AIMCH

TRANSFORMING HOW WE BUILD HOMES

Work package 11:

Whole Life Carbon Assessment

January 2022

mtc Manufacturing Technology Centre · L&Q · Construction Scotland Innovation Centre · Forster Group · Stewart Milne Group · Barratt Developments PLC Building Excellence Since 1958 · Industrial Strategy · UK Research and Innovation

CONTENTS

EXECUTIVE SUMMARY

Operational energy emissions (the in-use stage) during the 60-year modelling period are the largest contributor to the whole life carbon footprint of the homes, as expected. These do not differ between construction types.

On a typical 4 bed detached home, timber frame wall elements saves 5 tons CO2e, whole life carbon emissions, over aerated concrete wall elements, equivalent to 16,500 road miles*

Timber frame wall elements sent to landfill, produce up to 15% more carbon (0.5 tCO2e) at end of life, compared to aerated concrete blocks

As operational emissions drop, due to implementation of the Future Homes Standard, the lower whole life carbon benefits of, timber frame will become increasingly beneficial, over aerated blockwork.

** 1tCO2e = 3,300 road miles in medium sized petrol car (DEFRA 2021)*

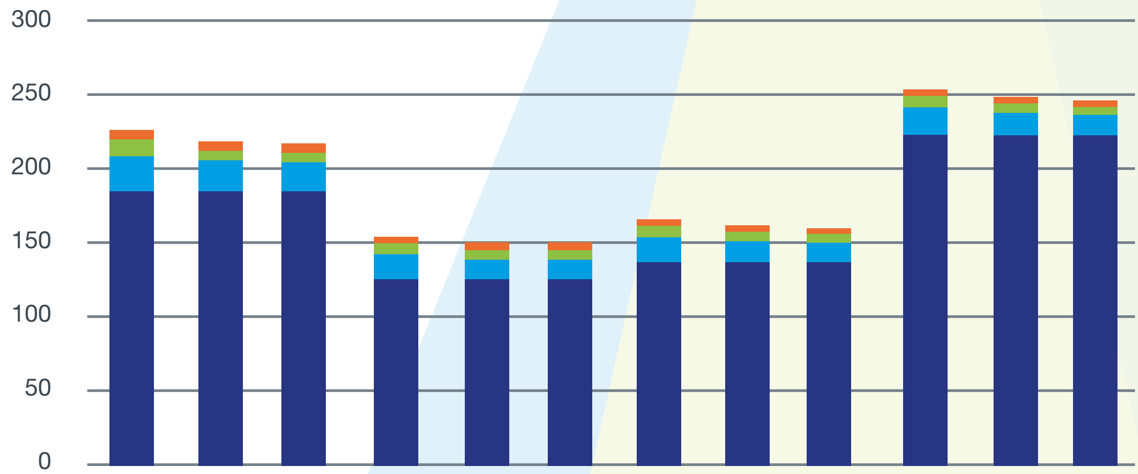
WHOLE LIFE CARBON EMISSIONS SUMMARY

This shows the whole life carbon emissions of the AIMCH houses over the 60-year occupancy period.

It includes timber carbon sequestration benefits and differing end of life criteria, applicable to timber frame and masonry construction.

As the houses are all designed to the same energy efficiency standard, the operational (use stage) emissions are the same regardless of the construction method.

The differentiating element is the superstructure wall elements, which makes up to 3% of the whole life carbon emissions of the homes.

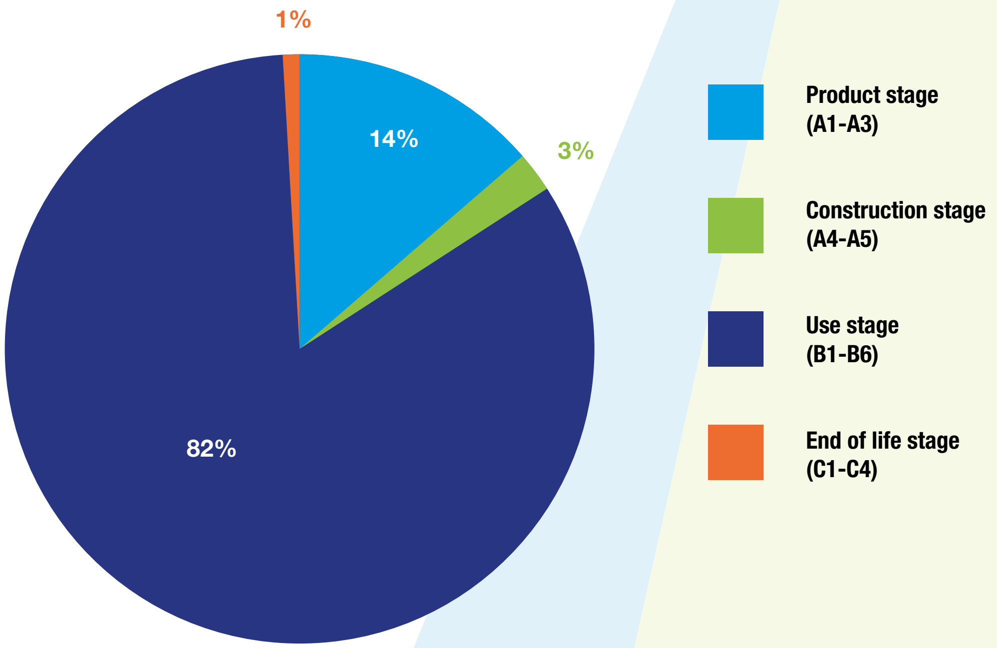


	Standard brick & block	Open panel	Closed panel	Standard brick & block	Open panel	Closed panel	Standard brick & block	Open panel	Closed panel	Standard brick & block	Open panel	Closed panel
	4 Bed			3 Bed			2 Bed			Townhouse		
End of life stage (C1-C4)	3.1	3.4	3.6	2.4	2.6	2.7	2.0	2.2	2.3	3.1	3.4	3.6
Construction stage (A4-A5)	7.3	5.0	4.8	5.2	3.3	3.1	5.4	3.7	3.4	6.3	4.0	3.8
Product stage (A1-A3)	25.5	22.5	21.7	14.2	12.4	11.6	15.4	14.0	13.3	19.8	17.3	16.3
Use stage (B1-B6)	185.2	185.2	185.2	131.9	131.9	131.9	142.7	142.7	142.7	223.0	223.0	223.0

1tCO2e = ~3300 miles in a medium petrol car (DEFRA 2021)

- Operational energy emissions (the in-use stage) during the 60-year modelling period are the largest contributor to the whole life carbon footprint of the homes, as expected. These do not differ between construction types.
- Strip foundations, external, party & loadbearing wall elements, roof tiles, ground floor slabs and underbuilding walls, are the key elements that contribute to the embodied emissions of the homes.
- These elements do not vary between masonry and timber frame construction methods, except where there are design specific point loads requiring extra concrete in the foundations

Example – 4 bed detached standard brick & block



CONCLUSIONS

The timber frame outperform masonry construction on a whole life carbon basis by up to 5t CO2e per dwelling, equivalent to 16,500 road miles, due to:

- lower embodied emissions of materials,
- lower emissions from transport to site,
- less energy and time spent on site, and
- the benefits of carbon sequestration during the life cycle of the building.

The cementitious products generally have the highest contribution to the lifecycle embodied emissions including roof tiles, concrete blocks, brick cladding, strip foundations and floor slabs.

However, masonry constructions performs better at end-of-life than timber frame construction, as no sequestrated carbon is released from 10% sent to landfill.

A key challenge is the lack of supplier EPDs. Much of the calculation was carried out on an average basis rather than a supplier specific basis. In order to more accurately calculate whole life carbon, there needs to be increased emphasis on EPDs for key products and suppliers.

The differentiating factors are the wall elements. The embodied emissions of the timber frames wall elements are up to 82% less than that of the masonry construction. This equates to up to 5t CO2e upfront savings per dwelling, equivalent to 16,600 road mile.

Operational emissions are predicted to reduce with the implementation of the Future Homes Standard, continued decarbonisation of the UK electricity grid, and increased electrification, the benefits of timber frame over masonry construction, will become increasingly significant, as will focus on reducing the embodied emissions, from cementitious products.

OVERVIEW

Verco was commissioned by the AIMCH housing developer partners (SMG, Barratt and L&Q) to assess the embodied carbon impact of concrete masonry built homes, compared to open-panel and closed-panel timber frame construction.

The purpose of this was to understand the differences in whole life cycle embodied carbon emissions between the construction methods, under current English building regulations (Approved Document L, published Mar 14).

In the future, additional modelling will be undertaken, to assess the implications on compliance to Jun 22 AD- L building regulation changes and Future Homes Standards.

PARTNER	HOUSE TYPES	METHOD OF CONSTRUCTION
BARRATT	4-bed detached	1. Standard masonry, using aerated concrete blockwork & brick cladding 2. Off-site manufactured open panel timber frame (Stewart Milne Timber Systems), with brick cladding 3. Off-site manufactured closed panel timber frame (Stewart Milne Timber Systems), with brick cladding
BARRATT	3-bed semi-detached	
L&Q	2-bed semi-detached	
L&Q	4-bed townhouse (3 storey)	

SCOPE

The embodied carbon analysis is based on the RICS Standard for Whole Life Carbon Assessment

Product stage [A1-A3]

- A1 Raw materials supply
- A2 Transport
- A3 Manufacturing

Construction stage [A4-A5]

- A4 Transport to site
- A5 Energy and waste disposal during construction

In-use stage [B1-B6]

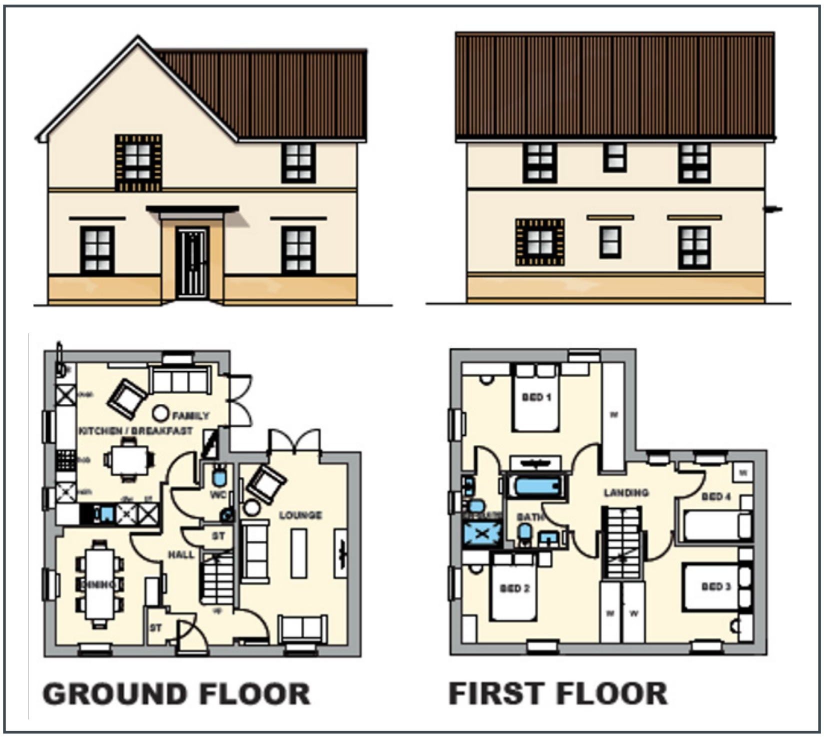
- B1 Use emissions
- B2 Maintenance
- B3 Repair
- B4 Replacement
- B5 Refurbishment

B6 Operational energy use

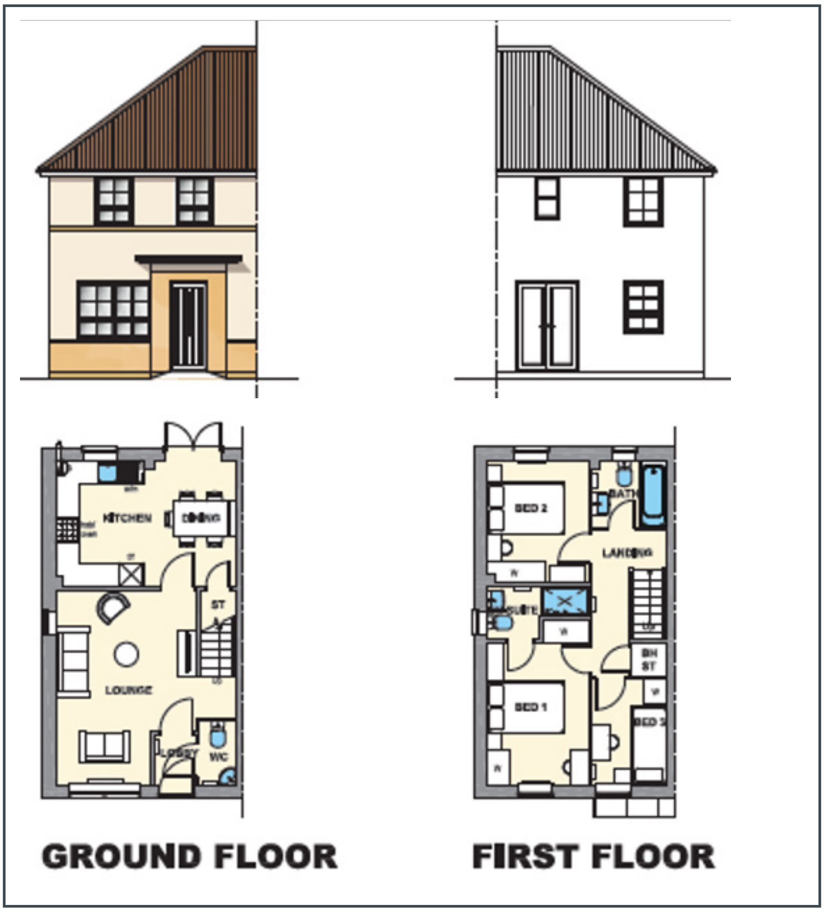
End of life stage [C1-C4]

- C1 Demolition process
- C2 Transport
- C3 Waste processing
- C4 Disposal

HOUSE TYPES MODELLED



4 Bed Detached



3 Bed Semi Detached

HOUSE TYPES MODELLED

3 Bed Semi Detached/Terrace

4 Bed Semi Detached Townhouse

METHODOLOGY NOTES

Timber and carbon sequestration

The model assesses the embodied carbon of the houses and its component materials on a cradle-to-grave basis.

For timber and timber derived products, this approach allows for the inclusion of emissions arising from the decomposition and incineration of timber at the end of its life, and therefore makes it possible to include the relative benefits of carbon sequestered within timber based products, used in all construction methods.

According to the RICS whole life carbon assessment for the built environment professional statement (2017):

> Carbon sequestration can only be considered when the following criteria are met:
>
> 1. **The whole life carbon assessment of the project includes the impacts of the end-of-life stage [C] and;**
> 2. **The timber originates from sustainable sources (certified by FSC, PEFC or equivalent).**
>
> Carbon sequestration figures should be reported separately but can be included in the total product stage figures [A1 - A3] provided the specified conditions above are met.

End of Life

End-of-life disposal methods (recycling, reuse, landfill, biomass etc.) represent current practices and might not reflect those in 60 years' time.

Trends have not been projected for future rates of recycling and reuse for the purposes of this project.

There are several inconsistent conclusions from different sources for timber end of life treatment ranging from <1% to 25% to landfill, as well as uncertainty around actual disposal practises at end of life in 60+ years' time. (See Appendix B)

Therefore, assuming the same proportion to landfill for both timber and aerated concrete blocks allows comparison purely on material characteristics.

This model assumes 10% to landfill and 90% recycled, for both aerated concrete blocks & timber elements, used within the differing construction methods.

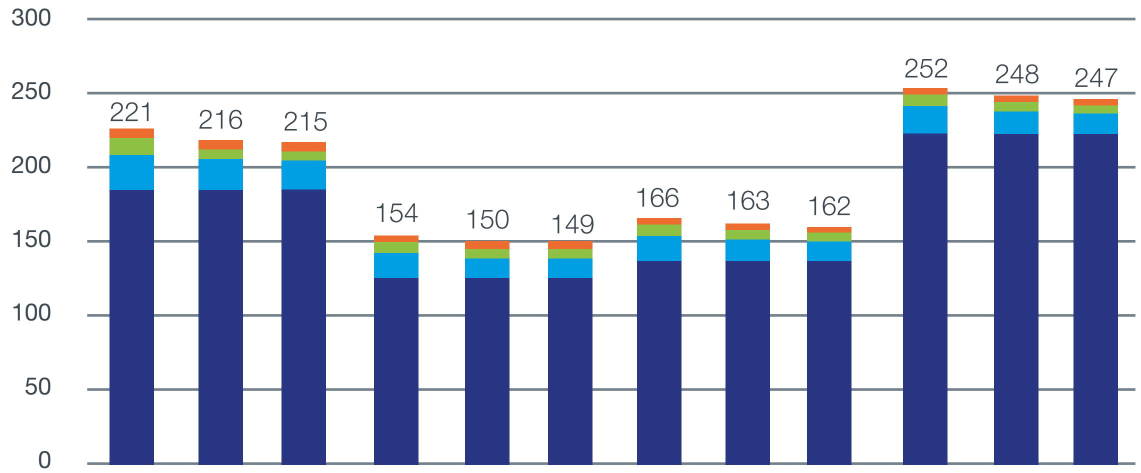
Data availability

House type	3-bed	4-bed	2-bed	4-bed townhouse
Standard brick & block	Full dataset	Full dataset	Quantities estimated	Quantities estimated
Open panel timber frame	Full dataset	Full dataset	Quantities estimated	Quantities estimated
Closed panel timber frame	Full dataset	Full dataset	Full dataset	Full dataset

- Full bills of quantities were available for the 3-bed and 4-bed house types. However, only a bill of quantities for the closed panel timber frame option where available for the 2-bed and townhouse.
- Therefore, the quantities and materials for the open-panel timber frame and masonry construction of the 2-bed and the townhouse were estimated and extrapolated based on the dimensions and material quantities given for the closed panel timber frame construction and informed by and compared to the 3-bed and 4-bed constructions.
- The accuracy of the results for the 2-bed and Townhouse masonry and open-panel timber frame constructions are therefore expected to be less than for the other house/build types.

SUMMARY RESULTS OVERVIEW ALL HOUSE TYPES

Whole life carbon emissions summary



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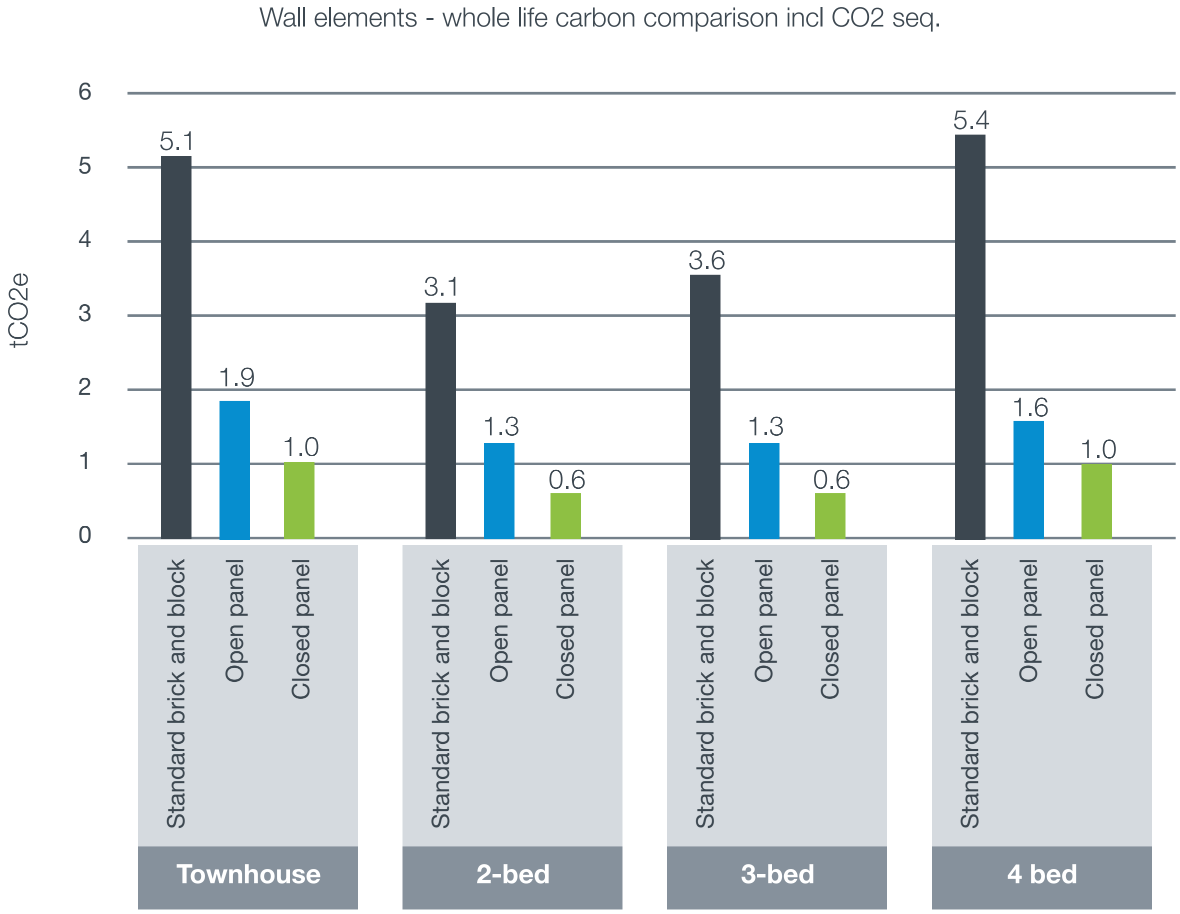
Material Comparison of timber frame, compared to aerated concrete, wall elements



The chart shows the emissions relating to the **external, party and internal load bearing walls**, where wall elements are interchangeable.

External brick cladding is not included here as it is consistent across construction methods.

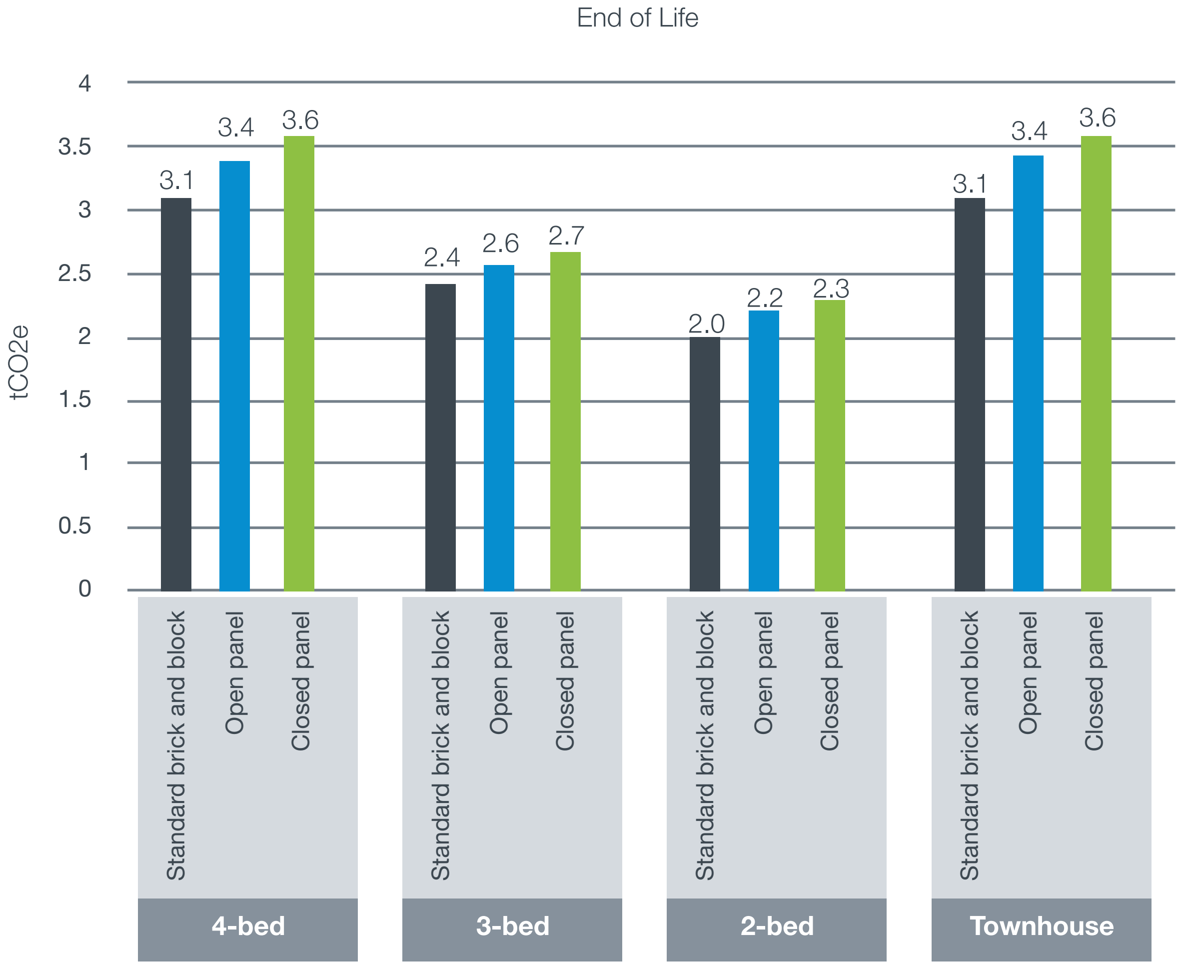
Timber frame wall elements perform consistently better than the aerated concrete masonry construction when the **whole life carbon** emissions are considered.

The embodied emissions of the timber frame wall elements are **up to 82% less** than that of concrete masonry construction.

The timber frame wall construction outperforms masonry at the construction stage, with reduced emissions from transport to site and shorter duration onsite. The emissions from the construction stage are **up to 40% less** for timber frame than masonry.

Detailed breakdowns are available within Appendix C

End of Life Comparison aerated concrete blockwork, compared to timber frame, wall elements



The chart shows the emissions relating to the **external, party and internal load bearing walls**, where wall elements are interchangeable

External brick cladding is not included here as it is consistent across construction methods.

The one area that masonry concrete differs to timber is at end of life, due to no carbon release, from concrete blocks sent to landfill

As the carbon sequestration benefits of timber products are claimed at the product stage, the **re-release of the carbon** into the atmosphere is accounted for **at end of life**, for the proportion of the material that is not reused or recycled.

The assumption for timber and concrete products is that **10% goes to landfill** and 90% is reused or recycled. (see slide 12)

Timber frame wall elements sent to landfill, produce **up to 15% more carbon (0.5 tCO2e)** at end of life, compared to aerated concrete blocks.

LIMITATIONS

The limitations of this study are primarily related to the assumptions associated with the long-term nature of the assessment spanning the 60-year life cycle of a building. Some of these key limitations are explained in more detail below:

- The carbon intensity relating to the manufacture of products is likely to fall over time as processes become more efficient either due to technological developments, environmental concerns, or the need to drive cost efficiencies. However, in the absence of data relating to how the manufacturing practices might change, it was assumed that these would remain the same. Therefore, emissions associated with the replacement of materials at refurbishment stage do not reflect the potential improvements in production efficiency that might occur in the future, and these may be lower than currently estimated.
- Assumptions used in the calculations regarding the end-of-life disposal methods (i.e. recycling, landfill or incineration) represent current practices and have been standardised across concrete blocks and timber products, and might not reflect those in 60 years' time. It is expected that relevant policies and environmental awareness will lead to higher rates of recycling in the future. However, no attempt has been made to project such future trends as part of this study. The emissions associated with waste disposal during refurbishment and demolitions are also based on current patterns on disposal routes for each material.
- Operational CO2 emissions, which relate to emissions from the forecasted energy use of the residents over a 60-year period, are based on the modelled energy consumption in the absence of monitored data for these homes. Modelled energy consumption could be significantly different from the actual consumption depending on the performance of the building components, the behaviour of the residents, and the weather conditions, all of which could vary over the life of the building. The findings from this study are also reliant on the quality of data on the material quantities provided by the developers, and the validity of the conclusions is directly linked to the robustness of this data. The data provided was reviewed with the data providers and observed anomalies were flagged to ensure as much consistency and accuracy as possible.

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@AIMCH2

aimch

aimch@cs-ic.org