deepki

White paper

Deepki's Sustainability CapEx Index

Retrofitting at Scale: Turning Climate Targets into Actionable Investment Plans

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Real estate is responsible for 36% of global CO$_2$ emissions.

Most trusted sustainability solutions for real estate.

Deepki is the leading and most trusted sustainability solution in real estate. Its SaaS platform helps real estate asset owners manage climate risk through data-driven insights, improve the financial performance of assets and comply with net zero regulations and investor requirements. Deepki combines AI & machine learning capabilities with an expert team of sustainability and real estate consultants, to enable visionary real estate owners and investors to take control of their sustainability and financial performance. It currently supports over 500 customers and monitors over €4 trillion in assets under management (AUM), helping them develop impactful strategies and implement carbon pathways to reach net zero. It facilitates strategic investment decisions through capabilities such as virtual retrofitting to support the environmental transition and protect the value of assets.

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real estate
AUM monitored

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countries where
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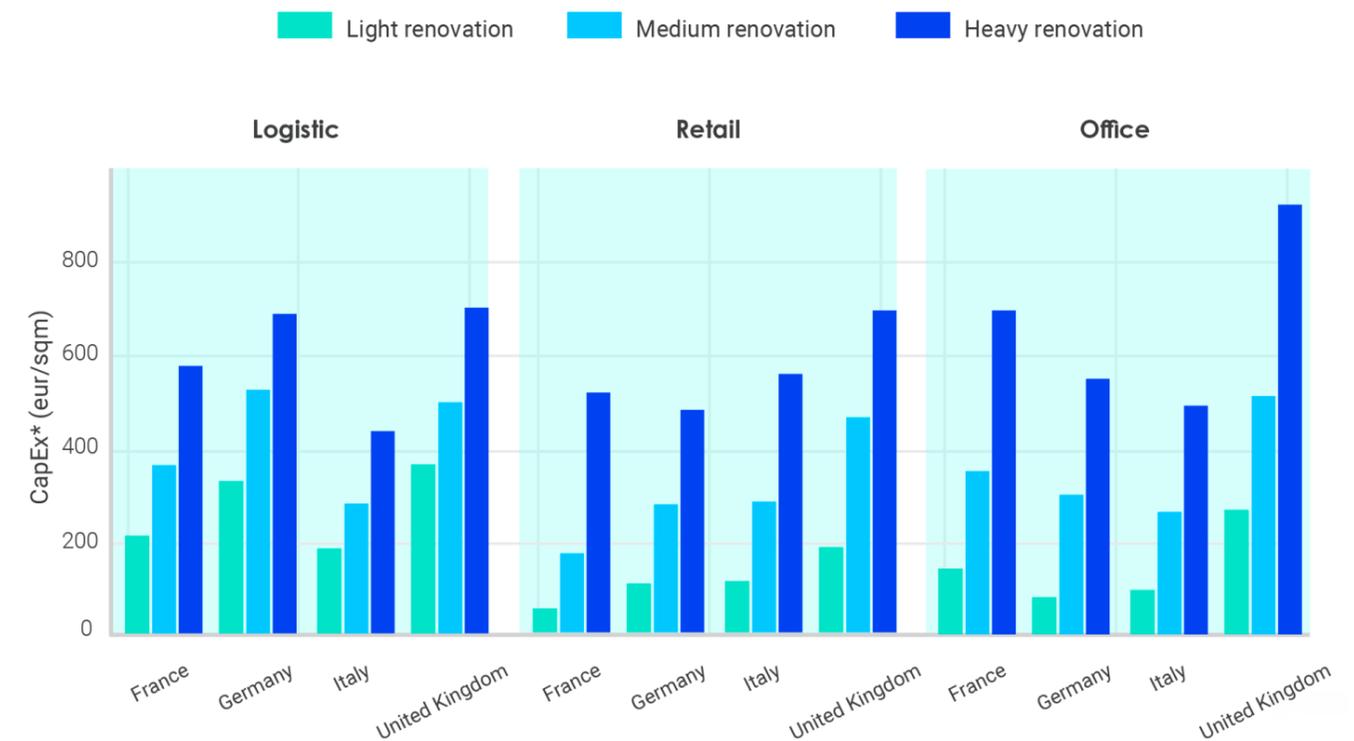
Executive Summary

With over 550,000 buildings in its database, Deepki is positioned as the largest and most trusted actor in sustainable real estate. The depth and breadth of data collected enables us to extract meaning, measure trends, and perform reliable benchmarks. This empowers us to help the industry track its progress and evolutions. Built on verified, audit-ready data, the Deepki Index provides real estate stakeholders with a reliable point of reference for energy consumption and CO_2 emissions across Europe and the US.

Building on those foundations, this paper proposes a complementary benchmarking exercise: comparing renovation CapEx requirements to align with decarbonisation targets. Our analysis is based on a representative sample of over 3,000 European buildings with detailed and verified consumption and performance data.

This study details the necessary investment to align an asset with the CRREM carbon pathway. This analysis was made possible by our latest advances in automated investment plan generation, highlighting Deepki's capability to create scalable action plans for portfolio-sized building samples.

We first outline the general methodology and scope of the study, followed by a comparison of renovation CapEx per square meter, concluding with a deep dive putting investment CapEx to asset value in the UK and in France.

Costs per sqm to comply with CRREM 1.5°C carbon pathway by 2050

Legend: Light renovation, Medium renovation, Heavy renovation

Y-axis: CapEx* (eur/sqm)

Groups: Logistic, Retail, Office — each with France, Germany, Italy, United Kingdom

*Total cost excludes OPEX, consultant/architect fees and taxes, and collateral costs.

Introduction

From Sustainability to Asset Value: Lessons from Deepki's Past Studies

Deepki previously published two in-depth studies on the relationship between sustainability performance and asset value: one focused on Parisian offices (2022), another on UK offices (2024). These sought to demonstrate the combination of Transitioning (cost of CapEx plan) and Opportunity costs (rent loss during the renovation period) as a percentage of asset value for several building typologies.

Building on these insights, Deepki is now leveraging its AI-powered Virtual Retrofit features to scale this analysis. The result is the first **Deepki Sustainability CapEx Index.**

Scaling Sustainability: AI-Powered CapEx Planning for 3,000+ Assets

In this new edition, Deepki is using its AI-powered CapEx features to generate investment plans, for an asset sample of over 3,000 assets, in order to align with the CRREM 1.5°C carbon pathway.

The model output will estimate the average cost in €/square meter (€/sqm) needed to align with the CRREM pathway.

Deepki aims at updating this average cost per country and asset typology on an annual basis.

This paper will also present these costs as a percentage of the asset value for offices and dry warehouses in France and offices UK.

WHITE PAPER

For a deeper dive into how sustainability investments impact financial performance, explore our Sustainable Finance paper to see how action planning, reporting, and innovative capital strategies unlock value in real estate.

↓ **Access the paper**

Index **Methodology**

I. A Representative Sample

In this first version of the Index, Deepki focused its analysis on three key typologies within four major European countries: France, the United Kingdom, Germany, and Italy.

The first typologies analysed are:

- Office
- Logistic (i.e dry warehouses)
- Retail (i.e non-food stores)

From Deepki's database of over 550,000 buildings, more than 3,000 assets were selected. This process involved applying advanced quality controls to ensure a representative, high-quality, and anonymised sample. All selected assets are drawn from the Deepki Index, guaranteeing strong data coverage, audit-ready quality, and reliable energy data, including both heating and cooling consumption, collected from client buildings.

This significant sample size is large enough to prevent any single building from disproportionately skewing the results, thereby supporting a robust and reliable index.

Put Energy and Carbon Performance into Context

What is the Deepki Index?

Now in its fourth year, the Deepki Index provides real, market-based benchmarks for energy use and carbon emissions in commercial real estate in Europe and in the US. It highlights the average, top 30%, and top 15% of performance across building typologies, helping the industry measure progress and align with frameworks such as the European Taxonomy, or compare against resources like CBECS.

Developed with leading industry bodies, the index is built on verified, audit-ready data rather than estimates, giving real estate stakeholders a reliable point of reference.

Its purpose is to bring clarity and comparability to a fragmented market, while supporting the transition toward lower-carbon real estate. We continue to expand the index with new partners, and welcome organizations that want to contribute data and expertise.

Visit our FAQ for more information.

II. Decarbonisation Reference Pathways

In order to assess an asset's ability to align over time with evolving regulations on environmental performance, Deepki chose the Carbon Risk Real Estate Monitor (CRREM) 1.5°C carbon pathway as a reference model. CRREM is an EU non-profit foundation providing different science-based decarbonisation scenarios for real estate assets, based on their emissions and energy intensities. The chosen carbon pathway is based on the Intergovernmental Panel for Climate Change (IPCC) projections and specifies how the CO2 emission of real estate assets must evolve to limit global warming to 1.5°C.

Consumption data for the assets is anchored to the reference year 2024, which serves as a proxy for 2025 consumption and establishes a consistent starting point for all calculations. The target year for the CRREM pathway is set to 2050. Finally, we take the same climate data (typical temperature time series) for a given asset for 2025 and 2050 and consider the occupation rate to be constant over time.

III. Forecast 2050 Energy Mix

To forecast carbon emissions of the energy mix, we relied on the CRREM data. In order to keep consistency and to ensure higher comparability of CapEx costs, we didn't apply the decarbonisation rate of the grid country by country. We used the median decarbonisation rate at the European level, based on CRREM scenarios and we applied this rate to our projections.

IV. Deepki AI-powered Virtual Retrofit Generation

Deepki's AI plan generator is based on a module developed in house. It relies on digital twins of assets built from their geometry, shell characteristics, fluids, systems, operations and weather data. It couples thermal simulation with a cost model including material, labour costs, and contractor margins based on RSMeans, Batiprix, Arcadis and audits to assess the impact of 70+ actions from our retrofit catalog on the building.

The use of thermal simulation is key in that it allows to account for interactions between retrofit measures (e.g: insulating a building decreases its heating needs and allows for the downsizing of a subsequent heat pump installation), yielding more accurate costs and savings than methods assuming actions are independent from one another.

Deepki's AI progressively builds optimised action plans by evaluating compatible measures based on their savings-to-cost ratio. At each step, the actions with the best savings-to-cost ratios are added to generate alternative scenarios, forming a tree of potential retrofit plans. The process continues until the savings target is reached or no further actions apply. After computing the costs and savings of all the plans in the tree, the one reaching the target at lowest cost (or the one with lowest retrofit consumption if no plan reaches the target) is chosen. The final plan is

Deepki's Latest Product Release Webinar: What's New in Deepki February 2026
WEBINAR ON DEMAND

Strategy is only as good as the data behind it. Stop manually chasing outliers and start driving performance with Deepki's newest capabilities.

▶ **Watch the replay**

Deepki's cost model includes material, labour costs, and contractor margins. However, it excludes OPEX, consultant/architect fees and taxes, and collateral costs such as agency costs and those arising from implementation difficulties or additional architectural, technical, or aesthetic work.

Deepki is then able to automatically generate customised action plans for each asset in the sample with an estimated cost per sqm to align with the CRREM Carbon pathway, or get as close as possible to reaching it, and combines the results to define an average cost per sqm for each cluster of the analysis.

Let's note that given the study covers a 25 year time frame, the action plan cost isn't to be considered as being strictly additional CapEx on top of usual life-cycle expenditures. For instance, the average life expectancy of a gas boiler is around 20 years, so a plan

suggesting to replace it with a heat pump in the next 25 years is accounting for an expense that should have happened regardless of sustainability considerations.

The Deepki digital twin model has been audited by the Consulting and Engineering firm Pouget Consultants in September 2025. Pouget Consultants certified that the model is based on a structured and rigorous methodology, combining documented technical assumptions, up-to-date reference data and cross-validation with real-life cases. The model matched the reference savings within a 25% error margin on the scenarios provided in the Pouget audits.
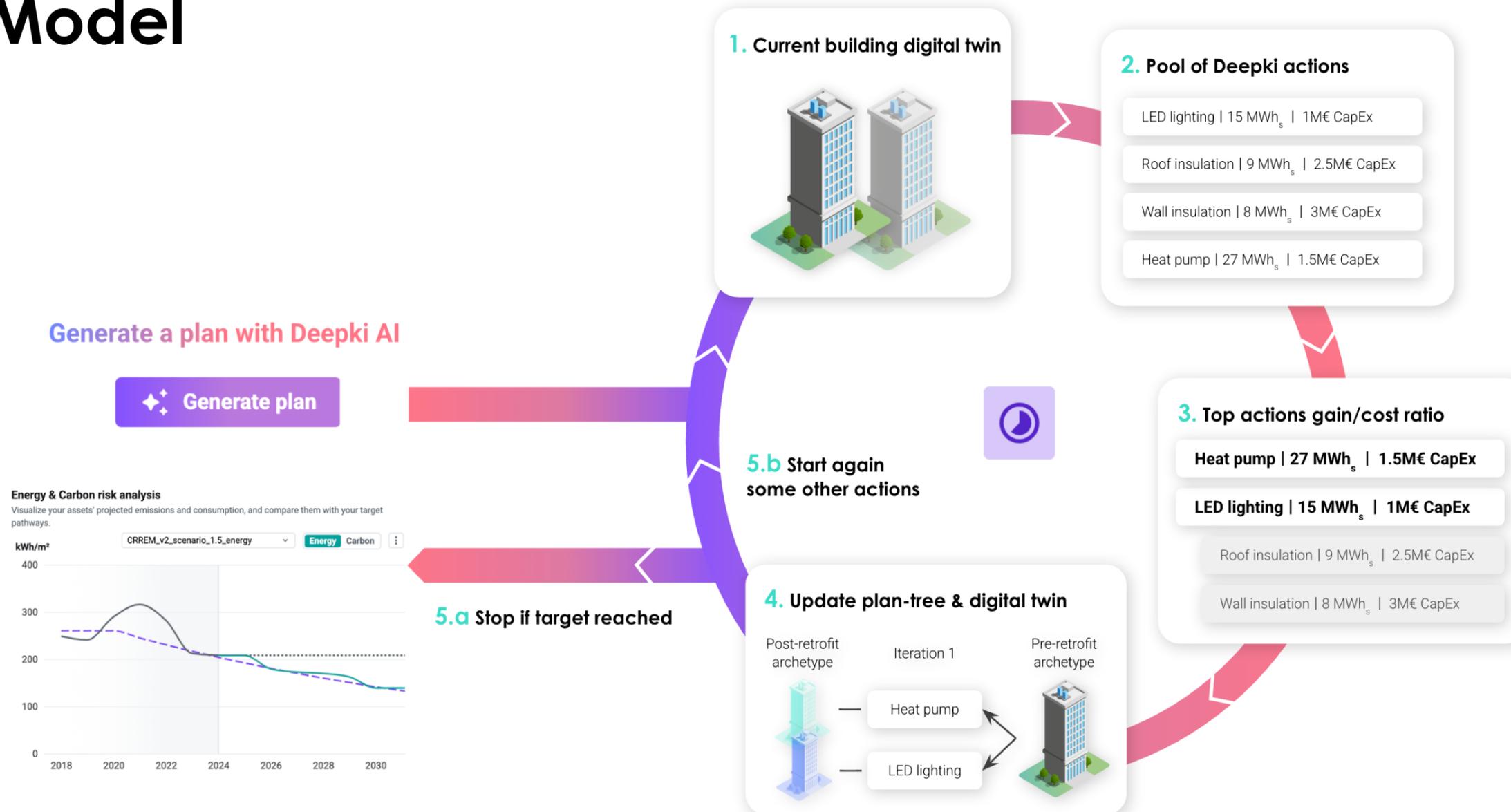
In addition, it passes 93% of ASHRAE's BESTEST-EX benchmarks, which is enough to be compliant. This test procedure ensures that the automatic inferring of parameters and calibration methodology can be trusted: the digital twin's output energy savings will be close to those estimated by other reference softwares such as EnergyPlus.

Deepki's Digital Twin Model

1. Current building digital twin

2. Pool of Deepki actions

LED lighting | 15 MWh_s | 1M€ CapEx

Roof insulation | 9 MWh_s | 2.5M€ CapEx

Wall insulation | 8 MWh_s | 3M€ CapEx

Heat pump | 27 MWh_s | 1.5M€ CapEx

3. Top actions gain/cost ratio

Heat pump | 27 MWh_s | 1.5M€ CapEx

LED lighting | 15 MWh_s | 1M€ CapEx

Roof insulation | 9 MWh_s | 2.5M€ CapEx

Wall insulation | 8 MWh_s | 3M€ CapEx

4. Update plan-tree & digital twin

Post-retrofit archetype | Iteration 1 | Pre-retrofit archetype

Heat pump

LED lighting

5.b Start again some other actions

5.a Stop if target reached

Generate a plan with Deepki AI

Generate plan

Energy & Carbon risk analysis

Visualize your assets' projected emissions and consumption, and compare them with your target pathways.

kWh/m²

CRREM_v2_scenario_1.5_energy   Energy Carbon

400

300

200

100

0

2018 2020 2022 2024 2026 2028 2030

9

V. Types of Retrofit Actions

Reducing a building's energy intensity requires focused action, achieved by implementing a combination of measures that effectively address all sources of inefficiency. Our energy management and R&D teams have carefully developed these measures from hundreds of client audits and specialized cost and energy savings databases, resulting in the reliable and constantly evolving Deepki catalog.

These actions form the essential foundation of the automatically generated investment plans and are strictly categorized into the five following types. We also present the average share of each cost type in the generated CapEx plans:

A. Shell renovations (representing 35% of total CapEx within an investment plan on average):
include all insulation works, such as wall, basement or ceiling insulation, as well as window replacements. These measures reduce the thermosensitivity of the building.

B. Equipment works (49% of total CapEx):
account for heating and cooling system replacements, ventilation upgrades, installation of building management systems (BMS), or relamping. Upgrading equipment improves the energy efficiency of the building.

C. Controlling (approx 0% of total CapEx):
once a BMS is installed in a building, its settings can be adjusted to optimize temperature setpoints or the lighting settings for instance. These measures are mostly considered free when compared to the surface area of a building.

D. Engagement (1% of total CapEx):
by educating tenants on energy sobriety behaviors, the building's energy intensity can be further reduced.

E. Energy mix (15% of total CapEx):
the CRREM CO2 target being very ambitious, one of the ways to further reduce the carbon emissions of a refurbished building is to install solar panels on the roof. This proves especially effective in logistic typologies with

Spill-over cost for misaligned assets after investment plan

In certain instances, even after implementing all typical refurbishment actions available within Deepki, the building's energy intensity may still not meet the CRREM target. We define the remaining energy intensity gap—the difference between the post-retrofit energy intensity and the target—as the spill-over, measured in kgCO2eq/sqm/year.

Positive spill-overs typically occur for buildings with a very high baseline energy consumption. This often includes significant consumption for non-thermosensitive uses (such as process-related energy). These uses may not yet be fully addressed by our current action catalog, and may require specific optimisation.

To calculate the financial impact of this unaddressed gap, the spill-over is multiplied by the average cost to reduce the emissions by 1 kgCO2eq/sqm/year. This average cost is determined for each building typology and heating energy source, based on assets whose investment plans successfully achieved the CRREM target, and is then adjusted by a country-specific ratio.

Using this method, for example, the cost to reduce the emissions of an office building in Germany heated with gas by 1 kgCO2eq/sqm/year is estimated at 25€. Consequently, a building in the same category with a spill-over of 10 kgCO2eq/sqm/year would incur an estimated cost of 250€/sqm for unaddressed actions.

Example: below is an automatically generated investment plan for an office building in the UK, bringing its CO2 emissions under the CRREM target of 560g/sqm/year for a total cost of 817€/sqm:

- **Energy source** - Photovoltaic production installation

- **Insulation** - Insulate the basement ceiling (cellar or parking space)

- **Insulation** - Reinforce the insulation from the outside (classic walls) - plaster finish

- **Windows & doors** - Replace doors/windows with higher efficiency doors/windows

- **Ventilation** - Replace old extractor fans with higher efficiency fans

- **Heating and cooling systems** - Replace the fan coil units with efficient units, including a thermostat

- **Heating and cooling systems** - Insulation of hot and cold hydraulic networks in unheated rooms

- **Heating and cooling systems** - Replace central heating system with an air-water heat pump
- **Lighting** - LED Relamping (internal and external lights)

- **Controls** - Install or replace the BMS (Building Management System)

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Results of the Study

I. Global output

The buildings from the sample were split across three spending categories depending on the total cost of the CapEx plan required to align with the CRREM pathway.

Light renovation

- Buildings with CapEx plan among the cheapest 30%

- It corresponds to buildings with good initial energy performance in need of light renovation: mainly equipment replacements and engagement actions

Medium renovation

- Buildings with CapEx between the lowest 30% and highest 30%

- It corresponds to buildings in need of medium renovation: equipment replacements and some shell refurbishments

Heavy renovation

- Buildings with CapEx among the highest 30%

- It corresponds to buildings with bad initial energy performance and in need of heavy renovation: require equipment replacements and extensive shell refurbishment (insulation, windows)

Costs per sqm to comply with CRREM 1.5°C carbon pathway by 2050
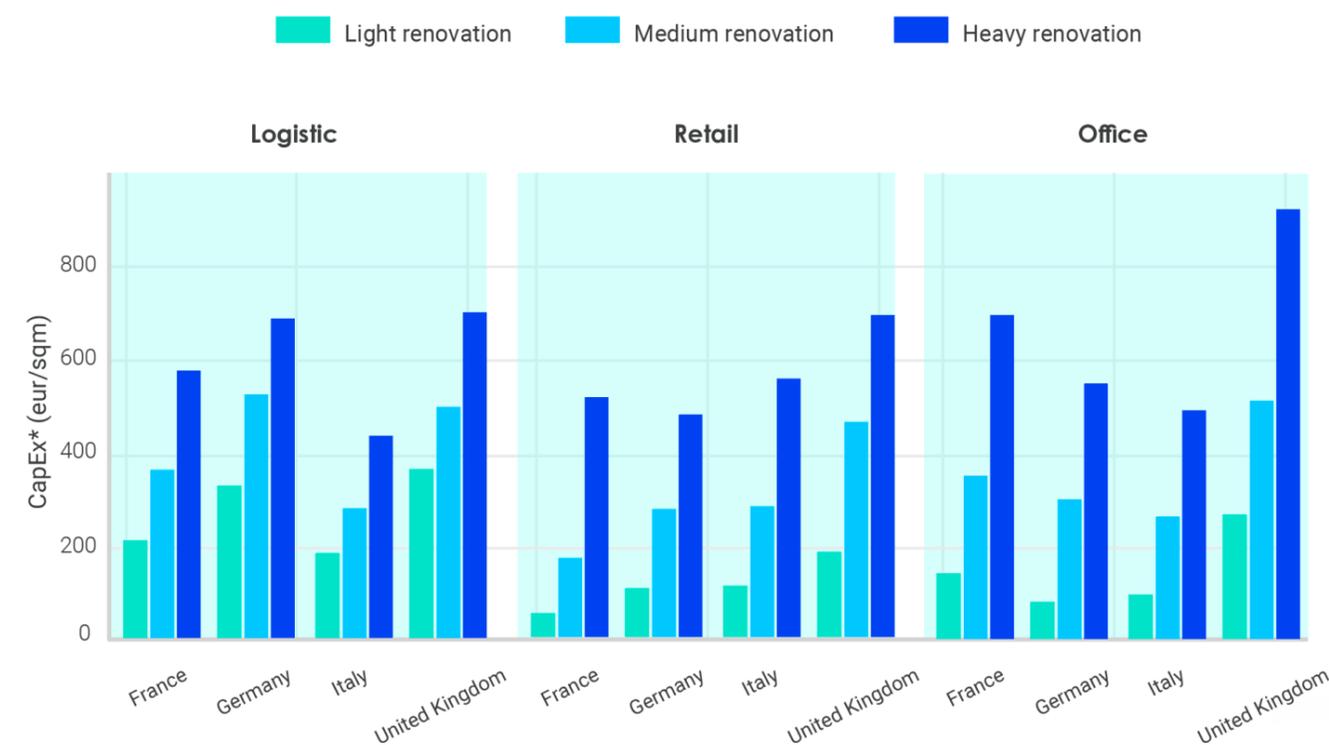
*Total cost excludes OPEX, consultant/architect fees and taxes, and collateral costs.

II. Insights to Understand the Results

To help better understand that graph, we also showcase the corresponding final energy mixes (to the right), and provide some elements of interpretation.
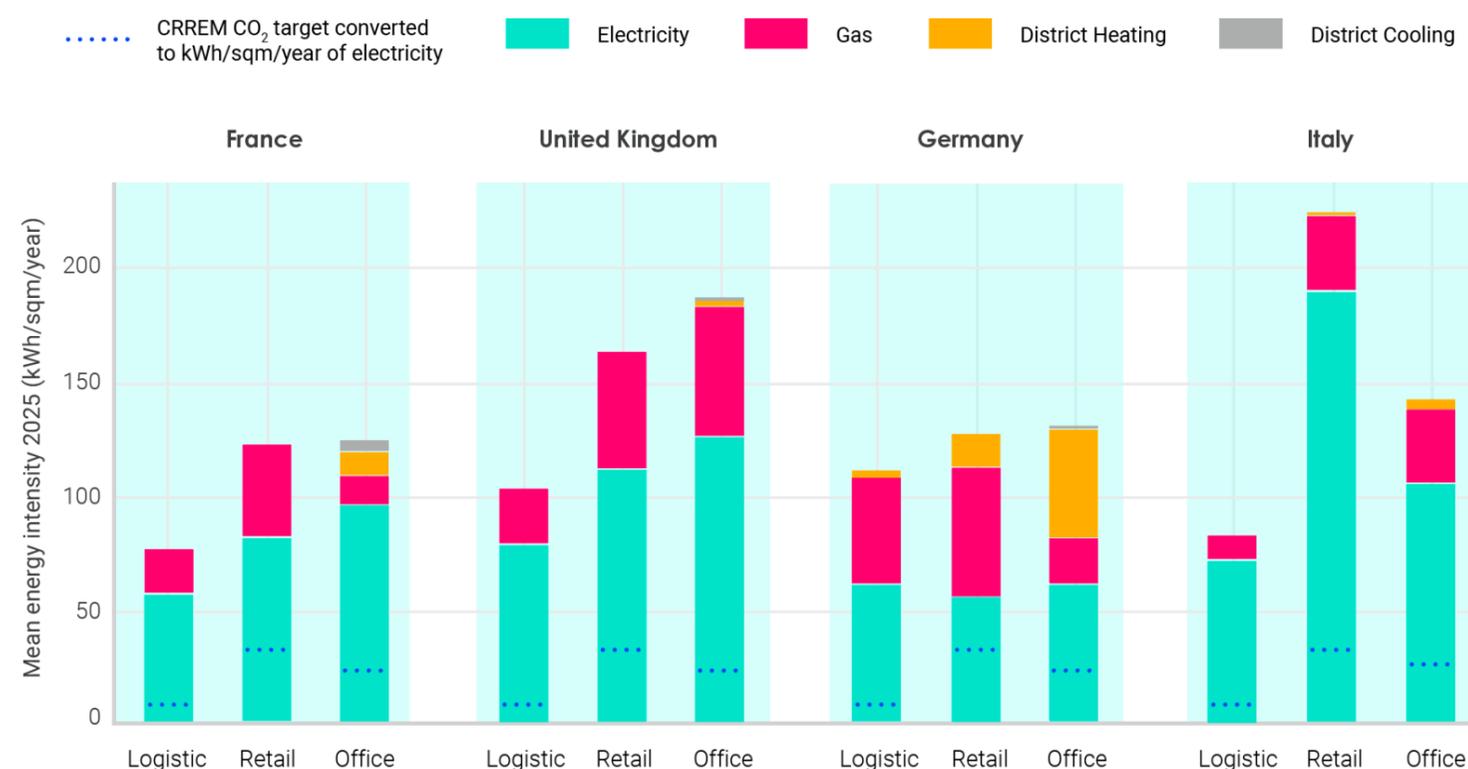
Consumption baseline and CRREM targets:

Higher CapEx requirements are associated with higher baseline consumption levels relative to the 2050 decarbonization target. For example, despite comparable overall consumption, the projected renovation CapEx is lower for French retails than for offices, which is attributed to the relatively stricter CRREM target for offices.

Fluid consumptions vary in their potential for reduction, with some representing significant wells of emission savings. Across our sample, we found that heat pumps, in particular, can lead to substantial emission savings (4.5 kgCO2eq/sqm) in buildings currently using gas or district heating. This finding helps explain why German offices, which have less than half of their total consumption attributed to electricity, display lower CapEx than French offices, despite having very similar baseline energy consumptions.

Sustainability in real estate now drives portfolio resilience, financial performance, and access to capital, not just compliance.

Baseline energy mixes of the building sample in 2025

Legend: CRREM CO_2 target converted to kWh/sqm/year of electricity · Electricity · Gas · District Heating · District Cooling

Understanding the effects of the model on costs, savings and savings-to-cost ratio

The CapEx model incorporates country-specific pricing, meaning the capital expenditure for identical energy-saving measures will differ depending on the building's location (e.g., Italy versus the UK).

The savings counterpart of the previous point is that the same renovation measure may yield different savings on different buildings. Insulating an asset built in 2020 will result in lower energy gains than insulating a building from the 1950's.

The first emission savings are more cost-effective than subsequent ones. This is because the measures with the most favorable savings-to-cost ratio are prioritized. For instance, heat pump actions offer savings around 4 kgCO2eq/sqm/m2 and savings-to-cost ratio up to 0.75 kgCO2eq/€ as they often are installed to replace

gas with less emitting electricity, while shell refurbishment actions yield savings under 1.2 kgCO2eq/sqm despite having costs over 80€/sqm on average. This explains why buildings with a light renovation burden have investment plans mostly comprised of equipment actions, whereas heavy burden plans require measures with increasingly low marginal savings to reach the target feature more shell actions.

To illustrate the two previous points, we note that the action of insulating from the outside is present in 22% of "light renovation" plans, 77% of "medium renovation" plans and 88% of "heavy renovation" plans. Among the 12% of heavy renovation plans where this insulation measure is not suggested by the plan generator, the majority corresponds to assets built after 2010 with an already performant shell: the action is deemed too expensive relative to its impact to be added to the plan.

Equipment actions with the best emission savings encountered in automated investment plans
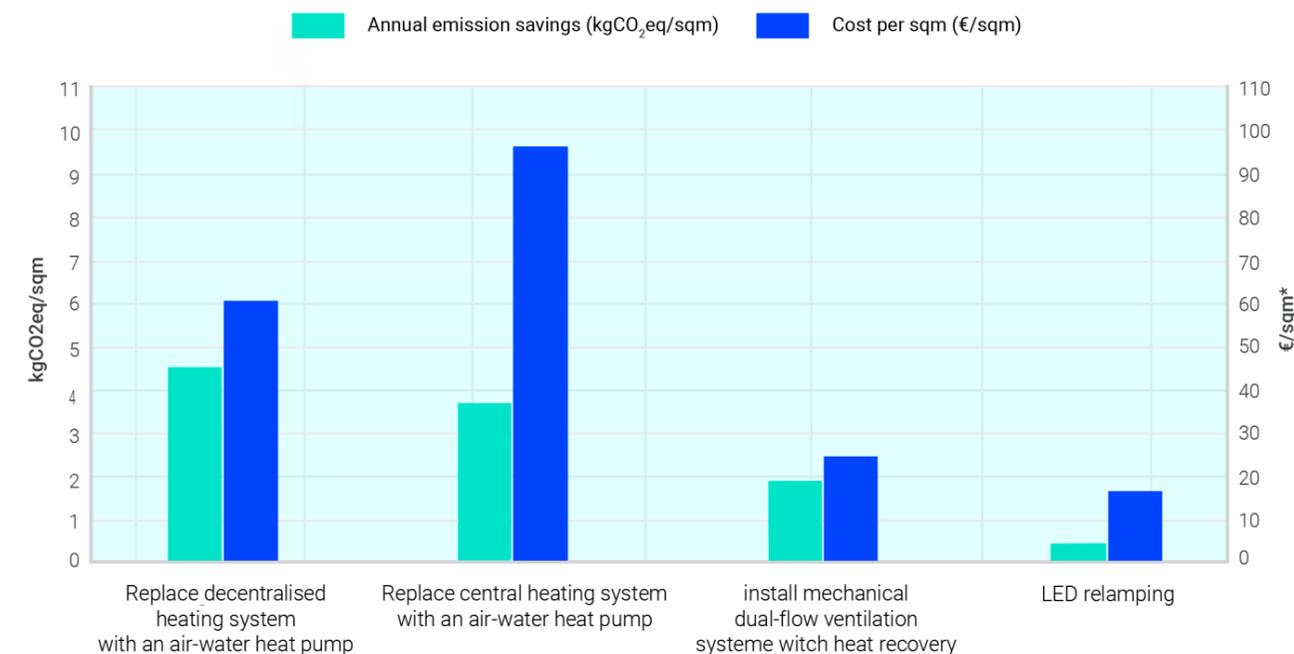
Shell refurbishment actions with the best emission savings encountered in automated investment plans
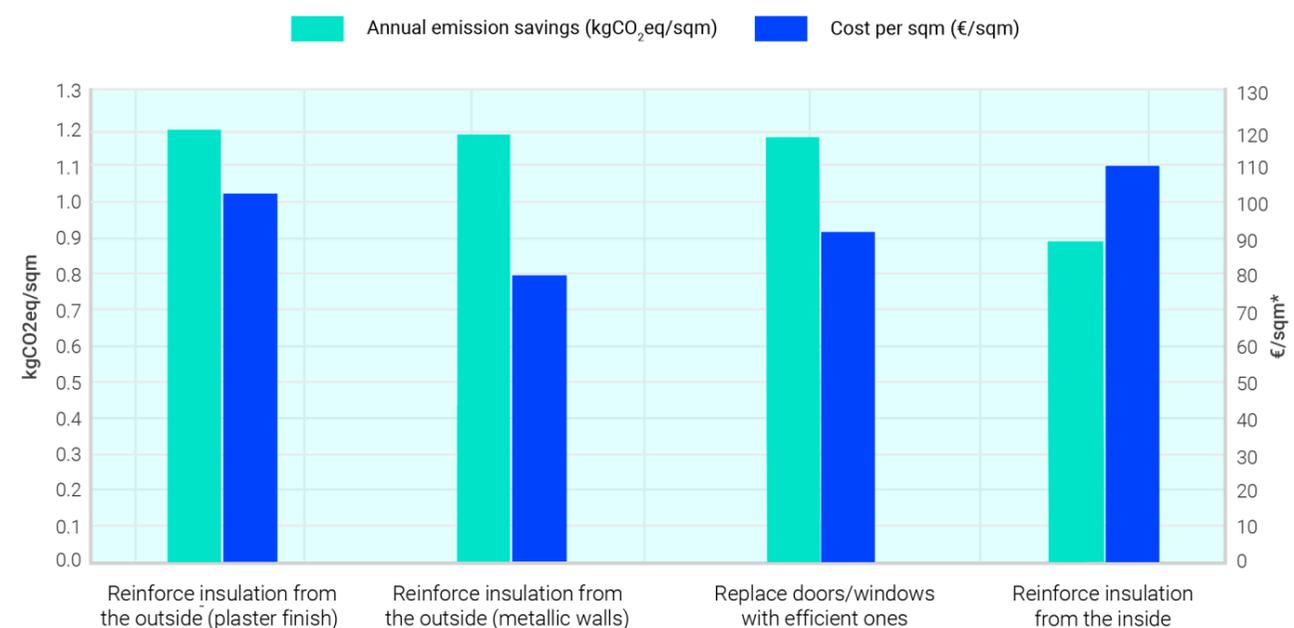
*Total cost excludes OPEX, consultant/architect fees and taxes, and collateral costs.

Use Cases: From CapEx to Asset Value

The relative cost of refurbishment heavily depends on the asset's value. In this section, we discount CapEx and express them as a percentage of asset value to invest yearly to align with the CRREM target by 2050.

Our analysis concentrates on office buildings in France and the UK. To deliver practical insights, and recognizing that asset value is location-dependent, we clustered assets into relevant groups based on geography, market attributes, and data from brokers (such as CBRE, Immostat, and BNP). This section presents CapEx as the annual percentage of the asset's value required to meet the CRREM target by 2050. This approach offers actionable insights into the relative refurbishment cost, which is significantly influenced by asset value.

For example, UK offices were divided into:

- London – City of London
- London – Greater London
- London – West End
- Regional Cities
- Other

For each cluster in France and in the UK, the use case will

showcase the cost of complying with the CRREM pathway in two ways:

1. in euros per square meter as previously, with a detailed cost split.

2. as an annualised cost expressed as a percentage of asset value.

The latter is defined as the annualised discounted CapEx over a 10-year holding period, divided by the asset's value with the following assumptions:

- We assume that the investments are spread uniformly across the holding period. For a CapEx of €2M, this means investing €200,000 per year.
- The inflation rate of renovation costs r is 2% per year.
- The discount rate R is 6%.

With these assumptions, the annualised discounted cost for a building, normalised by its asset **value V is**

$$\frac{1}{10V} \sum_{t=1}^{10} \frac{CapEx}{10} \times \left(\frac{1+r}{1+R} \right)^t$$

I. Deep Dive into French Offices

Deepki partnered with Cushman & Wakefield to estimate average asset values for each office in France. These estimations are based on each asset's location, typology, surface and construction date as recorded in the Deepki database. Leveraging this data, along with Cushman & Wakefield's market expertise and extensive public transaction records, the Cushman & Wakefield team was thus able to estimate for each asset from the sample expected prime and secondary rents, expected prime and secondary yields, as well as stamp duties and transaction costs.

Using those assumptions, the method used to compute assets market value is a capitalisation approach, through which estimated rent is divided by the yield, which represents the return the investor can achieve from a specific asset. While multiple factors can influence real estate valuation, the assumptions used by Cushman & Wakefield are the key variables used when assessing an asset value: the expected return and the amount of income generated by the asset.

Paris CBD stands out with the highest CapEx (460€/sqm on average) which could be attributed to high occupancies and less efficient Haussmannian building fabrics. Taking into account the asset value, the Paris city center boasts the lowest annualised costs, at around 25bp per year, due to the high office metric price. With lower average asset values in La Défense, the annualised investments amount to a larger portion of around 60bp. Finally, when looking at regional cities, the impact of sustainability CapEx in France is around 1.2% per year.

Compelling Outcome:

The relatively modest investment required for CRREM alignment is highly attractive when weighed against the significant advantages it yields. Achieving CRREM compliance directly enhances the asset manager's standing and boosts the asset's appeal to both lenders and prospective purchasers.

CapEx cost to comply with CRREM pathway in France
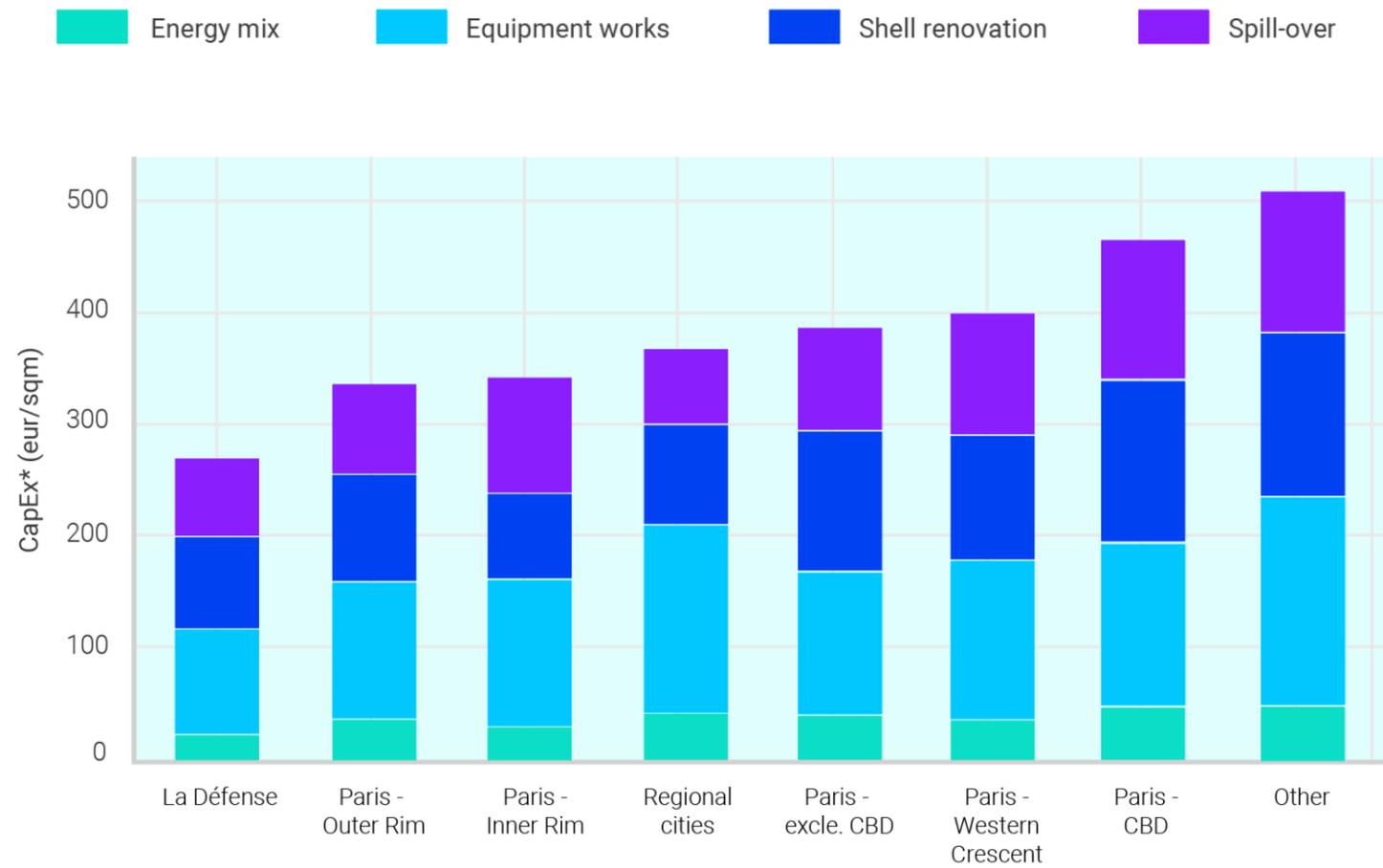
Annualized costs per sqm compared with asset value in France
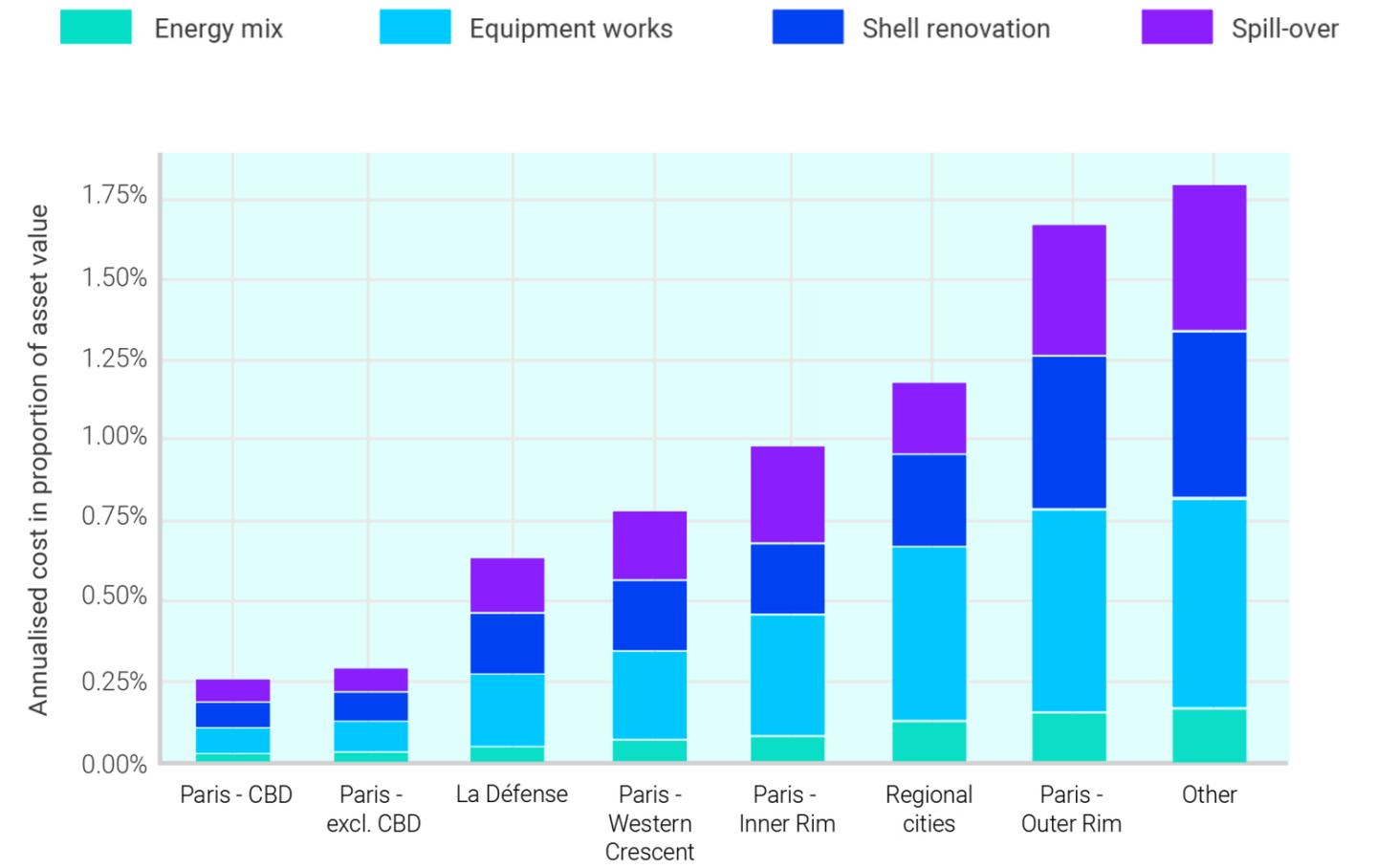
*Total cost excludes OPEX, consultant/architect fees and taxes, and collateral costs.

II. Deep Dive into UK Offices

Asset values for UK offices within each cluster were calculated using an anonymised, representative sample from Deepki's database to ensure confidentiality.

In the UK, the West End and City of London are characterized by the highest renovation CapEx and energy intensities. These high consumption levels are linked to high activity and occupancy rates. However, when asset value is factored in, these Central Business District (CBD) areas demonstrate the lowest annualised costs: approximately 38bp per year for the West End and 80bp per year for the City of London. In contrast, the impact of sustainability CapEx in regional UK cities is around 1.6% per year.

## III. Deep dive into French Logistics

For dry warehouses in France, Deepki partnered with Cushman & Wakefield to estimate the average asset value for each dry warehouse in the country.

The analysis shows that the annualized investment required to align with the CRREM pathway represents between **2.5** and **4.5% of the asset's value.**

CapEx cost to comply with CRREM pathway in the UK
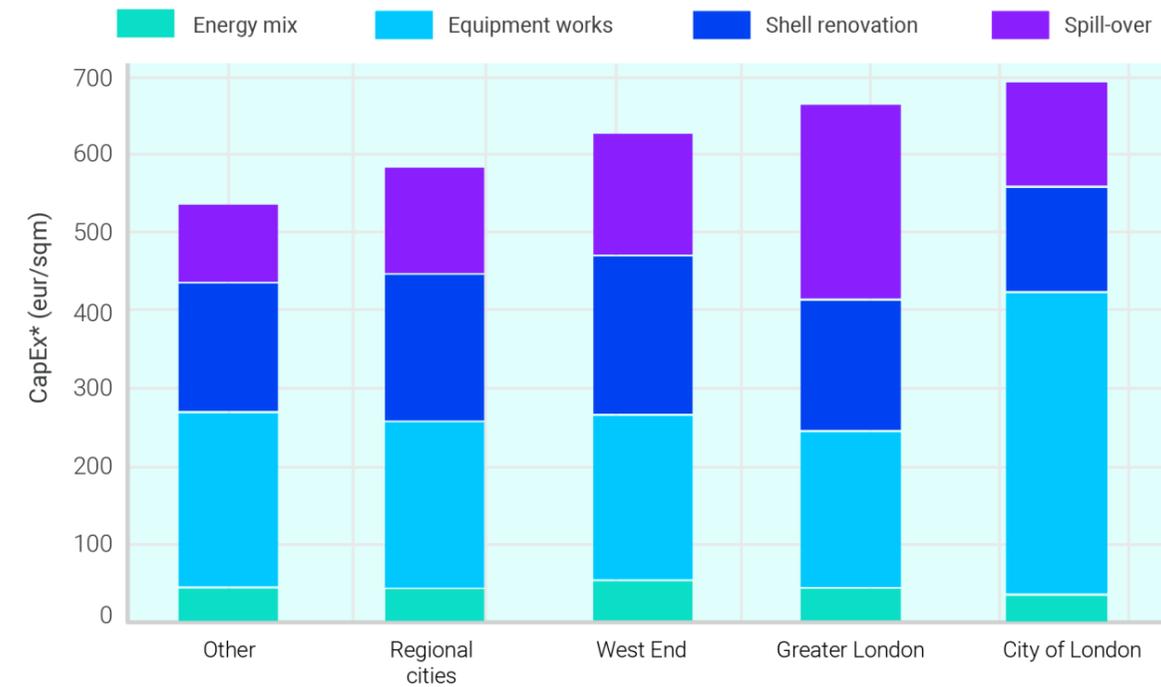
Annualized costs per sqm compared with asset value in the UK
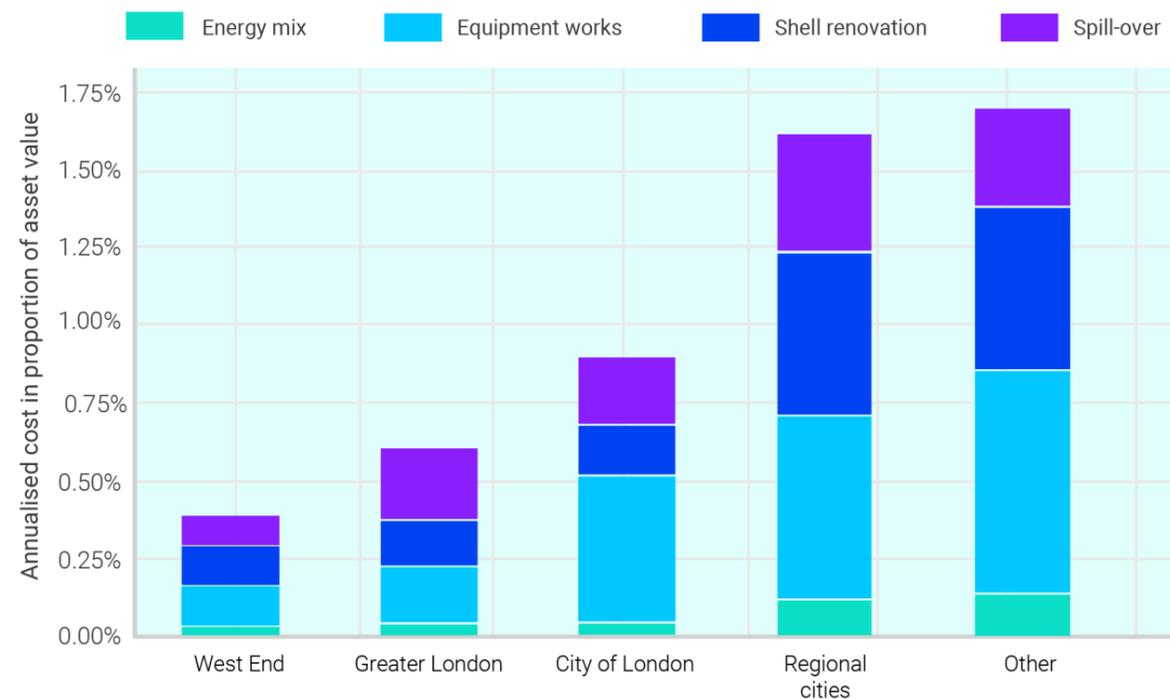
*Total cost excludes OPEX, consultant/architect fees and taxes, and collateral costs.

Acknowledgements

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