THE CARBON CASE FOR UPGRADING EXISTING INDUSTRIAL REAL ESTATE

This paper considers the carbon case for building new UK industrial space and compares it to the refurbishment of existing stock (where refurbishment is economically viable)

AI was not used in the preparation of this paper

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SUMMARY *(5-minute read)*

Buildings account for 40% of global carbon emissions[1]. Of these, up to 70% can be contributed by underlying building materials (and their supply chains) and construction processes[2], so-called ‘embodied carbon’. More than half of UK buildings existing today were built 30+ years ago[3]. Therefore, where viable, decarbonising these assets is critical to achieving wider carbon objectives.

Brand new assets, built to the latest energy efficiency specifications and recognised by one or more sustainability certifications, are rightly attributed with lower ongoing carbon emissions (and with increasing incidence zero/ negative net emissions). **However, our analysis demonstrates that there may be cases where the carbon emitted in creating new industrial stock is never ‘repaid’** (when compared to a viable refurbishment option). We focus on the carbon case to highlight the challenge presented by embodied carbon. Clearly, there are numerous factors that contribute to a refurbish/ demolish-and-rebuild decision, especially performance of an asset in the occupational and capital markets. For the purposes of this paper, we deliberately ignore these other factors – we focus solely on carbon.

We have considered a hypothetical case where there is the ability to substitute a building refurbishment decision with a new construction, and vice versa. And that the carbon emitted in constructing the original warehouse is already ‘sunk’. General understanding (and analysis) of embodied carbon is at an early stage – operational carbon analysis being widespread already. Data on this topic is also in its infancy, albeit improving rapidly. Wherever possible we have cross-referenced multiple sources and used the most optimistic estimates for new build, and the worst-case for refurbishment (see *References and Methodology* section at the end of this paper).

We have not taken into account carbon offsetting as we disagree with the arguments for its inclusion; it being an action entirely independent of the matter being analysed. Finally, we of

SUMMARY *(continues)*

course recognise that each real-world case is different and should be appraised on its own merits. Therefore, we are not attempting to make generalised conclusions.

1 Carbon emissions from new build construction are estimated to be around 350 $kgCO_2/m^2$ [4]. Carbon emissions from generalised refurbishment are estimated to be 110 $kgCO_2/m^2$ [5]. In practical terms, the refurbishment could comprise some or all of the following: retrofitting heat pumps; improving or replacing building fabric/ insulation; and installing LED lighting. For context, the 240 $kgCO_2/m^2$ difference for a building the size of a football pitch is broadly equivalent to 1,300 1.5L petrol cars running for a year with normal use. Intuitively this makes sense when the scale of process and quantity of materials is considered for refurbishment and new construction. Note that the carbon contribution from demolishing and disposing of existing materials is ignored.

2 In its first year of operation, a new building (EPC A+ rating) is assumed to emit -1.77 $kgCO_2/m^2$ [6]. The negative emissions are attributable to the excess clean energy from on-site solar being supplied into the grid. For the same year, a refurbished building is assumed to emit 23.10 $kgCO_2/m^2$ if an EPC B grade is achieved, or 11.85 $kgCO_2/m^2$/year if the benchmark is EPC A[7]. The delta to the new build is 13.62 $kgCO_2/m^2$/year and 24.87 $kgCO_2/m^2$/year, for the refurbished EPC A and EPC B, respectively. With no other variables considered the new build pays back the additional 240 $kgCO_2/m^2$ of construction emissions in 10 to 18 years.

3 This static analysis does not consider the decarbonization of the construction sector. In the future, more efficient processes, use of low-carbon fuels, and reusing materials (amongst other initiatives) should reduce emissions in both the new build and refurbishment scenarios. This, in turn, should reduce the ‘spread’ of 240 $kgCO_2/m^2$ (assuming a broadly similar proportional change), and improves (by shortening) the carbon payback period.

4 Alongside the decarbonization of construction is the decarbonization of the grid. As the grid decarbonizes the operational carbon ‘surplus’ of the refurbished asset reduces, and so to does the annual operational carbon saving of the new build. In other words, both trend to zero; the 13.62 $kgCO_2/m^2$/year to 24.87 $kgCO_2/m^2$/year saving diminishes over time. The National Grid ESO has developed Future Energy Scenarios (FES)[8], which model four decarbonization pathways. In these, electricity generation hits net zero carbon intensity in 2034 at the earliest, and 2048 at the latest. Starting with an initial embodied carbon delta of 240 $kgCO_2/m^2$, the refurbished asset (to an EPC B) may result in 19 $kgCO_2/m^2$ to 96 $kgCO_2/m^2$ fewer emissions over its lifetime, depending on the grid decarbonization scenario modelled. Or said another way, **there may no longer be a carbon emissions payback from the new build (see *Figure 5*).**

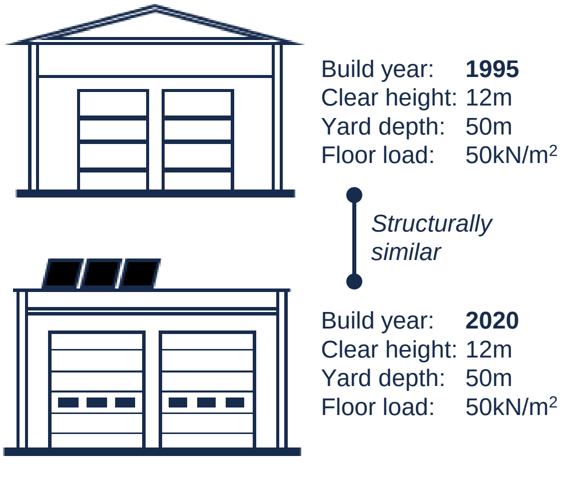
5 Whether the new build pays back the carbon emissions or not depends on the rate of decarbonization of the construction sector versus the rate of decarbonization of the grid. If the carbon intensity of generating electricity reduces faster than the construction industry decarbonizes, which is expected (see *Figure 4*), then it may not be possible for a new build to pay back the surplus carbon emissions.

6 Lastly, we have also considered that a refurbished asset has a permanently higher energy demand (because it is always less efficient than the new build). This means it requires incrementally more energy generation to run (and the associated emissions of creating that infrastructure, i.e., wind farms/ solar, etc.). The refurbished asset is estimated to use 35 to 139%[9] more energy (kWh) than the new build; the incremental annual carbon emissions from adding generation capacity being estimated at 0.01 to 0.60 $kgCO_2$/year[10], depending on whether the generation technology is solar or natural gas. Therefore, although lower efficiency property results in more generation capacity (and this in turn creates more emissions), the magnitude is such that it does not alter the findings above.

INTRODUCTION TO LOGISTICS

The two buildings in *Figure 1* have the same high-level technical specs (clears, yard depth and floor loading capacity). They may or may not have access to the same power supply. Ultimately, although they were constructed 25 years apart, they can be occupied for the same purpose. We also make the argument (that for now at least) we do not foresee any wholesale change in the format of logistics real estate in the UK, at least not one that would render the majority of existing stock obsolete, particularly that located outside of dense urban centres. Therefore, broad refurbishment of industrial property is a relevant analysis.

Figure 1: Illustrative specs comparison



Almost certainly, the energy efficiency of the two will differ. It's likely that the older asset is heated with gas and the modern asset with a heat pump. The modern asset will also have superior insulation and LED lighting. Having been constructed in accordance with the latest regulations, the modern asset uses less energy, and therefore has fewer carbon emissions. A typical EPC D rated property may emit 50 $kgCO_2/m^2/year$[11], whereas an A+ rated one will have negative carbon emissions (assuming it distributes excess energy from on site solar panels back to the grid). These environmental credentials are (correctly) sought after by investors and occupiers, contribute positively to various reporting metrics, and consequently affect demand and capital value.

However, assuming a new build is 'greener' (and therefore superior) solely based on its operational carbon emissions may be misleading. At the margin, this approach could substitute valid refurbishment programs for demolition and new construction, which could result in worse carbon outcomes.

NEW BUILD VS. REFURB

Full lifecycle carbon analysis shows up to 70% of a property's greenhouse gas emissions are attributed to its construction (inclusive of transportation and demolition of building materials[12]). For modern buildings with very low operating emissions, that percentage is necessarily even higher.

In general terms, refurbishing industrial assets often avoids carbon emissions associated with site preparation, sub-structure, frame and floor, and reduces those associated with the roof. By installing some of the following measures, the energy efficiency of the asset can be improved:

- Heating system
- Insulation
- Windows
- Lighting
- Water-saving measures
- EMS

Figure 2: New build vs refurbishment[13]

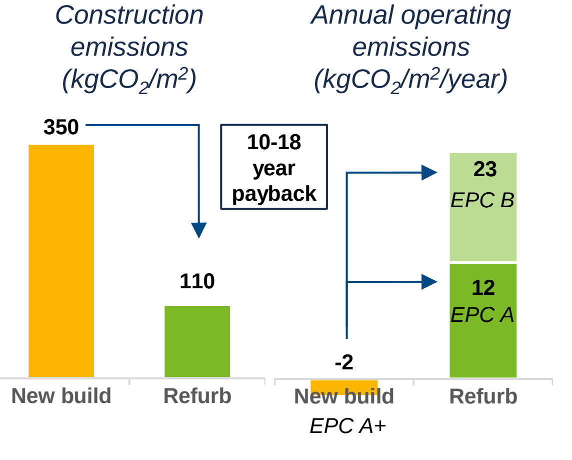


Figure 2 shows estimates for the carbon emissions associated with a new build and those of a retrofit, as well as the operating carbon emissions associated with each asset.

With no other variables taken into account, the new build pays back the additional 240 $kgCO_2/m^2$ of construction emissions in around 10 to 18 years.

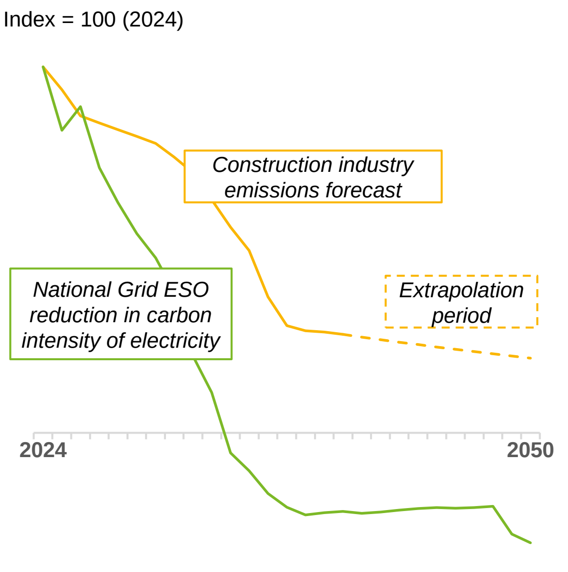
DECARBONIZATION OF CONSTRUCTION

As the construction industry decarbonizes, this offsets the initial excess carbon emissions of the new build (over the refurbishment) – the new build ‘decarbonizes’ faster in nominal terms due to the higher initial value. The faster the sector decarbonizes the shorter is the payback period on the excess carbon.

However, the overall impact on cumulative emissions spent/ saved is driven by the rate of decarbonization of construction relative to the rate of decarbonization of the grid.

Figure 3 shows the forecast rate of decarbonization of construction (Climate Change Committee forecast to 2040[14], with trendline extrapolated to 2050) compared to the National Grid ESO Consumer Transformation grid scenario (one of four scenarios for the grid).

Figure 3: Decarbonization rate of the grid vs construction sector[15]



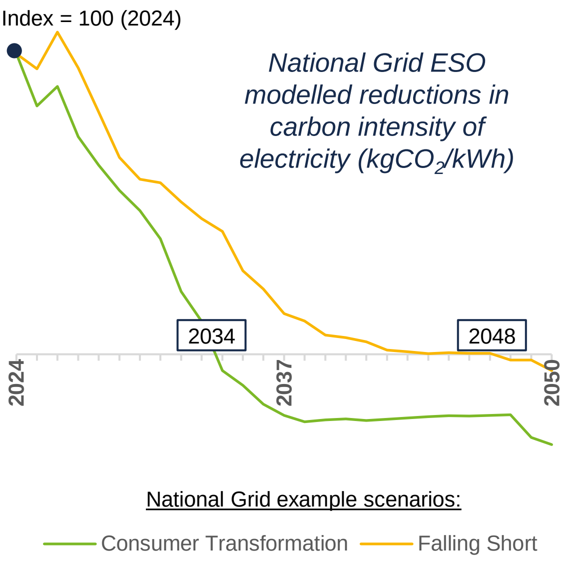
The comparison in *Figure 3* is crucial to the analysis of new build against refurbishment because, as the grid decarbonizes, the ‘spread’ in operational emissions between the new build asset and the refurbished one reduces.

GRID DECARBONIZATION

Considering the emissions saving in a single year doesn’t account for the progressive decarbonization of the grid.

The National Grid ESO has set out four

Figure 4: Grid decarbonization rates[16]

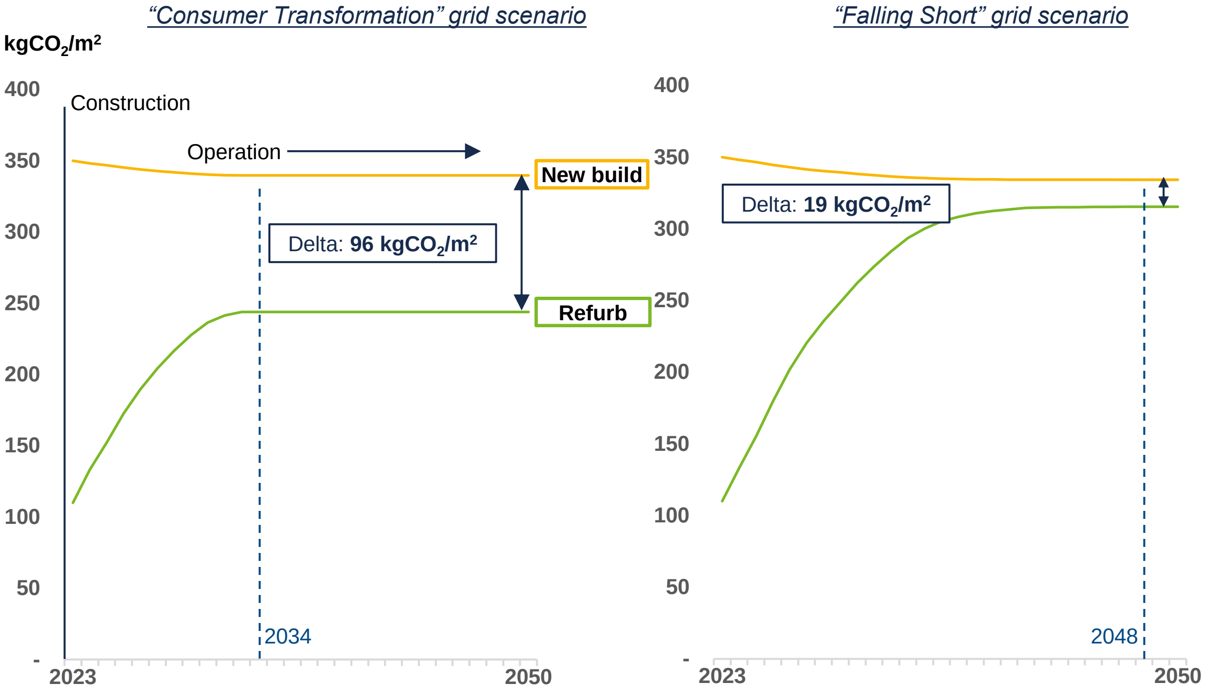


pathways for the future of the UK’s energy system[17]. Different rates of decarbonization are assumed for electricity – hitting zero average annual emissions between 2034 in the earliest scenario and 2048 in the latest (*Figure 4*).

Figure 5 shows our modelling of the cumulative emissions from the new build industrial asset and the refurbished one out to 2050, under the “Consumer Transformation” and “Falling Short” scenarios. <u>All of this analysis relies on the assumption that the refurbished asset is fully electrified.</u> The chart sets out the lower embodied carbon starting point of the refurbished asset and the effect of grid decarbonization on cumulative emissions, i.e., the line trends flat. The negative net operational carbon (or carbon saving) of the new build property diminishes as the grid decarbonizes. *(Note again we have ignored the ‘sunk’ carbon cost of the existing asset, which we think is the correct analysis.)*

We have modelled the refurbished property as achieving an EPC B. **This example demonstrates the possibility that the new build (again assuming it was substituted in place of the refurbished asset) will not ‘pay back’ the surplus carbon emissions generated from its construction** (n.b., the green line and the yellow line do not intersect). The refurbished asset saves between 19 $kgCO_2/m^2$ and 96 $kgCO_2/m^2$, depending on the grid decarbonization scenario used. If the

Figure 5: Cumulative emissions of new build and EPC B refurbished asset with grid decarbonization[18]



refurbished asset achieved an EPC A benchmark, then the lifetime saving of the refurbished asset would increase to between 119 $kgCO_2/m^2$ and 161 $kgCO_2/m^2$.

Furthermore, we have considered that a refurbished asset has a permanently higher energy demand (due to its lower efficiency), which results in additional investment (to create capacity) in the grid. So, a complete carbon analysis should take account of ongoing operating efficiency and the corresponding incremental carbon from the generation infrastructure needed to power the refurbished asset.

OPERATING EFFICIENCY

Based on energy performance data, an EPC B rated property uses 136 $kWh/m^2/year$, whereas an EPC A+ rated one uses 57 $kWh/m^2/year$[19]. I.e., the refurbished asset requires 139% more electricity to operate, or 2.39 kWh of electricity for every 1 kWh the new build uses. A property refurbished to an EPC A rating would use 1.35 kWh for every 1 kWh used by the new build.

The implication of this is that the grid requires an additional 35% to 139% of generation capacity to be constructed to power the refurbished asset. This clearly has a carbon cost. As is widely understood, it means that simply electrifying everything isn't a straightforward pathway to net zero.

Lifecycle carbon assessment data for different energy sources provides a benchmark of 0.0367 $kgCO_2/kWh$ for solar and 0.4340 $kgCO_2/kWh$ for natural gas (without carbon capture and storage)[20]. These figures reflect the carbon emitted over the full life of a solar or gas plant, so they are conservative estimates of the impact of constructing incremental generation capacity, since the carbon emitted during their operation overlaps with the operating period (and carbon assumptions) for our hypothetical assets.

Depending on the energy source and the energy performance assumption, the refurbished asset adds between 0.013 and 0.602 $kgCO_2/m^2/year$ (lower: EPC A and solar; upper: EPC B and gas). Over 100 years, that equates to an incremental 1.3 $kgCO_2/m^2$ to 60.2 $kgCO_2/m^2$. This may or may not cause the green line in *Figure 5* to intersect the yellow one.

This analysis supports the general principle that there needs to be intervention in one form or another in property with poor energy credentials (which is consistent with general policy direction). For example, an EPC D rated property uses 305 kWh/m²/year[21], equivalent to between 16.0 $kgCO_2/m^2$ and 188.8 $kgCO_2/m^2$ over 100 years depending on the grid power source (15%-170% of the total embodied carbon of refurbishment).

OUTLOOK

Demand for UK industrial space is generally expected to increase in the future, principally driven by the growing share of e-commerce and deglobalization trends/ supply chain onshoring.

New, best-in-class space will be required to expand the total stock, and these assets will continue to command the highest rents in part due to their lower occupational costs (of which energy is a meaningful component). **But given the carbon cost of creating new space, each case that capital is deployed into demolition and new construction (that substitutes capital out of refurbishment of existing viable stock), should be carefully considered.** Our expectation is that analysis of the full lifecycle carbon consequences of business plans will become commonplace in future. At the margin, this should mitigate any unintended detrimental consequences of new build decisions taken solely based on operational carbon savings.

REFERENCES AND METHODOLOGY

(1) UNEP report, 9 November 2022 - 2022 Global Status Report for Buildings and Construction. Report accessed April 2025: https://www.unep.org/resources/publication/2022-global-status-report-buildings-and-construction

(2) CRREM report, September 2023 – Embodied Carbon of Retrofits: Ensuring the ecological payback of energetic retrofits. Report accessed June 2024: https://www.crrem.eu/embodied-carbon-of-retrofits/

(3) CoStar article, 25 October 2023 – The UK's Ageing Warehouse Stock: Major Challenge or Untapped Opportunity? Article accessed June 2024: https://www.costar.com/article/468334401/the-uks-ageing-warehouse-stock-major-challenge-or-untapped-opportunity

(4) Sources for the embodied carbon of a new build logistics warehouse:

i. One Click LCA report, 2021 – Embodied Carbon Benchmarks for European Buildings. Reports a median embodied carbon for Western Europe Industrial assets of **390 $kgCO_2/m^2$** and a mean of **550 $kgCO_2/m^2$** (pg. 13) Report accessed June 2024: https://oneclicklca.com/resources/research-embodied-carbon-benchmark-european-buildings

ii. See (2). Reports a new commercial real estate building has an embodied carbon of **600-750 $kgCO_2/m^2$** (pg. 3).

iii. London Energy Transformation Initiative, 2020 – LETI Climate Emergency Design Guide: How new buildings can meet UK climate change targets. Sets a 2020 best practice embodied carbon for non-domestic real estate of **<600 $kgCO2/m^2$** (pg. 54). Report accessed June 2024: https://www.leti.uk/cedg

iv. CPW report, March 2024 – Embodied Carbon Assessment for a Block Industrial asset. Reports an embodied carbon figure of **350 $kgCO_2/m^2$** for a new build industrial building.

In order to be conservative, we have used the lowest figure in the above range, i.e. **350 $kgCO_2/m^2$**.

(5) Sources for the embodied carbon associated with refurbishing an existing logistics warehouse:

i. One Click LCA report, 2021 – Embodied Carbon Benchmarks for European Buildings. Reports a figure of 87% for the embodied carbon of an industrial building associated with the concrete, steel and gypsum, cement and mortar (pg. 19), which all relate to the structure and frame and would not be replaced in a refurbishment. Using their new build figures from source 2.i. gives a range for the refurbishment of **51 $kgCO_2/m^2$** (using median) and **72 $kgCO_2/m^2$** (using mean). Report accessed June 2024: https://oneclicklca.com/resources/research-embodied-carbon-benchmark-european-buildings

ii. See (2). Presents a case study for a retrofit of a logistics warehouse with an associated embodied carbon of **43 $kgCO_2/m^2$** (pg. 40).

iii. CPW report, March 2024 – Embodied Carbon Assessment for a Block Industrial asset. Reports a figure of 68% for the embodied carbon associated with the structure. This would equate to an embodied carbon estimate of **110 $kgCO_2/m^2$** for a refurbishment, based on the new build embodied carbon from source 2.iv..

iv. AECOM article, June 2020 - The carbon and business case for choosing refurbishment over new build. Reports a figure of 72% for the embodied carbon associated with the structure. This would equate to an embodied carbon estimate of **98 $kgCO_2/m^2$** for a refurbishment, based on the new build embodied carbon from source 2.iv.. Report accessed June 2024: https://aecom.com/without-limits/article/refurbishment-vs-new-build-the-carbon-and-business-case/

BLOCK INDUSTRIAL
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In order to be conservative, we have used the highest figure in the above range, i.e. **110 $kgCO_2/m^2$**.

(6) For the operating emissions of the new building we have analysed EPC's for buildings within the "B8 Storage or Distribution" use category, filtered with:

- Property floor area >700m^2;
- Certificates issued after June 2018 (SAP 10.0 was adopted on 24 July 2018, therefore this filter improves comparability); and
- Main heating fuel as grid supplied electricity, as an electric method of heating is assumed to be part of the new building, and is required in order to decarbonize.

We assume the new building would achieve an A+ EPC rating. The median operating emissions from this category within the above dataset are **-1.77 $kgCO_2/m^2$/year**.

The EPC database was accessed at https://epc.opendatacommunities.org/.

(7) For the operating emissions of the new building we have analysed EPC's for buildings within the "B8 Storage or Distribution" use category, filtered with:

- Property floor area >700m^2;
- Certificates issued after June 2018 (SAP 10.0 was adopted on 24 July 2018 , therefore this filter improves comparability); and
- Main heating fuel as grid supplied electricity, as an electric method of heating is assumed to be part of the refurbishment, and is required in order to decarbonize.

We can use a range from an EPC B to an EPC A rating to estimate the operating emissions post refurbishment. Using median values results in a range of **11.85-23.10 $kgCO_2/m^2$/year**.

The EPC database was accessed at https://epc.opendatacommunities.org/.

(8) National Grid ESO: Future Energy Scenarios, July 2023. Presents four scenarios for the decarbonization of the UK's energy system, which includes a forecast of power generation emissions under each scenario to 2050 (pg. 43). Accessed June 2024: https://www.nationalgrideso.com/future-energy/future-energy-scenarios-fes

(9) Using the same database as sources 4 and 5, the new building (EPC A+ rating) has an electrical consumption of 57 kWh/ m^2/year and a refurbished building (EPC B or A rating) has an electrical consumption of 77-136 kWh/ m^2/year.

(10) United Nations Economic Commission for Europe, 2020 - Carbon Neutrality in the UNECE Region: Integrated Life-cycle Assessment of Electricity Sources. Reports life cycle carbon dioxide emissions for various generation technologies per kWh. To generate a range, we take figures reported for natural gas (without CCS) and PV, which are 0.430 kg/kWh and 0.037 kg/kWh respectively.

(11) Same data source as (6) and (7).

(12) See (2) (Pg. 1.).

(13) *Figure 2* combines the data from sources (4), (5), (6) and (7).

(14) Climate Change Committee, June 2023 – Progress in reducing emissions: 2023 Report to Parliament. Includes a forecast of industry (note: in previous publications called 'manufacturing and construction') process emissions to 2040 (data indicator IN3). Report accessed June 2024: https://www.theccc.org.uk/publication/2023-progress-report-to-parliament/

(15) *Figure 3* combines the construction sector forecast from source (14) with the National Grid's System Transformation scenario (source (8)) for the carbon intensity of electricity generation.

(16) *Figure 4* presents scenarios from source (8).

(17) See source (8).

(18) *Figure 5* combines the data from sources (4), (5), (6), (7) and (8).

(19) See source (9).

(20) See source (10).

(21) Same data source as (6) and (7).