renovation costs are ultimately not profitable and that a funding gap may arise that the public sector should close with subsidies and subsidised loans.

Funding and grants should focus on, for example:

- Heating optimisation through highly efficient pumps,
- Heating exchange/change to renewable energy sources,
- Exchange of old refrigeration and air conditioning systems,
- Combined heat and power,

[99] IWU, 2020.

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- Renewable heat,
- Grants for energy reduction and
- Building district solutions.

The "Green New Deal" and the EU Sustainable Finance Action Plan are steps in the right direction to activate further financial resources for energy-efficient renovations and general sustainable real estate investments. Expanding the investment landscape and putting in place repayment frameworks to incentivise a more active and prominent role for private capital is paramount to mobilising many of the "inactive".

POLICY RECOMMENDATION 19:

EXPLORATION OF NEW AND INNOVATIVE FUNDING MODELS

Targeted support for investors and owners who are motivated but lack capacity (financial or technical) could initiate impactful reductions in carbon emissions within the real estate sector. In many cases these assets/portfolios have the most intensive carbon profiles and as such can generate "significant gains" through coordinated intervention strategies. The exploration of innovative "city-level" financial solutions also need to be accompanied with the requisite statutory powers for targeting and adaptation of "stranded" assets where owners/investors are unwilling or lack capacity to conform with policy evolution.

B.8 CRREM REAL ESTATE DECARBONISATION PATHWAYS

As identified in the inaugural *CRREM* public report, there have been no carbon targets broken down for the different markets within the real estate sector. As a result of this "knowledge gap" *CRREM* translated global carbon reduction targets into country- and sector-specific decarbonisation pathways that could be applied at property level and which are consistent with climate scenarios limiting global warming to 1.5°C and 2°C. Following the *Paris Agreement, CRREM* initially considered three possible scenarios to calculate **carbon intensity reduction pathways ($kgCO_2e/m^2$)** for the *EU* commercial building stock[100]. According to our calculations, Paris-aligned reduction requirements until 2030 are significantly more ambitious compared to *NDC* requirements, which is why *CRREM* finally developed its complete set of decarbonisation and energy reduction pathways only based on 1.5°C and 2°C global warming scenarios, waiving separate pathways based on the *NDC.* Also, the EU NDC and the EU Effort Sharing Decision do not include specific requirements for individual sectors like the real estate industry. According to *CRREM* calculations, achieving the 2°C target already requires large emission reduction in the real estate sector. The 1.5°C target comes with once again significantly more demanding abatement requirements and requires a very advances decarbonisation until 2050.

Table 1: Required emission and emission intensity reduction in the EU commercial real estate sector

Scenario	Required emission (intensity) reduction 2030 vs. 2020	Rationale
1.5°C	40% (-41%)	Paris Agreement aspirational
2°C	27% (-28%)	Paris Agreement binding

[100] Hirsch et al., 2019.

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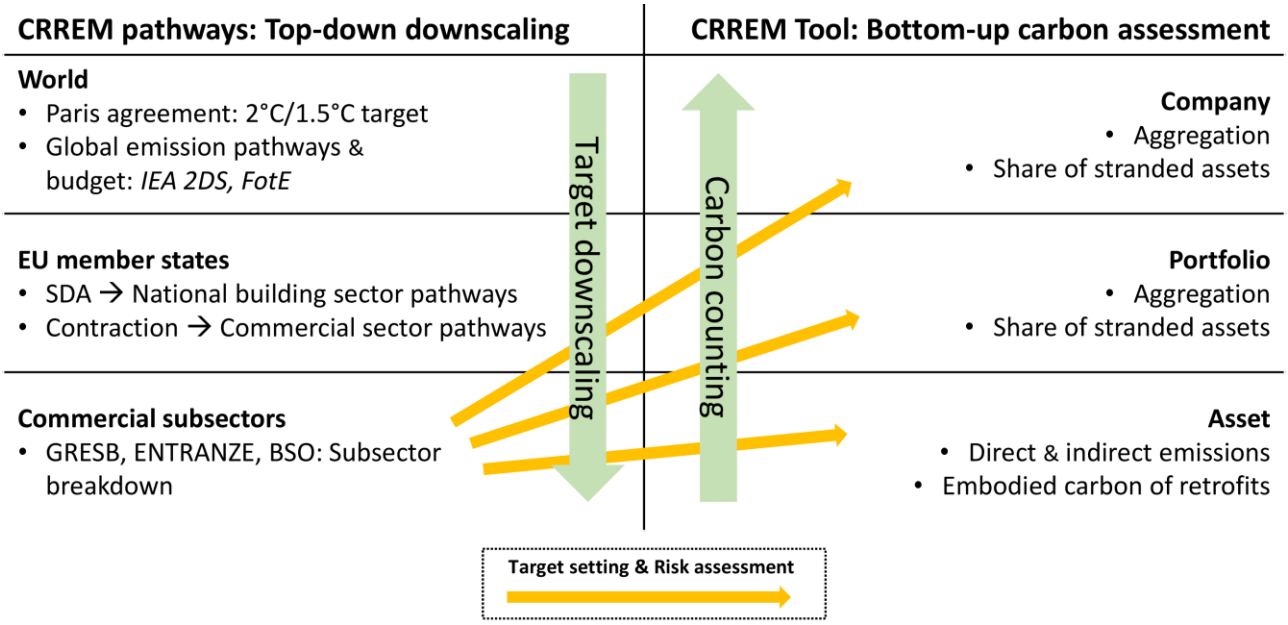
Since current political pledges are insufficient to keep global warming below 2°C, the targets and pathways developed by *CRREM* relied on scientific data and models from the *IPCC*, the *International Energy Agency,* the *European Commission* as well as further research centred on climate change implications for the real estate industry[101,102,103]. The **science-based decarbonisation pathways developed by *CRREM*** provide real estate stakeholders with clear annual targets and defined timelines of future carbon performance targets at individual property level with the capacity for these to be aggregated to depict portfolio or corporate level exposures. The pathways in combination with the *CRREM* risk assessment tool afford investors with objective science-based evidence to inform asset management and retrofit intervention strategies as well as to scenario-based disclosure of climate risks.

The data sources used provide 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. **Policy makers can directly take up the derived pathways in order to align their regulatory frameworks with the commitments of the *Paris Agreement.*** There are a number of **different approaches for downscaling global carbon budgets to single countries and industry sectors**. 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 3: Top-down approach for downscaling global carbon budgets and bottom-up carbon counting from asset to company level



Source: CRREM, 2020.

Figure 3 shows a general scheme of the top-down process of breaking down a global budget to the country and sector level, alongside the bottom-up carbon counting approach which is supported by the *CRREM* tool. Based on asset level energy consumption data the user enters into the tool, it enables the assessment of GHG emission rates and intensities that can be further aggregated to portfolio and finally company specific emission figures.

[101] IPCC, 2014.

[102] IEA, 2017.

[103] European Commission, 2016.

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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, floor area 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)[104]. Regarding the real estate industry, the commonly applied converging indicator is the energy intensity or GHG intensity, 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 that consider different growth rates between individual countries or companies. In contrast, **contraction approaches** assume the same rate of absolute or intensity-based reduction for all regarded entities (countries, sectors and companies).

CRREM applies a **global convergence approach** based on converging GHG intensity levels of each country's real estate sector (residential and commercial buildings). 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 while considering different floor area growth rates. Regarding the downscaling from a given country's overall building sector carbon intensity to separate pathways for the residential and the **commercial building sector,** *CRREM* takes into account and retains the generally higher carbon intensity of commercial buildings but assumes an EU-wide process of assimilation of the current differences between commercial and residential buildings in individual countries until 2050.

POLICY RECOMMENDATION 20:

TRANSLATION OF NATIONAL AND INTERNATIONAL DECARBONISATION TARGETS INTO REAL ESTATE BENCHMARKS

CRREM has developed a series of decarbonisation pathways for the commercial real estate sector facilitating detailed analysis by location and sector. These have been developed with guidance and input from leading institutional investors and industry professional bodies. The ideology being the translation of national and international decarbonisation targets into meaningful, actionable goals and time defined outcomes which more effectively enable owners and investors to position themselves and initiate impactful intervention strategies relative to the commitments signed up in the Paris Agreement. **Policy makers should utilise the *CRREM* pathways** to visualise stranding risks associated with evolutions on climatic policy and initiated targeted strategies for educating and mobilising owners and investors most susceptible to stranding risk.

[104] Hirsch et al., 2019.

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POLICY RECOMMENDATION 21:

COMBINE DIRECT AND INDIRECT EMISSIONS

An emissions reduction pathway for the commercial real estate sector has to **combine reduction targets derived from both direct emissions (from burning fuels) and indirect emissions (from using electricity and district heating).** Within the *CRREM* methodology, direct and indirect emissions have therefore been combined with present and future data accounting for the floor area on country-level to derive carbon intensity pathways until 2050. Both figures can be of particular relevance for policy development, but carbon performance on asset level should be benchmarked against the combined carbon intensity figure of direct and indirect emissions.

POLICY RECOMMENDATION 22:

HARNESS INDUSTRY LEADERSHIP THROUGH "ACTIVE PARTNERING"

There is a need for leadership in terms of the initiation and deliverance of change. In order to attain 2030 and 2050 targets the real estate sector will need continuous investment in innovation and technical development and to reinforce cultural and behavioural norms which underpin the decarbonisation journey. The real estate industry has "green leaders" whilst ESG frameworks form the epicentre of corporate decision-making. **Policy makers need to collaborate** with and support this pioneering leadership, expertise **and knowledge to transpose innovation** and applied learning across real estate sector in order to mobilise adaptation and mitigation measures to scale and to advocate a more proactive approach to the decarbonisation challenge. The roll-out of green retrofit solutions beyond those that are already "financially incentivised" will require policy support and collaboration.

POLICY RECOMMENDATION 23:

ALIGN AND ENHANCE DATA GOVERNANCE FRAMEWORKS TO SUPPORT DECARBONISATION TARGETS

The **alignment** and enhancement of data governance frameworks is to create a guidance for *EU* member companies to **ensure the consistency between different data collection and calculation methodologies**. To ensure compatibility in the calculation methods defined by all member states, data collection and calculation frameworks pertaining to decarbonisation of the sector needs additional guidance. A **common calculation methodology and consistent key performance indicators** are needed with specific emphasis required on the rationale and need for data monitoring, anonymised collection, reporting and recording of indicators in an ***EU*-based data repository** to address data deficiencies within the real estate value chain. Expanding the scope of data collection of the *Building Stock Observatory* to include unregulated operational carbon emissions released by occupants' activity would be a fruitful step in addressing existing data gaps.

Concluding, however, for the effective containment of global warming and economic-efficiency a coordinated and collaborative action plan is vital – single countries, even the *EU* alone can only achieve a small contribution towards global warming, even if their GHG emissions are fully reduced.

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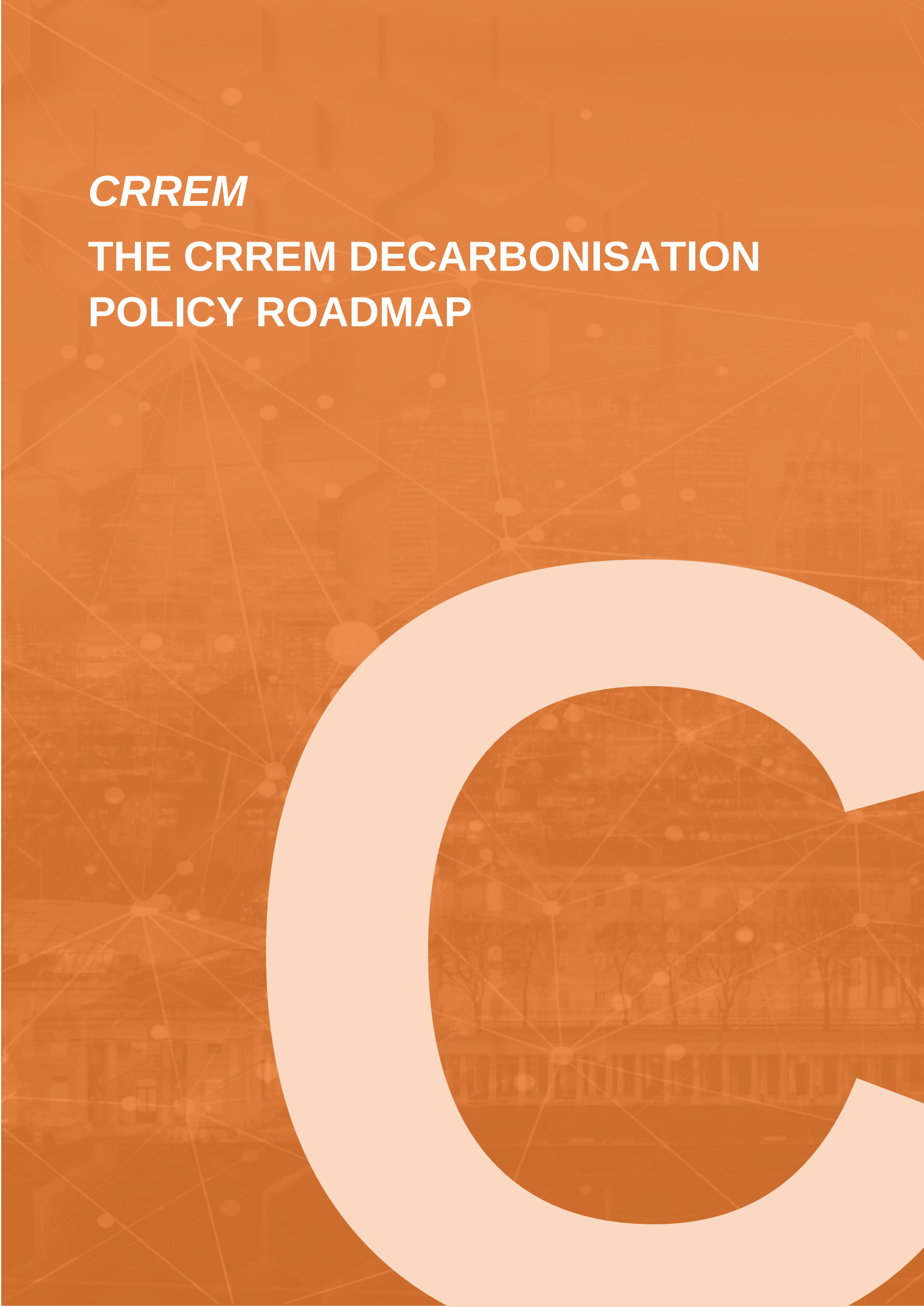
CRREM

THE CRREM DECARBONISATION POLICY ROADMAP

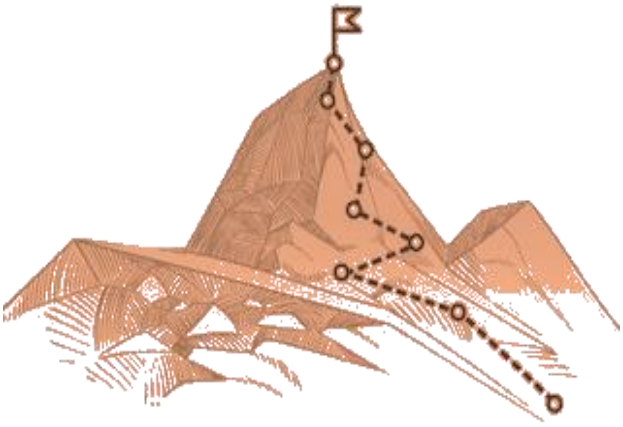


SECTION C THE CRREM DECARBONISATION POLICY ROADMAP

The entire sector will need to be addressed and engaged with a variety of policies, informed and enabled by *CRREM* and its peers. This will require not only a "Coalition of the Willing", but indeed a "Coalition of the Willing, the Unsure and the Unwilling" **– to turn aspiration into reality**. Therefore, it is not only relevant to define new insights and thoughts on additional or revised regulation / policies but also outline how investors and other market participants shall potentially respond and adopt these policies.

C.1 RESTATING THE CHALLENGE

Whilst it is a point that has been made many times before, it is worth restating the importance of the context of the existing built environment in answering the great challenge of climate change. We have not only inherited, but will also need to retain the vast bulk of the built environment that we currently have for the vital next phase of the climate change challenge – arguably the next 50 years**.** Existing buildings are heterogeneous and anything but the "clean slate" presented by a new build. They are owned and operated by a heterogeneous population. This population has a variety of attitudes and attributes, with varying levels of aptitude when it comes to complying with the green agenda and undertaking the timeous, ideal deep retrofit necessary to bring the real estate sector into line with climate change abatement aspirations.



Most of the improvement in the built environment required will need to be delivered by existing buildings. These are owned and occupied by the full array of market participants – not just those committed to an extent to the green agenda (the typical market for new green buildings). The wider market has a wide array of perspectives, attitudes and capabilities with regards to **their appetite to voluntarily adopt**

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greener practices and this is reflected in their activities and response to policy. This means that **policy must address all sector participants in a tailored way – there is no "one size" that "fits all".**

In order to develop the *CRREM* Decarbonisation Policy Roadmap, the approach will be to further develop and exploit the policy nexus investigated in the development of the *CRREM* Policy Analysis Matrix (see the *CRREM* 2019 Report No. 2)[105]. The following sections will outline the approach, by briefly introducing the **Policy Matrix and then charting how this has been evolved into the *CRREM* Decarbonisation Policy Roadmap.** The Roadmap will be developed in three main sections. The first of these is identifying the policy challenges facing each main sector of industry. This is then developed to identify how policy should **address these challenges and, finally, the policy approach to drive from the "status quo" through to a sustainable alternative.**

C.2 A STARTING POINT: THE CRREM POLICY ANALYSIS MATRIX

The *CRREM* Policy Analysis Matrix was developed (see *CRREM* Report No. 2) to allow a "status quo ground-proofing" of current green real estate policies (both government and industry)[106]. The purpose of the *CRREM* Policy Analysis was to facilitate a two way "communication" of sorts – a policy "nexus" between the policy community and the industry participants, by allowing each side to investigate the likely response of industry groupings with different characteristics, to policies with different characteristics. In order to do this the Policy Analysis Matrix establishes broad representative market participant attributes and a set of broad yet representative policy attributes. The resulting scoring allows policies to be analysed both generally and also according to a set of market participant categories, allowing a sectoral analysis to be undertaken. These market categories are broadly drawn according to a relative appetite for participation in activities connected with the sustainability agenda (in this case green retrofit). **In this way the Policy Analysis Matrix allows specific policies and more general categories of policies to be digested in a very intuitive way, with the ability to gain insights into the policy implications on specific firms, sectors or broad categories.**

Whilst this "sense making" activity provides us with a valuable context for understanding current and proposed policies, it is limited to signalling *current* issues, albeit *implying* aspects which *may* lead to improvement. By a process of identifying the range of inputs and ascribing a score, it can be implied that a move to a different input would change the score – and thus the outcome. Whilst useful in this regard it is both possible and necessary to develop this policy landscape contextualisation into a useful mechanism to map out future processes aimed at improving on the status quo and achieving the stated Paris-aligned targets of *CRREM* and the broader scientific and societal consensus to combat climate change.

C.3 A NEW PROPOSAL: THE CRREM POLICY ROADMAP

In order to achieve this the ***CREEM* Policy Roadmap** has been developed. This takes as a starting point the *CREEM* Policy Analysis Matrix characteristics and categories and uses these as a framework to understand how the knowledge, tools and policy understanding developed in the course of the *CRREM* project can be harnessed and tailored into a series of policy prescriptions to drive market participants towards enhanced performance.

[105] Haran et al., 2019.

[106] Haran et al., 2019.

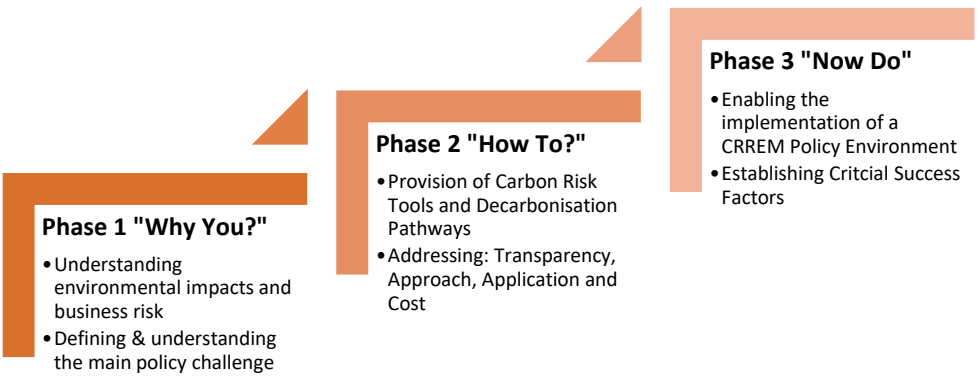
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 785058.

C.3.1 THE CRREM POLICY ROADMAP 3 PHASE APPROACH – "WHY YOU?", "HOW TO?" & "NOW DO"

The *CRREM* Policy Roadmap has followed a three-phase overarching structure which can be summarised as "Why You?", "How To" & "NOW DO".

Beneath this layer is a further 3 "stream" structure which addresses each of *CRREM* Policy Analysis Matrix market segments, conceptualised as "Reluctant Laggards" who are the hardest to engage, "Pragmatic Adopters" who will tend to act when the conditions are favourable, and "Green Unicorns" who are already committed and active.

Table 1: CRREM Roadmap – Policy Actions/ Market Segment



C.3.2.1 PHASE 1 "WHY YOU?"

The 3-phase-approach evolves from an initial phase of actively assessing the starting point capturing attention and orienting the market participants towards action. This is conceptualised in the question "Why You?". Given that all market participants vary widely, the activities in this phase do need to be tailored and in fact result in very different policy activities. This initial phase starts with an **initial status assessment,** defines the **main policy challenge** in the segment and culminates in the **distillation of a strong policy message** – the headline which emotes the task at hand. In this phase the work of *CRREM* and its peers is vital in understanding the scale and nature of the environmental, physical and organisational challenge.

C.3.2.2 PHASE 2 "HOW TO?"

Once the policy status, challenge and message has been established, the second phase is enabled. This is conceptualised as the "How to?" phase. This is the phase when the **main *CRREM* outputs can be deployed to maximum effect.** A key facet of the challenge is the **lack of appropriately scaled targets, methods to accurately assess performance and guidance on how to effect appropriate change.** It is this knowledge gap that is bridged with the *CRREM* knowledge tools and insights, notably the *CRREM* pathways which elucidate a variety of complex information and serve to operationalise the science and knowledge developed in *CRREM*. These are incorporated into the *CRREM* Policy Roadmap Model as cross-cutting **"Roadmap Actions".** The purpose of these is to create the "enabling environment" within which market segment process change and attitude realignment can take place. Again, given the different starting points and attitudes, each of the market segments requires a tailored approach to engaging with this enabling material.

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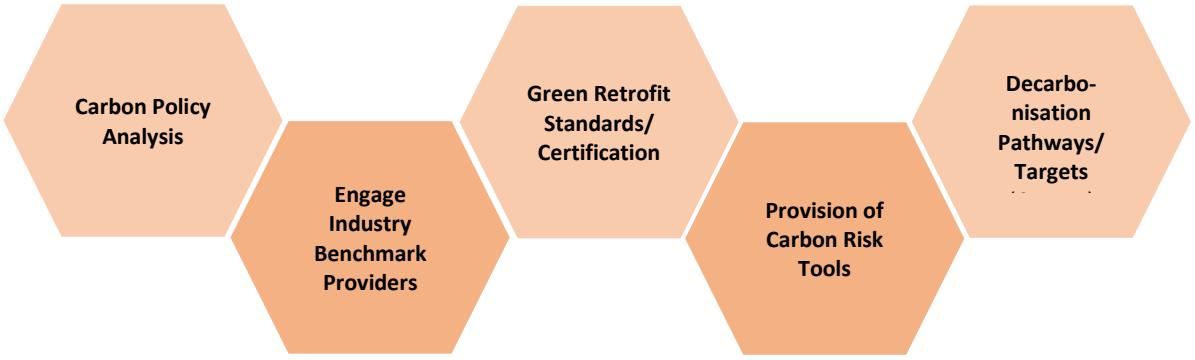
Table 2: The CRREM Roadmap Actions



Alongside the improved knowledge base provided by the *CRREM* pathways and the fostering of an enhanced policy analysis environment via the *CRREM* Policy Analysis Matrix the *CRREM* tool deployment and *CRREM* pathways will actively enhance operational capacity. Aligned to these activities, *CRREM* will foster an enhanced environment via fostering relationships with both the policy community and with established industry providers of crucial benchmarking products and services. This is a vital activity for two reasons:

- Established and respected benchmark providers like *GRESB* need enhanced processes to engage in the refurbishment space – to build coverage, trust and transparency. This can be achieved by partnering with the *CRREM* pathways to establish a form of "prequalification" for refurbishments using the *CRREM* tool and complying with the pathways. This may require a reconceptualisation of "Green Building" to include ***"Greened Building"*** – where all practical steps have been taken and the building is at its best performance – this may still be markedly short of a best performing new build – but it is exactly this activity in the existing stock which is required to achieve the carbon targets – we cannot demolish and rebuild our way out of our problems.

- Government and the wider policy community need to **understand** this "best effort" refurbishment philosophy and **respect it**, by recognising it as an acceptable status and outcome for most if not all policies that affect the built environment. This may for example form part of an enhanced *EPC Display Certificate* which gives the *EPC* performance but which also provides an accompanying **"Green Tick"** signalling acceptable "sign off" – meaning that the building will be eligible for some support and that it will categorically NOT face statute-based stranding risk. This will allow the market to absorb these signals and **differentiate between buildings which are performance restricted by reality and those which have been neglected.** Such a distinction can have a powerful effect in cases such as **heritage buildings** with legal restrictions or preservation notices. These buildings are, ultimately, likely to be exempt from stranding due to legal sanction as they cannot readily or legally comply with environmental performance targets. Under the proposed approach, they could legitimately be required to act.

This "How To?" phase can help answer many of the current questions facing the owners and occupiers of real estate, contribute significantly to reduction in risk and enhance market transparency, allowing market forces to operate more efficiently and effectively in an area which is currently exhibiting many signs of market failure.

The "How To?" phase is structured around an additional "status check" which identifies the general attitude of the market segment. This is followed by an approach to address this status, structured around the *CRREM* Policy Analysis Matrix **"Policy Attributes" of Transparency, Approach, Application & Cost** - to identify actions to positively drive improvement in these aspects. This concludes phase 2.

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C.3.2.3 PHASE 3 "NOW DO"

This is the crucial operationalised phase of the *CRREM* Policy Roadmap. The approach and instruction are clear as emoted by the lack of framing as a question and the capitalisation implying and element of command. The earlier phases established the initial problem and provided solutions. In this phase the change must occur, the activity has to happen, and the performance has to be achieved. Again, one must acknowledge that all participants are not "equal" in their attitude and aptitude, and so once again there is need for a nuanced approach.

The phase has two critical aspects – an overall summary of the policy approach to be adopted, followed by an important critical success factors which can be used through time to establish whether the "basket" of policies and processes are achieving their aims.

C.4 TAILORING THE CRREM POLICY ROADMAP FOR MARKET SEGMENTS

As intimated earlier, the *CRREM* Policy Roadmap Model interprets the policy agenda for each of the 3 market segments derived from the *CRREM* Policy Analysis Matrix, and can be defined as the hard-cases, mid-market and leading-edge market participants. These nuanced policy prescriptions are outlined below.

C.4.1 THE CRREM POLICY ROADMAP FOR THE "HARD CASES"

The "Reluctant Laggard" segment can be viewed as the "hard cases" being the most difficult to contact, connect, communicate and motivate by policy initiatives. They can be characterised as viewing the efforts with scepticism and suspicion – indicating that it is very hostile to the green agenda espoused by *CRREM*.

Phase 1 "Why You?" – The Status analysis in respect of this question can be characterised as "falling on deaf ears" with regards to both the risks posed by climate change AND the economic risks posed by policy responses to it. This sector may view such challenges as being overstated and / or sufficiently distant. Leading from this, the main policy challenge identified is the need to drive this segment towards acceptable actions – that is to break the cycle of inertia and inaction by affirmative action. This segment is unlikely to "come to the table" willingly or respond to awareness raising "guilt tripping" or enticements. As a result, the policy approach may well need to be somewhat coercive in nature – creating a "hostile environment" for wilful inaction. This may take the form of strengthened building codes for existing buildings or outlawing some inefficient plant. The approach needs to be stopped in its tracks – to coin a policy message the segment must **Strand or Deliver** – that is, it must change or face active stranding – removing the element of risk and replacing it with certainty. This is akin to the current minimum *EPC* standard enforcement which is now coming into force – but in fact emboldened and strengthened to require all reasonable steps to be taken – regardless of starting point. The *CRREM* Tool provides the industry with global decarbonisation pathways for 28 countries in Europe, North America and Asia-Pacific for the different asset classes such as office, retail, logistics and the residential sector. The pathways **identify annual energy- and carbon-intensity trajectories until 2050** across real estate markets and sectors that are consistent with keeping global warming below 2°C. These pathways create added value for stakeholders and **increase risk awareness**. Added value for example includes the transparent analysis of carbon risks, calculation of the abatement costs and analysing the correct timing of retrofit measures that are needed to minimize climate-related transition risk[107].

[107] The *CRREM* Tool is available via www.crrem.eu/tool.

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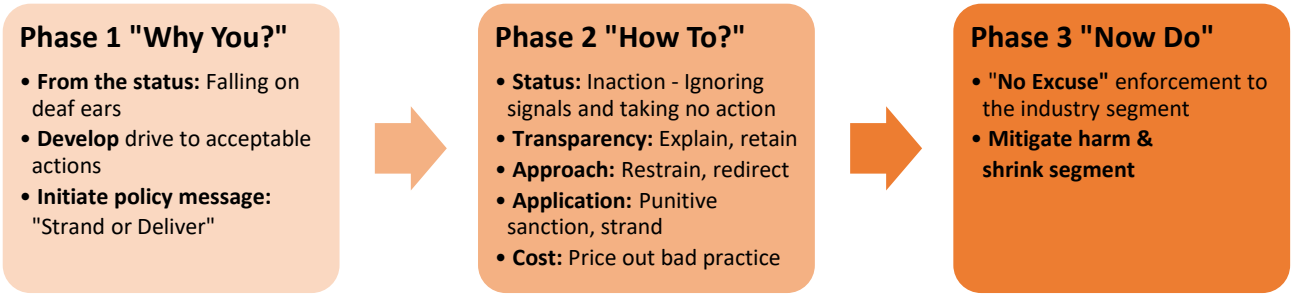
Table 3: The CRREM Roadmap for the "Hard Cases" – The Reluctant Laggards



Phase 2 "How To" – In this phase the **Status** remains "inaction" as the segment continues to ignore signals and takes no action, this negative approach is by no means a green outlook. Currently there are considerable mitigating circumstances to explain this, however the *CRREM* related activities will act to remove these as valid or viable excuses. The policy approach is therefore to address the policy attributes as follows: With regards to **Transparency**, the approach is to carry out active efforts to explain and retrain – by policy which requires owners and occupiers to demonstrate appreciation of the issues or undertake mandatory training. With regards to the general **Approach** of the policy, this will be to restrain undesirable activities and redirect (via information and mandatory training) towards better alternative products or courses of action. In terms of the **Application** – this is viewed as a process of punitive sanctions for poor performance – effectively stranding the asset. With regards to the question of **Cost** – policy needs to "price out bad practice".

Phase 3 "Now Do" – In this phase the natural tendency of this segment towards inaction needs to be tackled head on in a "no excuse" environment. The *CRREM* derived information, tools and pathways have enabled positive action and there should be no excuse for not engaging with this enabling environment.

In terms of **"critical success factors"** this can be viewed as successfully mitigating the harm potential of this segment by forcing it to become somewhat green in practice, if not in outlook. Also, the overt actions of policy in a *CRREM* enabled environment must also strive to shrink the segment, by effectively reorienting the attitudes and enhancing the aptitude of segment participants to such an extent that they can no longer be classified as belonging to this segment. In this phase the most difficult segment has been successfully brought to a minimum acceptable standard.

POLICY RECOMMENDATION 24:

MITIGATION OF RELUCTANT INDUSTRY SECTORS

More reluctant industry sectors will require a combination of overt enablement and coercive action to drive behaviour – these are *not* willing participants. **They are not "receiving" the current messages and will not actively engage as the "change environment" becomes enabled – improvement will need to be "driven" by a combination of compulsory engagement and punitive sanctions** – this is the fundamental purpose of a policy enabled "stranding risk". The main policy challenge is to mitigate the harm they pose and shrink the sector affected as much as possible.

The *CRREM* decarbonisation pathways can help to increase risk awareness. The *CRREM* global decarbonisation pathways and the *CRREM* tool can help to implement policy and assist stakeholders to manage stranding risks for individual buildings. Using the tool industry sectors, have the advantage of a **transparent analysis of carbon risks, calculation of abatement costs** and evaluating the **correct timing of future retrofit measures.** The outputs and analysis of the tool directly address the needs of its user base.

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C.4.2 THE CRREM POLICY ROADMAP FOR THE "MID MARKET"

The "mid-market" segment identified in the *CRREM* Policy Analysis as "pragmatic adopters" is somewhat different to the "Reluctant Laggards" in that they have a different starting position, a more dynamic "response reflex" and a much more optimistic "terminal velocity" in terms of policy outcome.

Phase 1 "Why You?" – With regards to phase 1, this segment has an initial **Status** of appreciation, implies no hostility but does not yet pursue a green approach. This lack of the laggards antipathy and generally more open and engaged attitude allows a more positive main policy change based around **encouragement of positive action** – whilst some "push" may be involved to counteract market inertia, it is more a case of enabling and signposting than the earlier coercion – this segment largely wants to change and achieve positive outcomes – they perhaps are not sure how to best achieve this and are reluctant to face the challenge and risks of false starts and poor choices. As a result of this situation, the **policy message** can be tailored much more positively as **"welcome on board"** – implying that this segment will be a willing participant in a process of enablement.

Table 4: The CRREM Policy Roadmap for the "Mid-Market" – The Pragmatic Adopters

Phase 1 "Why You?"	Phase 2 "How To?"	Phase 3 "Now Do"
• **From the status:** Sympathetic but inactive • **Require** the encouragement of positive action • **Initiate policy message:** "Welcome on Board"	• **Status:** Enabled - Accessing help, advice & products • **Transparency:** Clarify, demonstrate • **Approach:** Entice, reward • **Application:** Certify, accept • **Cost:** Incentivise good practice	• **Result:** Enthusiastic adoption • **Creation of "Mainstream Best Practice"**

Phase 2 "How To?" becomes a far more active space for this segment – as the current **Status** is characterised by a willingness to engage resulting in an enabled segment, **actively taking advantage of the *CRREM* enabling environment to achieve positive improvement and aims for a definably "green" outlook.**

With regards to **Transparency** it is clear that active participants require a different approach, based around clarification (it is still a complex environment to operate within) and demonstration (examples of best practice in action are powerful agents for change). With regards to the intended **Approach**, there is a sound basis here **for incentives to encourage engagement such as enticements and rewards.** This helps to make the business case that this pragmatic segment will always use as the fundamental determinant of action. In terms of application, this is of key importance and is related closely to the *CRREM* partnering approach with policy and benchmarking, as it is vitally important that efforts are adequately and appropriately certified and accepted without undue friction. With regards to the key aspect of **Cost** – again, business cases will rule in this segment but the general approach will be to incentivise good practice, via a basket of grants and funding support for costly items and a conducive taxation environment. **Of key importance is the avoidance of "perverse incentives" in the tax and regulatory systems.** Examples of this can be found in most tax codes – such as in ad valorem-based taxes, where higher values result in higher taxes. Where positive pricing effects can be achieved for green or "greened" buildings, this supports the business case for adopting greener practices. However, ad valorem taxes such as recurrent property taxes and transfer-based taxes such as Stamp Duty and Capital Gain taxes would place a heavier burden on such value-enhanced properties. It is important that these issues are examined and addressed with policy makers to avoid hampering the momentum of the change to greener practices.

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Phase 3 "Now Do" is contextualised by this more enthusiastic engagement with the enabling *CRREM* environment with the outflowing **result being "enthusiastic adoption".** The critical success factor drawn from this phase is reflective of the reality that this is likely to be the biggest segment, containing the majority of the market – in that regard success is measured as **"mainstreaming best practice"** – with *CRREM* enabling the advances in scientific understanding to move from "green practices" to "normal business practice". This transformation is essential to hit current targets, let alone more stretching ones which may become necessary.

POLICY RECOMMENDATION 25:

RECOGNITION OF "GREENED" BUILDINGS

A considerable proportion of businesses are in fact willing to make the necessary changes but need an enabling environment to facilitate change. They require their efforts to be "de-risked" by clearer guidance and certainty that their actions will be recognised and respected by both the enforcement regime and by policies designed to promote positive behaviour – **limiting this support to only the most "green" alternatives such as zero-carbon buildings – which are likely to be new build – is counterproductive** for the majority of buildings and industry participants, driving many to take no action and adopt a "wait and see" approach. The Policy challenge for this sector is to encourage the mainstream adoption of best practice solutions for their context – recognising not only "green buildings" (mostly new build) but also "greened buildings" (as green as reasonably possible). Policy should be adapted to operationalise this perspective.

C.4.3 THE CRREM POLICY ROADMAP FOR THE "LEADING EDGE"

This segment is at the leading edge of practice, characterised in the *CRREM* Policy Analysis Matrix as "Green Unicorns". These are the firms that have already acknowledged both the challenge and to an extent the opportunity presented by climate change and have voluntarily travelled beyond the requirements of current policy to engage in green activities – placing these at the core of their business philosophy. Whilst it would be tempting to view this segment as outside of the focus of *CRREM* Policy Roadmap "prescriptions", as they are "already there", it is important not to do so. In any successful roadmap to a sustainable built environment, this segment has a vital role to play, which must be harnessed and nurtured in a distinct way from the other two segments. Whilst the other two were in apposition to require support to achieve, this segment is capable of providing support, and delivering ongoing innovation which will serve to consolidate success and drive further success.

Phase 1 "Why You?" – In this phase the **Status** can be understood as "already on board". This section is characterised by early adopters that have already risen to the challenge faced by climate related environmental and policy risk. As a result, there is a distinctly different tone to the main policy challenge with this being distilled as "Celebrate and Share". The challenge is to make capital from the success of the segment and get the positive messages out, to help create the positive environment within which the other segments can evolve. From this the policy message can be characterised as **"We are the Champions"**. This has a subtle double meaning, in that this segment are indeed the champions in this particular "contest" and should be celebrated as such. This is distinct from being directly "rewarded" as there is no obvious policy advantage in providing financial incentives where the behaviour is already ingrained. The second meaning is that this segment must be engaged to "Champion the cause" in the phase 2 activities of the other segments.

The *CRREM* reporting templates can not only aid the reluctant or pragmatic adopters, but also the leading market segment for transparent reporting, with the templates linked to the tool. Market leaders can use these to share and communicate reached goals and current market position in terms of being on track with the Paris targets.

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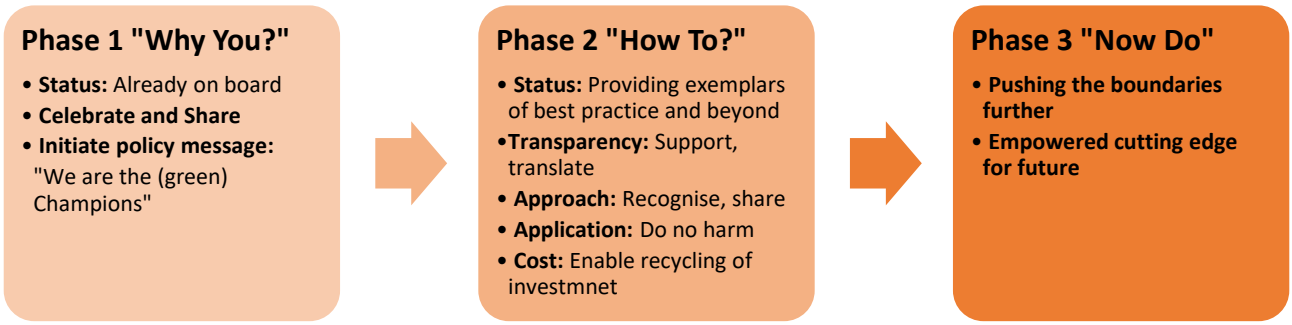
Table 5: The CRREM Roadmap for the "Leading Edge" – Green Unicorns



Phase 2 "How To" also looks quite distinct from the other segments. The initial Status is set as "Leading" by way of engagement and provision of exemplars case studies of current best practice and beyond state-of-the-art aspirational actions and activities, as part of the *CRREM* enabling environment. The *CRREM* Policy Analysis "Policy Attributes" follow a theme of "partnership for progress". **Transparency** is addressed by providing support for the natural tendency of this segment to proselytise regarding the green agenda and providing mechanisms to translate their possibly lofty ambitions and complex approaches into more digestible formats for consumption by the other segments. The **Approach** adopted is again distinct – being summarised as recognition (awards, positive press allowing the self-actualisation often driving this activity) and sharing – again this is a policy of **capturing the learning and achievements** of this segment for the greater good – the segment does not require sanctions or incentives – it needs effective avenues of engagement and dissemination. In terms of application, the **overriding policy direction is "Do no Harm".**

This segment is by its very nature entrepreneurial in nature and on the cutting edge (and by association outer edge) of the economy. Innovation is a risky area and the business environment can be extremely harsh at the fringe. Policy should be mindful of these realities and be "health checked" to ensure that it is not creating unintended challenges or worsening a hostile business environment for environmental innovators. In terms of the vital element of **Cost**, as previously intimated, there is no policy justification for direct financial support where it will not result in change – imagine a policy that pays non-smokers rather than taxing smokers. That said, there may be "proof of concept" activities which may be enabled by financial subsidies and this should be encouraged. Of more critical importance **is the need to foster innovation and experimentation by facilitating the recycling of reinvestment into green innovation**. These innovators have an important role to play in initiating, sustaining and maintain progress and should be viewed more in terms of a value-added sector rather than as a tax income cost centre. Where justified tax policy should be structured to facilitate the retention of capital and profits for the expansion and development of the sector. Creating an environment conducive to medium- to **long-term** investment in an area of innovation has been successful in the past – with the development of the emerging pharmaceutical industry via guaranteed *National Health Service* purchase agreements being a notable example. The emphasis here is very much in maintaining and augmenting the operating environment of this vital yet fragile segment and using it as the delivery mechanism to demonstrate the viability of sustainable practices in the built environment.

Phase 3 "Now Do" is again summarised as **"pushing the boundaries".** A larger, more transparent marketplace for green alternatives fostered in the *CRREM* environment should see this sector flourish, moving forward with programmes to tackle the remaining challenges of climate change – broadening and deepening the sector response to these challenges. This segment is effecting real positive change in this large and vital arena, this is the carbon equivalent of "Silicon Valley" and will be required and relied upon to provide leadership to the built environment sector into the future. Allied to this, the critical success factor is distilled out as the existence of an **"empowered cutting edge for the future"** – robust, resilient and mature innovation-based entities and a conducive environment fostering the emergence of new green innovators.

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Those organisations that are at the leading edge of the green real estate sector need a **policy environment which does no harm, rewards continued activity and which celebrates their success** – proselytising for the purposes of encouraging the willing, yet less able majority. The main policy challenge here is to preserve **and expand the green real estate "cutting edge" moving forward.**

Recommendation: The real estate industry includes a number of pioneering companies and figure heads who have carried the mantle as innovators, pioneers and facilitators in responding to the decarbonisation challenge. This expertise and know-how needs to more effectively harnessed and showcased as live case studies of best practice and pathway development. There exists a huge audience of "willing but reluctant" owners and investors that need reassurance and informed insights from an operational viewpoint. This is crucial to upscaling and optimising impactful change going forward beyond the "elitist" investors.

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ANNEX

LIST OF FIGURES

LIST OF TABLES

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

REFERENCES

ACEEE (2012): How does Energy Efficiency Create Jobs. In: The ACEEE factsheet.

Allcott, H., Greenstone, M. (2012): Is There an Energy Efficiency Gap? In: Journal of Economic Perspectives, 26 (1): 3-28.

Allcott, H., Mullainathan, S. (2010): Behavior and Energy Policy. Journal: Department of Economics, Massachusetts Institute of Technology, vol 327, issue 5970, pp. 1204-1205. Better Buildings Partnership (2020): Reality bites – can we really deliver net zero carbon buildings by 2050? Online: https://www.egi.co.uk/news/reality-bites-can-we-really-deliver-net-zero-carbon-buildings-by-2050/ (Last accessed: 30.01.2020).

Bals, C., Cuntz, C., Caspar, O., Burch, J. (2013): The End of EU Climate Leadership. Briefing Paper, Germanwatch e.V. Online: https://germanwatch.org/sites/germanwatch.org/files/publication/8591.pdf (Last accessed: 27.04.2020).

Better Building Partnership (BBP) (2020): Press Release: Real Estate Companies Continue To Drive Energy Reductions. Online: http://www.betterbuildingspartnership.co.uk/press-release-real-estate-companies-continue-drive-energy-reductions (Last accessed: 13.04.2020).

Bienert, S.; Cajias, M.; Geiger, P. (2012): Green agenda and green performance: Empirical evidence for real estate companies. Journal of European Real Estate Research.

BMU (2018): Klimaschutz in Zahlen: Fakten, Trends und Impulse deutscher Klimapolitik Ausgabe 2018, Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit, Berlin.

BMU (2017): Verpflichtungsperioden, https://www.bmu.de/themen/klimaenergie/klimaschutz/internationale-klimapolitik/kyoto-protokoll/verpflichtungsperioden

BMU (2017): Die Klimakonferenz in Paris, https://www.bmu.de/themen/klimaenergie/klimaschutz/internationale-klimapolitik/pariser-abkommen/

BMWi (2015): Energieeffizienzstrategie Gebäude – Wege zu einem nahezu klimaneutralen Gebäudebestand, Bundesministerium für Wirtschaft und Energie, Berlin.

Bodansky, D. (2016): The Paris Climate Change Agreement: A New Hope? In: The International Law journal 2016, p. 100, p. 288–319.

BPIE (2019): The Zero Carbon and Circular Economy Challenge in The Built Environment: Policy Options for The European Union and Its Member States, June, Belgium. Online: http://bpie.eu/publication/a-zero-carbon-and-circular-built-environment-policy-options-for-the-european-union-and-its-member-states (Last accessed: 30.01.2020).

BRE Group (2018): BRE Global Methodology for The Environmental Assessment of Buildings Using EN 15978:2011. Online: http://www.greenbooklive.com/filelibrary/EN_15804/PN326-BRE-EN-15978-Methodology.pdf (Last accessed: 05.02.2020).

Buildings Performance Institute Europe (BPIE) (2011). Europe's Buildings under the—A Country-by-Country Review of the Energy Performance of Buildings; BPIE: Brussels, Belgium.

Buildings Performance Institute Europe (BPIE) (2019). Future-Proof Buildings for All Europeans. A Guide to Implement the Energy Performance of Buildings Directive (2018/844). Available online at: http://bpie.eu/wp-content/uploads/2019/04/Implementing-the-EPBD_BPIE_2019.pdf

Carbon Buzz (2020): The Performance Gap. Online: http://www.carbonbuzz.org/index.jsp#performancegap (Last accessed: 07.04.2020).

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

Carbon Transparency Initiative (2019): The CTI 2050 Roadmap Tool. Online: http://https://www.buildup.eu/en/learn/tools/cti-2050-roadmap-tool (Last accessed: 19.02.2020)

Carbon Trust (2014): Breaking the 'circle of inertia' on energy efficiency in the commercial buildings sector. Online: https://www.carbontrust.com/news/2014/10/breaking-circle-of-inertia-on-energy-efficiency-commercial-buildings-sector (Last accessed: 30.01.2020).

Cassen, C., Hamdi-Chérif, M., Cotella, G., Toniolo, J., Lombardi, P., & Hourcade, J. C. (2018): Low Carbon Scenarios for Europe: An Evaluation of Upscaling Low Carbon Experiments. Sustainability, p. 10(3), p. 848.

CBI (2009a): Going the distance: the low-carbon transport roadmap, UK. Online: https://friendsoftheearth.uk/sites/default/files/downloads/low_carbon_trans_roadmap.pdf (Last accessed: 28.01.2020).

CBI (2009b): Going the distance: the low-carbon building roadmap, UK. Online: https://friendsoftheearth.uk/sites/default/files/downloads/low_carbon_buildings.pdf (Last accessed: 28.01.2020).

Center for European Reform (2019): Moving back the finishing line: The EUs progress on climate. Online: https://www.cer.eu/sites/default/files/insight_NG_23.9.19.pdf (Last accessed: 28.04.2020).

Climate Action Tracker (2019a): Warming Projections Global Update. Online: https://climateactiontracker.org/documents/698/CAT_2019-12-10_BriefingCOP25_WarmingProjectionsGlobalUpdate_Dec2019.pdf (Last accessed: 10.04.2020).

Climate Action Tracker (2019b): Pledged action leads to 2.9°C – time to boost national climate action. Online: https://climateactiontracker.org/documents/644/CAT_2019-09 19_BriefingUNSG_WarmingProjectionsGlobalUpdate_Sept2019.pdf (Last accessed: 23.04.2020)

Climate Action Tracker (2019c): Country Summary – EU. Online: https://climateactiontracker.org/countries/eu/, (Last accessed: 23.04.2020)

Christensen, P. H., Robinson, S. J., & Simons, R. A. (2018) : The influence of energy considerations on decision making by institutional real estate owners in the US. In: Renewable and Sustainable Energy Reviews, p. 94, p. 275-284

Committee on Climate Change (2019): A report for the committee on climate change – Behaviour change, public engagement and net zero. Imperial College London.

Deka Deutsche Girozentrale (2016): Metastudie: Nachhaltigkeit Contra Rendite? Die Implikationen nachhaltigen Wirtschaftens für offene Immobilienfonds am Beispiel der Deka Immobilien Investment GmbH und der WestInvest GmbH. Online https://epub.uni-regensburg.de/33825/1/Metastudie.pdf (Last Accessed: 08.04.2020).

DGNB (2020): Klimaschutz und das Gebäudeenergiegesetz (GEG): Ohne Innovationsklausel fördert das GEG klimaschutzorientierte Innovationen nur unzureichend. Online: https://www.dgnb.de/de/aktuell/positionspapiere-stellungnahmen/stellungnahme-klimaschutz-und-geg-2020 (Last accessed: 14.04.2020).

Department of Energy and Climate Change (2011): UK Renewable Energy Roadmap, Department of Energy and Climate Change, London, UK. Online: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/48128/2167-uk-renewable-energy-roadmap.pdf (Last accessed: 29.01.2020).

De T'Serclaes (2007): Financing Energy Efficient Homes: Existing Policy Responses to Financial Barriers, Paris: International Energy Agency.

Deutsche Energie-Agentur GmbH (2018): Impulse für die Gestaltung des Energiesystems bis 2050, page 16. Deutsche Energie-Agentur GmbH (dena)

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

EEA (2018): Entwicklung der Effort Sharing Decision nach Sektoren in Deutschland.

Fraunhofer Institute for Systems and Innovation Research ISI. (2009). Study on Energy Savings Potentials in EU Member States, Candidate Countries and EEA Countries: Final Report for the European Commission Directorate-General Energy and Transport; Institute for Systems and Innovation Research ISI: Karlsruhe, Germany.

De Wolf, C., Pomponi, F., & Moncaster, A. (2017): Measuring embodied carbon dioxide equivalent of buildings: A review and critique of current industry practice. In: Journal of Energy and Buildings, p. 140, p. 68-80.

Eoin, M. et al. (2003): Barriers to energy efficiency: evidence from selected sectors. Other. The Economic and Social Research Institute, Dublin. Online: http://sro.sussex.ac.uk/id/eprint/53997/1/PRS47.pdf (Last accessed: 25.02.2020).

European Climate Foundation (2011a): Roadmap 2050: a practical guide to a prosperous, low-carbon Europe, the Hague, the Netherlands. Online: https://www.roadmap2050.eu/attachments/files/Roadmap2050-AllData-MinimalSize.pdf (Last accessed: 30.01.2020).

European Climate Foundation (2011b): Roadmap 2050: Financing for a Zero-carbon Power Sector in Europe, the Hague, the Netherlands. Online: https://www.roadmap2050.eu/attachments/files/Roadmap2050-AllData-MinimalSize.pdf (Last accessed: 30.01.2020).

European Climate Foundation (2013): From Roadmaps to reality: A Framework for Power Sector Decarbonisation in Europe, the Hague, the Netherlands. Online: https://www.roadmap2050.eu/attachments/files/Fromroadmapstoreality(web).pdf (Last accessed: 29.01.2020).

European Commission (2008): Proposal for a Decision of the European Parliament and of the Council on the Effort of Member States to Reduce Their Greenhouse Gas Emissions to Meet the Community's Greenhouse Gas Emission Reduction Commitments up to 2020.

European Commission (2011): A resource-efficient Europe—Flagship Initiative under the Europe 2020 Strategy. In: Brussels: European Commission.

European Commission (2011a): Regional Policy Contributing to Sustainable Growth in Europe 2020.

European Commission (2011b): Regional Policy Contributing to Sustainable Growth in Europe 2020.

European Commission (2012): Energy Roadmap 2050.

European Commission (2019): Energy Roadmap 2050.

European Commission (2013): A 2030 Framework for Climate and Energy Policies; Green Paper.

European Commission (2016): Climate strategies and targets: 2020 climate and energy package.

European Commission (2016): Commission Staff Working Document. Online: https://ec.europa.eu/energy/sites/ener/files/documents/5_en_autre_document_travail_service_part3_v4.pdf (Last accessed: 18.05.2020).

European Commission (2019a): European policies on climate and energy towards 2020,2030 and 2050. Online: https://www.europarl.europa.eu/RegData/etudes/BRIE/2019/631047/IPOL_BRI(2019)631047_EN.pdf (Last accessed: 23.04.2020).

European Commission (2019b): European policies on climate and energy towards 2020,2030 and 2050. Online: https://www.europarl.europa.eu/RegData/etudes/BRIE/2019/631047/IPOL_BRI(2019)631047_EN.pdf (Last accessed: 23.04.2020).

European Commission (2020): Taxonomy: Final report of the Technical Expert Group on Sustainable Finance.

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

European Commission Energy Roadmap 2050 (2019): European Energy Roadmap for 2050. Online: http://www.newslettereuropean.eu/european-energy-roadmap-2050/ (Last accessed: 09.04.2020).

European Technical Expert Group on Sustainable Finance (2020): Technical Report. Taxonomy: Final report of the Technical Expert Group on Sustainable Finance.

European Union (2017): Level(s) – A Common EU Framework of Core Sustainability Indicators for Office and Residential Buildings: Parts 1 and 2.

European Union (2018): Official Journal of the European Union, L 156, 19 June 2018 – Regulation 2018/842. Online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L:2018:156:TOC (Last accessed: 05.04.2020).

European Union (2019): European policies on climate and energy towards 2020,2030 and 2050. Online: www.europarl.europa.eu/supporting-analyses (Last accessed: 06.04.2020).

Eurostat (2016): Greenhouse gas emission statistics.

Eurostat (2019): Statistics on Gross profit share of non-financial corporations in the euro area and the European Union, EU.

Fisk, William J. (2000): Health and productivity gains from better indoor environments and their relationship with building energy efficiency. In: The Annual Review of Energy and the Environment, Vol. 25, p. 537 – 566.

Geltner et al. (2017): The Effect of Green Retrofitting on US Office Properties: An Investment Perspective. Online: SSRN: http://dx.doi.org/10.2139/ssrn.3028183 (Last accessed: 25.02.2020).

Gillingham & James Sweeney (2012): "Barriers To Implementing Low-Carbon Technologies," Climate Change Economics (CCE), World Scientific Publishing Co. Pte. Ltd., vol. 3(04), pages 1-21.

Giordano, R., Serra, V., Tortalla, E., Valentini, V., & Aghemo, C. (2015): Embodied energy and operational energy assessment in the framework of nearly zero energy building and building energy rating. In: Journal of Energy Procedia, p. 78, 3204-3209.

Global Alliance for Buildings and Construction, International Energy Agency and the United Nations Environment Programme (2018): 2018 Global Status Report for Buildings and Construction 2018. Towards a zero-emission, efficient, and resilient buildings and construction sector. Online: https://www.unenvironment.org/resources/report/global-status-report-2018 (Last accessed: 30.01.2020).

Global Alliance for Buildings and Construction, International Energy Agency and the United Nations Environment Programme (2019): 2019 Global Status Report for Buildings and Construction. Towards a zero-emission, efficient, and resilient buildings and construction sector. Online: https://www.worldgbc.org/sites/default/files/2019%20Global%20Status%20Report%20for%20Buildings%20and%20Construction.pdf (Last accessed: 10.04.2020).

Green Energy Money blog. (2016): Brown Discounts & Green Premium Value Trends–New Real Estate Market Emerging Risk. Online: http://www.greenenergy.money/browndiscounts-green-premium-value-trends-new-real-estate-market-emerging-risk (Last accessed: 24.02.2020).

GRESB (2019): Real Estate Results 2019. Online: https://gresb.com/2019-real-estate-results/(Last accessed: 29.01.2020).

Haran, M.; Davis, P.; McCord, M., Lo, D., Hirsch, J.; Bienert, S.; Spanner, M.; Geiger, P.; Lafuente, J.; Recourt, R.; Taltavull, P.; Perez, R.; Juárez, F.; Martinez, A.; Brounen, D. (2019): Carbon Risk Integration in Corporate Strategies within the Real Estate sector. CRREM report No. 2, 2019, Wörgl, Austria. Online: https://www.crrem.eu/wp-content/uploads/2019/12/CRREM-Carbon-Risk-Integration-in-Corporate-Strategies-within-the-Real-Estate-Sector.pdf (Last accessed: 02.03.2020).

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

Hewicker, L., M. Hogan. & A, Mogren (2011): Power Perspectives 2030, On the Road to a Decarbonised Power Sector. In: ECF European Climate Foundation, the Hague, the Netherlands.

Hirsch, J.; Lafuente, J.; Recourt, R.; Spanner, M.; Geiger, P.; Haran, M.; McGreal, S.; Davis, P.; Taltavull, P.; Perez, R.; Juárez, F.; Martinez, A.; Brounen, D. (2019): Stranding Risk & Carbon. Science based decarbonising of the EU commercial real estate sector. CRREM report No.1, 2019, Wörgl, Austria. Online: https://www.crrem.eu/wp-content/uploads/2019/09/CRREM-Stranding-Risk-Carbon-Science-based-decarbonising-of-the-EU-commercial-real-estate-sector.pdf (Last accessed: 02.03.2020).

Internal Energy Agency (2016): Energy Efficiency Market Report, p.81.

International Energy Agency (2017): Energy Technology Perspectives 2017. Online: https://www.iea.org/reports/energy-technology-perspectives-2017(Last accessed: 29.01.2020).

International Energy Agency (2019): Global Energy and CO2 Status Report 2019. The Latest Trends in Energy and Emissions in 2018. Online: https://www.iea.org/reports/global-energy-and-co2-status-report-2019/emissions#abstract (Last accessed: 30.01.2020).

IPCC (2014): ZWISCHENSTAATLICHER AUSSCHUSS FÜR Klimaänderungen, Klimaänderungen 2014. Online: https://www.ipcc.ch/site/assets/uploads/2018/02/IPCC-AR5_SYR_barrierefrei.pdf (Last accessed: 14.04.2020).

IPCC Intergovernmental Panel on Climate Change (2019): Global Warming of 1.5°C, an IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. Finale Version. Online: https://www.ipcc.ch/sr15/download/#full (Last accessed: 23.04.2020)

Ivanova, D., Vita, G., Steen-Olsen, K., Stadler, K., Melo, P. C., Wood, R., & Hertwich, E. G. (2017): Mapping the carbon footprint of EU regions. In: Journal of Environmental Research Letters, 12(5), 054013. Online: https://iopscience.iop.org/article/10.1088/1748-9326/aa6da9/meta#erlaa6da9r18 (Last accessed: 29.01.2020).

IWU Institut Wohnen und Umwelt (2011): Evaluierung und Fortentwicklung der EnEV 2009: Untersuchung zu ökonomischen Rahmenbedingungen im Wohnungsbau, Darmstadt, page 167.

IWU Institut Wohnen und Umwelt (2020): Institut Wohnen und Umwelt.

Klimaschutzplan 2050 (2016): Klimaschutzplan 2050 – Die deutsche Klimaschutzlangfriststrategie, Page 15. Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit.

Kumbaroğlu, G., Madlener, R. (2011): Evaluation of Economically Optimal Retrofit Investment Options for Energy Savings in Buildings, FCN Working Paper No. 14/2011. Online: http://dx.doi.org/10.2139/ssrn.1950577 (Last accessed: 25.02.2020).

Mercer (2011): Climate Change Scenarios – Implications for Strategic Asset Allocation. Online: http://documents.worldbank.org/curated/en/138101493381025955/pdf/114650-IFC-Brief-Mercer-web-PUBLIC.pdf (Last accessed: 30.01.2020).

Münchener Rückversicherungs Gesellschaft (2013): Topics Geo: Natural catastrophes 2012 - Analyses, assessments, positions. In: The Journal Topics Geo, Munich, p. 52.

Nicholls, R. J. et al. (2008): Ranking Port Cities with High Exposure and Vulnerability to Climate Extremes: Exposure Estimates. In: The OECD Environment Working Papers, No. 1, OECD Publishing.

Polesello, V., Johnson, K. (2016): Energy-efficient buildings for low-carbon cities. In: Journal ICCG Reflection No. 47, March 2016.

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

Renovate Europe (2016): Multiple benefits of investing in energy efficient renovation of buildings. In: Journal, A study by Copenhagen Economics.

Ramos, A.; Gago, A,; Labandeira, X.; Linares, P. (2015): The role of information for energy efficiency in the residential sector. Energy Economics, pages 17-29.

RenoValue (2016): A Training toolkit to integrate energy efficiency and renewable energy into property valuation practices. Online: http://renovalue.eu/ (Last accessed: 08.04.2020).

RentalCal (2016): RentalCal Tool: Rentability Calculation of Energy Efficiency Investments. Online: http://www.rentalcal.eu/home (Last accessed: 08.04.2020).

Reuters (2020): EU presses on with tighter 2030 climate target despite pandemic. Online: https://www.reuters.com/article/us-climate-change-eu/eu-presses-on-with-tighter-2030-climate-target-despite-pandemic-idUSKBN21I386 (Last accessed: 22.04.2020).

RICS (2017): The Future of Valuations: The relevance of real estate valuations for institutional investors and banks – views from a European expert group. RICS, Parliament Square, London SW1P 3AD. Online: https://anavaliadores.pt/wp-content/uploads/2018/04/RICS-Future-of-Valuations-insights-paper.pdf (Last accessed: 08.04.2020).

RICS (2018): Co2 Pricing. https://www.rics.org/de/news-insight/latest-news/news-opinion/co2-bepreisung-deutschland-muss-nicht-bei-null-anfangen/ (Last accessed: 08.04.2020).

Rocky Mountain Institute - RMI. (2014): How to calculate and present deep retrofit value, Rocky Mountain Institute, Boulder.

Robinson, S., R. Simons, E. Lee, and A. Kern. (2016): Demand for Green Buildings: Office Tenants' Willingness-to-Pay for Green Features. In: Journal of Real Estate Research 38(3), p. 423-452.

Shogren, J., Taylor, L. (2008): Review of Environmental Economics and Policy. Journal: volume 2, issue 1, winter 2008, pp. 26–44. Online: https://doi.org/10.1093/reep/rem027 (Last accessed: 25.02.2020).

Strachan, M. E., Janda, K. B., & McKeown, B. (2015): Change from within? Carbon management in commercial real estate. In: The ECEEE Summer Study, p. 101-111.

TEG, European Commission (2020): EU Taxonomy for Sustainable Activities. Online: https://ec.europa.eu/info/publications/sustainable-finance-teg-taxonomy_en (Last accessed: 10.04.2020).

Transport and Environment (2018a): Roadmap to decarbonisation of European Shipping. Online: https://www.transportenvironment.org/sites/te/files/publications/2050_strategy_cars_FINAL.pdf (Last accessed: 25.01.2020).

Transport and Environment (2018b): Roadmap to decarbonisation of European Shipping. Online: https://www.transportenvironment.org/sites/te/files/publications/2050_strategy_cars_FINAL.pdf (Last accessed: 25.01.2020).

Transport and Environment (2018c): Roadmap to decarbonisation of European Shipping. Online: https://www.transportenvironment.org/sites/te/files/publications/2050_strategy_cars_FINAL.pdf (Last accessed: 25.01.2020).

UK Green Building Council (2019)**:** Guide to Scope 3 Reporting in Commercial Real Estate. July 2019. Online: https://www.ukgbc.org/wp-content/uploads/2019/07/Scope-3-guide-for-commercial-real-estate.pdf (Last accessed: 30.01.2020).

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

UNFCCC (2015): Adoption of the Paris Agreement. Online: http://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf (Last accessed: 29.01.2020).

UN Environment and International Energy Agency (2017): Towards a zero-emission, efficient, and resilient buildings and construction sector. Global Status Report 2017. Online: https://www.worldgbc.org/sites/default/files/UNEP%20188_GABC_en%20%28web%29.pdf (Last accessed: 10.04.2020).

UNPRI (2016): Sustainable Real Estate Investment Implementing the Paris Climate Agreement: An Action Framework February 2016. Online: https://www.Unpri.Org/Real-Estate/Sustainable-Real-Estate-Investment-Implementing-The-Paris-Climate-Agreement/138.Article (Last accessed: 29.01.2020).

UNPRI (2016): SUSTAINABLE REAL ESTATE INVESTMENT IMPLEMENTING THE PARIS CLIMATE AGREEMENT: AN ACTION FRAMEWORK. Online: https://www.unpri.org/real-estate/sustainable-real-estate-investment-implementing-the-paris-climate-agreement/138.article (Last accessed: 30.01.2020).

Urban Land Institute (2016): L'Accord de Paris: A Potential Game Changer for the Global Real Estate Industry: Summary for decision makers. Online: http://uli.org/wp-content/uploads/ULI-Documents/21st-Annual-Conference-of-the-Parties-to-the-United-Nations-Framework-Convention-on-Climate-Change-COP-21.pdf (Last accessed: 28.01.2020).

Urban Land Institute (2019): Greenprint Performance Report – Volume 10. Online: https://americas.uli.org/wp-content/uploads/sites/2/ULI-Documents/Greenprint_PerformanceReport_VOL-10.pdf (Last accessed: 28.01.2020).

US Green Building Council (USGBC) (2018): Employee Satisfaction Survey. Online: http://plus.usgbc.org/survey-says-employees-are-happier-healthier-and-more-productive-in-leed-buildings/ (Last accessed 30-01-20).

World Green Building Council (WGBC) (2018): Delivering the Paris Agreement – The Role of the Built Environment. Online: https://www.worldgbc.org/sites/default/files/2050%20Letter%20Final_0.pdf (Last accessed: 30.01.2020).

Weber, R. (2010): Selling City Futures: The Financialisation of Urban Redevelopment Policy. In: Journal of Economic Geography, 86(3), p. 251–274.

Wilkinson, S. J., Remøy, H. & Langston, C. (2014): Sustainable Building Adaptations. In: Oxford, Wiley-Blackwell, World Economic Forum 2016, Environmental Sustainability Principles for the Real Estate Industry.

World Economic Forum Industry Agenda Council on the Future of Real Estate and Urbanisation (2014): Intergovernmental Panel on Climate Change. In: The Fifth Assessment Report, AR5, IRENA, January, IPCC.

World Green Building Council (2017): Global Status Report. Towards a zero-emission, efficient, and resilient buildings and construction sector. Online: https://www.worldgbc.org/sites/default/files/UNEP%20188_GABC_en%20%28web%29.pdf (Last accessed: 09.04.2020).

World Resources Institute (2020): What's changing as countries turn INDCs to NDCs? 5 early insights. Online verfügbar unter: https://www.wri.org/publication/implementing-ndcs (Last accessed: 23.04.2020).

Zancanella, P. (2018): Energy Efficiency, the value of buildings and the payment default risk. JRC Science for Policy Report. Online: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC113215/jrc113215_kjna29471enn_v2_ipo_final.pdf (Last accessed: 24.02.2020).

ZEBRA 2020 (2016) Nearly Zero-Energy Building Strategy 2020: Strategies for A Nearly Zero-Energy Building Market Transition in The European Union. October 2016. Available online at: https://www.zebra2020.eu/website/wp-content/uploads/2014/08/FINAL-ZEBRA2020_Strategies-for-nZEB_06.pdf

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

Zeitler, J. (2018): "H2020 – RentalCal – European rental housing framework for the profitability calculation of energy efficiency retrofitting investments". In: Journal of Property Investment & Finance, Vol. 36, No. 1, p. 125-131. Online: https://doi.org/10.1108/JPIF-12-2017-0089 (Last accessed: 30.01.2020).

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ACRONYMS AND ABBREVIATIONS

ABBREVIATION	MEANING
CCC	Committee on Climate Change
CTI	Carbon Transparency Initiative
CO_2	Carbon dioxide
$CO_2e(q)$	Carrbon 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.
CRREM	Carbon Risk Real Estate Monitor
EEA	European Environment Agency
EF	Emission Factor
EJ	Exajoule
EN	European Norm / European Standard
EPBD	Energy Performance of Buildings Directive
EPC	Energy Performance Certificate
ESD	Effort Sharing Decision
ESG	Environmental, Social and Governance
ETS	Emission Trading System
EU	European Union
EU-ETS	European Union Emission Trading System
ESR	Effort Sharing Regulation
GHG	Greenhouse Gas
GRESB	Global Real Estate Sustainability Benchmark
$GtCO_2e$	Giga tonnes of Carbon dioxide equivalent
HRS	Hierarchical repeated sales
ICG	Integrated Consultation Group
IEA	International Energy Agency
INDCs	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organisation for Standardisation
Kg	Kilogram

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kWh	Kilowatt hour
LULUCF	Land Use, Land-Use Change and Forestry
m^2	Square meter
$MtCO_2$	Metric ton of Carbon dioxide
NDC	Nationally Determined Contributions
NPV	Net Present Value
OECD	Organisation for Economic Cooperation and Development
PA	Policy Advice
PAS	Public Available Specification
RICS	Royal Institution of Chartered Surveyors
RMI	Rocky Mountain Institute
SBT	Science Based Targets
SDA	Sectoral Decarbonisation Approach
SDG	Sustainable Development Goals
TCFD	Task Force on Climate-related Financial Disclosures
ULI	Urban Land Institute
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
USGBC	United States Green Building Council

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