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Viable Homes

Practical guidance for planners and developers on carbon optimisation of housing developments

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Revision	**Date**	**Modifications**
R00	29/11/23	1st version
R01	21/01/24	Peer review comments incorporated

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Acronyms

AHB	Approved Housing Body
BER	Building Energy Rating
DMURS	Design Manual for Urban Roads and Streets
DPH	Dwellings per hectare
EU	European Union
IGBC	Irish Green Building Council
LCA	Life Cycle Assessment
MMC	Modern Methods of Construction
NZEB	Nearly Zero Energy Buildings
SCSG	Sustainable Compact Settlement Guidelines
SDZ	Strategic Development Zone
SHD	Strategic Housing Development
SuDS	Sustainable Drainage Systems
TGD	Technical Guidance Document
UCD	University College Dublin
UDZ	Urban Development Zones
UK	United Kingdom

1 Introduction

This report intends to highlight to planners and other key stakeholders of the built environment the whole life carbon impacts of the continued construction of new low-rise, low-density dwellings on greenfield sites and to provide recommendations to mitigate these impacts by promoting a switch to a low-rise, medium-density model.

To date, in the construction industry, the emphasis has been placed upon the reduction in operational energy and little emphasis has been placed on the embodied energy of materials and in particular external areas and infrastructure. The size and density of developments, road engineering, and car parking requirements, along with the shape and orientation of dwellings greatly influence the whole life carbon of our homes.

Each square meter of constructed home adds approximately 600 to 1400 kilograms of carbon dioxide equivalent ($kgCO_2e$)[1]. This is before the carbon cost of each car parking space, the linear metre of road, water, and utility infrastructure needed to serve these dwellings is counted. The Viable Homes project has started to quantify for the first time in the Irish context the carbon cost of infrastructure, in addition to the dwellings themselves. This report shows that the optimisation of newly built areas and the efficiency of infrastructure per dwelling must play a critical role in reducing carbon emissions at the early design stage before material selection is considered.

This report and its accompanying handbook is the first part of a longer ongoing research project carried out by the Irish Green Building Council (IGBC) and Gillian Brady, Philip Comerford, Ciara Reddy, Philip Crowe and Oliver Kinnane from University College Dublin (UCD) to understand, quantify, and provide guidance on the connection between compact growth, development typologies and carbon mitigation, assessing the climate impact of housing size, mix, layout and density on whole life carbon.

Within this report, we start by looking at the current state of play in Ireland, reviewing the demographics of the country, the demand for housing in the future, and the potential conflicts that could arise between these and the legally binding sectoral carbon emission budgets.

We then investigate what is driving the design decisions of new large-scale, low-rise residential development. This analysis was done through semi-structured interviews with key stakeholders exploring the question of what they find viable to build today and the barriers to compact urban growth.

Using case studies provided by some of these stakeholders, an embodied carbon analysis was carried out on typical low-rise, low-density residential developments and the infrastructure needed to serve these developments. With this analysis, we can highlight the different carbon 'hotspots' within a development.

We then examined different case studies both nationally and internationally, looking at the design decisions they implemented that would help reduce the impact of the carbon 'hotspots' identified in our earlier embodied carbon analysis.

Lastly, a handbook has been produced which outlines the key recommendations arising from this research.

[1] LCA includes all life cycle stages from A1-C4

1.1 Demographics

Ireland's population continues to grow, with 5.15 million people recorded in the 2022 census. This is projected to grow to between 5.6 million and 6.7 million in 2051 according to the CSO[2]. The average household size was 2.74 in 2022. However, assumptions can be made that this figure is inflated due to the well-documented housing shortage in Ireland. The shortage leads to adults living with their parents or in shared rental accommodation longer than they would if there were alternate viable housing options available. This inflation can be seen in the census, with the number of adults living with their parents increasing by 14% in 2022 compared to the 2016 census.[3]

According to the 2022 Census, 69% of private dwellings were occupied by families, 23% were one-person dwellings, and 8% were non-family dwellings.[4]

1.2 Current stock

From the census[5], we can see that the majority of the existing housing stock is detached and semi-detached housing with three to four bedrooms.

Table 1. Quantity and typology breakdown of existing housing stock

House type	Number of units	% of housing stock
Detached house	756,660	41.2%
Semi-detached house	466,261	25.4%
Terraced house	372,849	20.3%
Apartment in a purpose-built block	190,197	10.4%
Apartment in a converted house or commercial building	49,102	2.7%
Bed-sit	1,659	0.1%
Total	1,836,728	100%

Table 2. Quantity and bedroom breakdown of existing housing stock

Number of bedrooms	Number of units	% of housing stock
One Bedroom	101,644	5.53%
Two bedrooms	291,785	15.89%
Three bedrooms	655,422	35.68%
Four bedrooms	471,449	25.67%
Five bedrooms	113,041	6.15%
Six bedrooms	22,391	1.22%
Seven or more bedrooms	7,013	0.38%
Not stated	173,983	9.47%
Total	1,836,728	100%

[2] https://www.cso.ie/en/releasesandpublications/ep/p-plfp/populationandlabourforceprojections2017-2051/populationprojectionsresults/

[3] https://www.cso.ie/en/releasesandpublications/ep/p-cpp3/censusofpopulation2022profile3-householdsfamiliesandchildcare/adultslivingwiththeirparents/

[4] https://www.cso.ie/en/releasesandpublications/ep/p-cpp3/censusofpopulation2022profile3-householdsfamiliesandchildcare/privatehouseholdsandlivingalone/

[5] https://www.cso.ie/en/releasesandpublications/ep/p-cpp2/censusofpopulation2022profile2-housinginireland/occupieddwellings/

1.3 What is being built?

From Q1 2020 to Q3 2023, have been 93,290 new dwellings built.[6] The majority of these dwellings are scheme houses[7] both in terms of the number of dwellings built and a percentage of the total floor area of dwellings built. Scheme houses are developments commonly made up of detached, semi-detached, terraced, and duplex houses.

Table 3. Quantity and dwelling typology built from Q1 2020 to Q3 2023

House type	Number of units	% of housing stock
Scheme house	48,256	51.73%
Apartment	25,751	27.60%
Single house	19,283	20.67%
Total	93,290	100%

Table 4. Floor area built per dwelling typology from Q1 2020 to Q3 2023

House type	Number of units	Average floor area per unit (m2)	Total floor area built per type (m2)	% of total built floor area
Scheme house	48,256	118	5.7 million	47%
Apartment	25,751	78	2 million	17%
Single house	19,283	223	4.3 million	36%
Total			12 million	100%

1.4 What is needed and why it must be looked at?

The Government of Ireland has stated that an average of 33,000 new homes will be needed every year from 2021 to 2030 to meet demand.[8]

With the ongoing popularity of scheme houses, and the assumption that the factors for their continued popularity remain in place for the foreseeable future, the true carbon cost of the typology must be quantified. This report takes the first national look at the actual cost of scheme houses. The report shows that carbon savings can be made by making adjustments to the typology and moving the model from its current low-rise low-density to a low-rise medium-density model.

In 2022, carbon modelling of the National Development Plan and the Housing for All strategy was carried out by UCD to underpin IGBC's roadmap: Building a zero-carbon Ireland. This study demonstrated the challenge of cutting carbon emissions by 51% from the construction and property sector by 2030.

Due to the greatly increased levels of construction up to 2030, driven by the National Development Plan and Housing for All, this would offset the savings being made in the ongoing reduction of operational carbon in the building stock. Cutting the carbon intensity of construction by 50% per square metre by moving to low-

[6] https://www.cso.ie/en/releasesandpublications/ep/p-ndc/newdwellingcompletionsq32023/

[7] CSO define Scheme houses as: "a new multi-unit development with two or more houses is to be connected to the ESB Network, Form NC1 (through an online application system) must be completed, and each dwelling is defined as a 'scheme'".

[8] https://www.gov.ie/en/publication/ef5ec-housing-for-all-a-new-housing-plan-for-ireland/

carbon materials and modern methods of construction (MMC) would help but would not be enough on its own. To meet climate targets, this needs to be combined with making better use of the existing stock and existing vacant space, minimising the need for new construction, and limiting sprawl when new construction is required.

To achieve the aim of cutting national carbon emissions by 51% by 2030, the Government has set 5-year sectoral climate budgets from 2021 to 2035. As part of these budgets, Local Authorities are required to develop their climate action plans. Local Authorities have responsibility for spatial planning and their climate action plans should account for the greater carbon cost related to the different typologies, location, and density of housing developments this report highlights.

For the years 2026-2030, the budget for the residential sector has been set at 23 $MtCO_2e$[9]. If we continue with business as usual using the figures above in terms of what is being built and an average embodied carbon figure of 400$kgCO_2e$[10], construction of new scheme housing could account for 17% of the 2026-2030 budget. This is only for the development of about 85,300 new dwellings, with the remaining budget needed to develop the other 79,700 new dwellings (apartments and single housing), the embodied carbon resulting from renovations in that period, as well as the on-site operational emissions of the existing 1.8 million dwellings.

It is, therefore, crucial that we look at lowering the carbon demand of these low-rise, low-density developments. Failure to appropriately plan will lead to conflict between addressing the ongoing housing crisis and meeting our climate targets. To ensure we meet our housing needs without exceeding the carbon budget, it is necessary to prioritise what gets built. To do this, we need better identification of the mix, type, and size of new dwellings required.

[9] https://www.gov.ie/pdf/?file=https://assets.gov.ie/234926/2ebb2431-d558-4a54-a15c-605817c37b2f.pdf#page=null
[10] LCA stages A1-A5

2 Engagement with Industry

With the aim of establishing an understanding of how we can build housing at required densities to meet demand and achieve carbon targets, we set out to gather the knowledge and experiences of those working within the industry through a series of conversations.

Methodology:

Primary data was collected through ten semi-structured interviews carried out in May and June 2023. Interviewees included five home builder developers (private and semi-state), one approved housing body, two architecture practices, one estate agency and one quantity surveying practice. Participants were selected based upon their membership of the Irish Green Building Council and Construct Innovate, along with their experience in the delivery of housing at scale in Ireland. All conversations were recorded to enable verbatim transcription, and each participant was allocated a pseudonym. An academic peer review was carried out in advance for ethical compliance.

Purpose:

With the question of 'what is currently viable?' as our point of departure, we focused upon viability, embodied carbon, and the future of these developments in these discussions.

The purpose of the interviews was to understand.

1. **Viability:** What typologies do developers consider viable to build, and what are the drivers of the same/barriers of compact urban growth?
2. **Embodied Carbon:** To what extent do the stages of whole life carbon assessment influence design and construction decisions?
3. **The Future:** In what way do industry representatives think the delivery of housing will evolve up to 2030?

The findings of these conversations are outlined below, with a strong focus on question 1.

2.1 Viability

The first question asked of participants was what type(s) of housing developments they find most viable to build in Ireland within the regulations and density guidelines at present?

Nine out of ten respondents stated that single family dwellings in semi-detached or terraced format on greenfield sites at a density of 30-40 dwellings per hectare (dph) are most viable. However, in order to achieve densities dictated by policy, higher density models are also built as part of these developments. Two of the nine noted that given the availability of the State as a buyer, these higher density models are equally viable at present.

Architect 1 stated, *"The developer's answer to this is going to be houses, houses all day long. They can be built in a timber frame system, can be rolled out quickly, can be completed in phases and sizes that suit them; they can sell them incrementally, which works with their funding model".*

Developer 5 added, *"In an ideal world for us, it would be housing, pure traditional terraced housing". They added, "At the moment, because of interest rates and all the rest, the only thing that's viable is owner occupied housing. Duplexes or apartments just aren't viable for the private market."*

Estate agent 1 backed this up, *"We all know the answer: the most viable is traditional housing, at a typically lower density…Medium density and higher has not been transacted in any volume to anybody other than the AHBs and non-household buyers as it's categorised."*

Developer 2 noted, *"In terms of low density, [we've] no issue selling privately all day long but having said that, there are other routes to market, which are available at the moment, which means that the high density schemes are perfectly viable in the current political or economic climate….What we're seeing now is that entire schemes or certainly entire blocks will be purchased by either the LDA or an AHB."*

QS1 backed this up, *"Most of the developers we're working with right now have pulled back from their apartment schemes… most of them if they've got the land banks to do it, are ticking away building houses, traditional low-density, low-rise houses. "*

Developer 1 stated, *"The most viable are single-family homes, and the duplex model is about as dense as we from a cost viability point of view."*

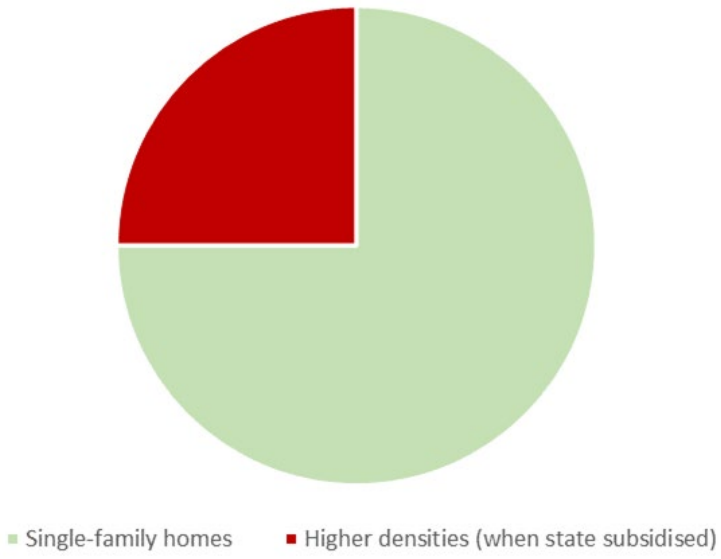

Figure 1. Industry expert responses to the question of what's currently viable?

As a follow up, interviewees were asked what the current barriers are to building low rise, medium density housing[11] of circa 80 dwellings per hectare over 4-storeys on these sites. The responses fall broadly into two categories of construction costs and car parking, in summary:

1. **Cars:** a large proportion of sites are taken up by car parking & roads.
2. **Costs:** duplexes and apartments cost more to construct and achieve lower sales prices than equivalent houses.

[11] The reason for choosing low-rise medium-density when considering embodied carbon is explained here: https://www.londonfestivalofarchitecture.org/blog-post/high-density-low-rise-zero-carbon/

Figure 2. Low-rise, low-density edge-of-town housing

These two aspects are detailed as follows:

Cars:

The provision of, on average, two parking spaces per dwelling and associated roads limit achievable density. The reasons for providing this quantum of parking, however, varied across interviewees; some attributed the issue to local authority requirements, while others related it to market preferences.

According to Architect 1, *"developers are very comfortable in the shared surface space and with Design Manual for Urban Roads and Streets (DMURS) and the reduction of the percentage of site that is occupied by road infrastructure." Said architect noted the conflict between "many development plan standards and DMURS and the conservative attitude of particularly the engineering departments within those local authorities".*

This sentiment was echoed by developer 5, who stated, *"Notwithstanding official policy, a lot of local authorities will still look for two parking spaces per house. We can live with one parking space per unit but a lot of the time, they're looking for two. The planners will never override the role of engineers. The road engineers are still kind of the kings."*

Similarly, AHB1 noted a *"pushback from local authorities"* with regard to a reduction in the quantum of parking.

Developer 1 stated, *"DMURS makes much more sense than the way we're forced to build roads around these estates. They are still predominantly car focused rather than people."* Adding that one particular local authority dictates that houses are only built upon one side of a road, *"One of the issues we have from a density point of view is the requirement for roads that only have houses on one side."*

On the contrary, a number of interviewees stated that **market preferences** are the driver behind the quantum and type of car parking provided.
Developer 2 noted, *"Generally, we put a relatively high figure against the parking."* For example Strategic

Development Zones where there is a cap on parking, they stated that their *"marketing team are having to work hard to get their heads around how we sell something which doesn't have a dedicated parking space with it."*

AHB 1 noted the risk associated with providing one space per dwelling. *"I know we're in a housing crisis, but we don't want to be left with an estate with all of these lovely houses that people are turning down as they have two cars or it could be someone with kids that can't park at the opposite side of the site."*

Developer 4 stated, *"The other thing that is a real struggle is car parking. One of our projects, we're looking at 1.4 as a car parking ratio at the density of 50 dwellings per hectare, that's very challenging and ends up with under croft or podium car parking."*

While Architect 1 relayed anecdotal evidence from a homebuyer, *"If I can't see the headlights of my car from the sitting room, I don't want the unit."* But added that this attitude is changing in well-connected locations.

Similarly, Estate Agent 1 noted that attitudes are changing within the market. *"The last six months have been transformative in terms of how people think around sustainability and their footprint. Last October [2022], nearly every other sale was cancelled because people were saying; we can't just deal with one car space, but there's an awareness now that it's the right thing to do, so it's less of an issue."* They also noted that *"Car charging is a much bigger issue now, so if you're off-curtilage parking, how do you charge your car?"*

Developer 3 described how these two issues of local authority requirements and market preferences are linked. *"The local authorities can say no. Fingal now wants 0.5 space for a 2-bed house. Now, that's all very well, in principle, but people are still going to buy two cars or at least a car, so it's going to be abandoned on the street, so your streetscape is going to be dire, there's no way of controlling that. Unless it's infrastructure led, it just won't work."*

Costs:

Respondents stated that higher density typologies (including duplexes and apartments) cost more to construct than houses and sell for less.

Developer 3 described the situation *"A 2-bed apartment costs twice as much to build as a 2-bed house. A 2-bed apartment on average will cost €400,000 plus to build, a 2-bed house would be around the €200,000/220,000."*

Estate Agent 1 echoed this sentiment *"Typically, the guidance we're getting is that the duplex construction cost is somewhere between an apartment and a house. Then depending on where the policy supports are, the duplex will trade below a house".*

Developer 2 noted, *"If we had our way, we probably wouldn't want to build duplex blocks. They have a lower value than a house, and they're more complicated to build, so therefore, the return on them is lower than on the house."*

The factors contributing to the higher construction cost for denser typologies are outlined below in order of frequency mentioned.

2.1.1 Building Regulations

According to respondents, when units are stacked to increase density, compliance with the building regulations becomes more complex. For example, accessibility requirements (TGD M) mean larger staircases and the introduction of lifts, while additional fireproofing between dwellings dictates a change to floor build-ups (TGD B).

Developer 2 stated, *"The regulations will dictate that we deliver a really high-quality product. It makes them very expensive to build, and there's no getting away from that. If you had a four-storey walk-up and you didn't have to put in lifts and so on and so forth, is that going to bring the price down? Yes, of course it is."*

Architect 2 backed this up *"What we're advocating for is that we make allowances to keep the existing provisions of Part M, to allow a duplex with an apartment on top or an apartment on the bottom with a duplex on top or duplex stacked and also allow up to four floors with a Part M residential type staircase in the centre, which allows you to go 1800mm between breaks of landings, with two apartments per floor. That would really open up a much more economical way of doing housing with a provision to put a lift in at a later date if required."*

Architect 1 noted, albeit with an acknowledgement of the importance of the regulations, *"Over the last 10 years, nearly every aspect of the Building Regulations has become more onerous… the cumulative effect of all those things does make things more expensive. What would be useful is if there were percentages where there could be latitude. If you had, for example, 20% of units in a scheme that had a lower level of Part M accessibility, you will begin to see a different pattern emerging."*

The method of construction for houses is familiar and quick. Much of the construction can take place off site and is not reliant on specialist subcontractors or external design teams. Many respondents noted complexities associated with achieving compliance with TGDs when constructing duplexes and apartments using a timber frame system but stated that they are currently trialling solutions.

Developer 5 stated: *"Traditionally for housing for a long time, we've been doing timber frame, but that's more of a cost decision rather than a green decision… I think it's challenging to do duplexes with timber frames. If we could do three and four storey buildings in timber frame, I think that'd be a useful thing."*

Developer 2 stated, *"We have trialled a model of using a fully timber framed duplex unit."*

Developer 1 noted, *"We'd like to go down the mass timber route for some of those [higher density schemes], but then we fall into the fire regulation limitations on that. That's something that is definitely holding back that side because we can find a business case for building with mass timber from the cost point of view, but it's something that just isn't as feasible at the moment with those fire regs."*
Please refer to the 'Case Studies' chapter of this report for ideas on how some of these issues could be overcome.

2.1.2 Spatial standards

Back-to-back distances and garden sizes were noted by 40% of respondents as a barrier to compact urban growth. These interviews occurred in the weeks before the release of the Sustainable Compact Settlement Guidelines (SCSG). Therefore, the discussions acknowledge the reductions in garden sizes and back-to-back distances proposed by the draft document.

Developer 3 noted, *"In terms of setting our typology, we do a lot of consumer research… A lot of people were saying the long-elongated gardens, the back third, were always underutilised."*

However, developer 4, who had examined the proposed changes suggested by the draft SCSG noted, *"When we looked at it, it resulted in wider houses, your garden is shorter because they've reduced the back-to-back, but in order to get the minimum area, you end up building wider houses… You end up losing out in the other dimension in terms of the density."*

Developer 2 noted, *"At the moment, for a house, you have to over 45 square metres of private open space etc. Whereas, for an apartment, you only need 7 square metres of balcony. Is there something that can happen there?"* They also stated the impact of these guidelines on typologies. *"Typically, to get over 35 or 40dph, you would have had to build some duplex blocks. With the compact growth [proposed SCSG guidelines], you may no longer need to build a duplex block; you could potentially do a scheme of all housing, quite compact housing onto a site now, just over 35dph."*

Equally, regarding the internal layout of dwellings (and storage in particular), respondents noted the multiple standards and differing criteria depending upon whether a dwelling is classified as a house or an apartment. For example, as outlined in the *'Design Manual for Quality Housing'* and consistent with the 2022 *'Sustainable Urban Housing: Design Standards for New Apartments, 2022'*, a 3-bed/5P House requires internal storage of 5 square metres while an equivalently sized apartment requires 9 square metres.

As Architect 1 noted, *"If you're providing a three-bedroom duplex, and you have to provide nine metres squared of storage internally within that unit, which you do, then it ends up being bigger than a house."*

Developer 3 stated, *"The fact is, we have our minimum house area, but then we have about eight other sub standards, minimum living room area, minimum living room width, and they don't relate to each other. So, to deliver all those sub standards, we have to inflate our house by 20% above the minimum."*

With regards to apartments, Developer 4 has addressed this issue through the exclusion of ensuites. *"The way the areas have been set for apartments is if you don't have an ensuite, largely they're achievable. If you have an ensuite, it can be quite challenging to get down to the minimum areas."*

2.1.3 Finance model

The manner in which the construction of lower density houses is financed usually differs from multi-unit apartment or duplex developments. Houses can be built in small numbers and sold off incrementally to finance subsequent phases, whereas developers are often reliant on external sources of financing for longer periods of time when constructing higher density typologies.

When referring to apartment schemes Architect 2 noted, *"All of those schemes depended on international funding, largely because you had to build the entire scheme out, and you have to finish the whole damn thing and pay the interest costs on borrowings etc, until the whole scheme is finished."*

While Developer 3 stated, again with reference to apartment schemes, *"So a lot of developers have to carry or forward fund that for up to two years before you get any profit, whereas, in a housing development, you can subdivide it and release sections."*

With regards to traditional low-density, low-rise houses, QS 1 noted, *"They can build 10, sell 10, build 10, they can self-fund."*

2.1.4 Planning risk

Due to the lengthy timescales associated with achieving planning permission, respondents were reluctant to take any risks in this area.

Architect 1 stated, *"At the moment, what our clients are saying to us is it takes them multiples of time longer to get planning permission than it does to build something. They can build a scheme in six months or a year, but it might take them two or three years to get to the point where they have planning permission, and that's a real problem."*

Developer 5 reflected this position, *"We know what the mix is, what the market is looking for, we know the local authorities, we have a relationship with individuals within local authorities, and we know what they look for."*

Developer 2 stated *"We need to have a better agile planning system to give us more transparency in terms of timelines and more guarantee as well."*

Developer 2 noted, *"Do we just stick to what we know? There is a certain element of that, and there is a risk associated with bringing something new to market… It'd be safe to say that we don't take on planning risk very lightly."*

Architect 1 elaborated upon the relevant complexities within the planning system. Although these points were not raised in this manner by others interviewed, it is recognised that they are key regulatory drivers of issues noted by others, and as such, the information is included.

A lack of leadership within Local Authorities resulting in the Roads Department dictating car parking and road infrastructure within housing developments was discussed. *"Instead of instructing the road engineering department to get on board with something, that is in an urban area, it is appropriate to use DMURS (Design Manual for Urban Roads and Streets), they don't. It leads to a lot of frustration."*

A disconnect between Local and National Policy, where development plans take a more conservative approach which is driven by local objectives rather than national policy, was noted. *"One of the benefits of the SHD (Strategic Housing Development) system was that when you were sitting in a tripartite meeting with the board and the Local Authority, the board was very, very clear that national policy was the primary legislation."*

The Strategic Development Zone (SDZ) mechanism provided greater certainty and clarity for developers. *"I think the SDZ might be the favourite form of development model for a lot of developers. It gave them such security, making the planning process timely and predictable."* Urban Development Zones (UDZ) were noted as another positive, albeit with a question mark around when these will be introduced. *"There was genuine excitement from developers when the idea of the UDZ first came out."*

Uncertainty on timelines associated with the release of planning guidance and standards is resulting in developers pausing projects or proceeding in a piecemeal manner. Architect 1 described how homebuilders are thinking about this, *"Do we not think at scale until such a time as we have a new set of standards and*

some clarity on what has been achieved before 2030 in terms of sustainability and decarbonising."

Finally, providing a mechanism to enable small changes to Planning Applications would reduce the above noted timescales and associated risks. *"So instead of a six-week turnaround on a quick change, which might be the trigger to releasing your project, it just doesn't happen at all because nobody has the appetite to go through that process for small changes."*

2.1.5 Market preferences

A reluctance amongst home-buyers to purchase higher density own-door typologies such as duplexes or maisonettes beyond metropolitan centres was stated by almost all respondents as a barrier to compact urban growth. Respondents noted that semi-detached dwellings are seen as 'premium products', end-of-terrace units sell for more than mid-terrace while duplex units sell for less than houses. These market preferences influence site layouts and dictate terrace lengths.

Although duplex units or small apartment blocks are built as part of these developments to achieve densities dictated by planning regulations, developers' business model relies upon these units being sold back to the state for use as social and affordable housing due to a lack of appetite within the private market.

Developer 3 described this process, *"At the moment, with the current development standards, own door housing maxes out at about 31 units per hectare, so that falls short of the minimum 35 for Celbridge or Leixlip. You always have to introduce the apartments and duplexes to bring it up. Now, it's alright. We can offload a portion as social housing, but again, there is less demand for that."*

Architect 2 elaborated upon the reason these typologies are favoured neither by estate agents nor the market. *"There is a predisposition in house builders against duplexes… Estate agents don't like them because basically, you've got quite a nice unit just upstairs, but the problem is you only get balconies, so you've effectively got an apartment over two floors with balcony accommodation."*

Developer 5 stated, *"Traditionally, we at X haven't liked duplexes, I think largely because the ones that were built in the 90s and the noughties weren't very sophisticated. They were pretty ugly, looking very basic. We steered away from them, but we can't avoid it now. So, we are looking at different ways of doing it. We are looking at things like perhaps a shared garden area at the back, rather than traditional back gardens of 60 square metres, that you would have courtyards that would be shared by families. That could address a lot of the bins stores and bike store problems that I've been talking about earlier."*

AHB 1 noted issues in accessibility associated with duplex units. *"But the problem with duplexes is my client is very different to what the private sector client is; there might be two or three young kids. If we have a ground floor unit for an elderly person and we have a 2/3 bed duplex above that, I'm asking someone to drag a buggy, or they're shopping up two or three flights of stairs potentially."*

Figure 3. Duplex residential building (source Daft.ie)

All the private developer home builders interviewed relied upon a combination of in-house team expertise (customer research teams) and Estate Agents' knowledge to inform typologies who, hence, have a strong influence on house design and systems.

Developer 1 described this process, *"I have arguments with them [Estate Agents] about whether we should have a heat recovery ventilation in a house. They say 'oh no, people would prefer an extra toilet'."*

While Estate Agent 1 noted the lack of built examples of compact urban growth available to inform home buyers of possibilities. *"We've been advocates of low-rise medium density, we've been in Cambridge a couple of times, but we can't bring all the buyers to Cambridge to show them it."*

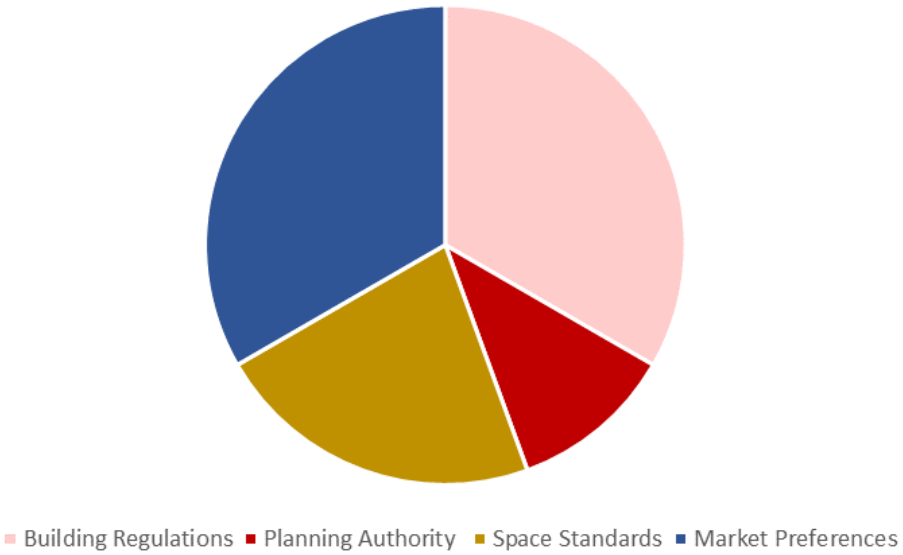

Figure 4. Industry expert responses to the question of what are the barriers to Compact Urban Growth?

2.2 Embodied carbon

Interviewees were then asked about the extent to which the stages of whole life carbon assessment influence design and construction decisions for these housing developments. The outcomes of the discussion are grouped under 3 overarching questions as follows.

2.2.1 Who is measuring carbon in the housing development industry at present in Ireland?

All developers, both private and public, responded that they are currently calculating the carbon associated with their developments; however, in most cases, this information has not yet started to inform any changes. Of the two architects interviewed, both stated that they are not currently calculating carbon, while the quantity surveyor we spoke to suggested that their profession is best placed to calculate embodied carbon.

Architect 1 referred to a first principles approach: *"We smuggled in a lot of thinking around this kind of stuff because it wasn't really on anybody's agenda."* They noted, *"Developers, from my point of view, are not really there yet. They're not forced to be there. Compliance with all the regulatory regimes is still very much their preoccupation."*

Architect 2 stated, *"Disappointingly no. We'd love to, but we haven't because we're mostly working in the private sector and haven't been asked to do it."*

Developer 4 stated *"We're asking our design teams to provide some analysis under embodied and operational carbon. We're still in the data collection stage of it… we'd obviously see an alignment between reduced carbon and reduced cost in that sense."*

QS1 noted, *"Last year, we developed a tool to do the upfront embodied carbon calculation… We're now rapidly developing a tool to model the whole life because the conversations have changed so quickly from just the upfront embodied to the whole life assessment. It will be part of our remit, as QSs, anything that needs measuring and quantifying should sit with us."*

2.2.2 How can embodied carbon be reduced in the construction of housing developments in Ireland?

In terms of reducing operational carbon, the majority of respondents stated that they had not commenced addressing this issue but suggested solutions.

Developer 2 noted, *"I think it has to be legislation. If not, carbon tax. That'd be another big stick to threaten people with."* Similarly, developer 5 noted, *"I think the general assumption is that there's going to be a carbon tax, which is going to impact the cost of concrete. We're trying to move away from concrete."*

All developers interviewed stated that they were looking at solutions relating to the embodied carbon of the dwellings alone. Developer 3 noted, *"Infrastructure is going to be a challenge because that's where we haemorrhage a lot of our money and a lot of our carbon, below the ground. We're looking at solutions for the house at the moment, but we need to come up with solutions for the infrastructure…. We're focusing on the units themselves and the houses and getting our typologies right so we can enhance our pre-manufacture value on those."*

Three out of the four private developers interviewed cited Modern Methods of Construction as a means of reducing carbon associated with these developments. Developer 3 noted, *"We are removing the brick outer*

leaf because it is a high carbon offender. We want to go with a lightweight product in this with a synthetic product to mimic brick in order to "bring the consumer on the journey."

Architect 1 noted, *"Our clients from the private side are more aware of it now, but the decarbonising of transport as a solution is their main interest."*

2.2.3 Are home-buyers concerned about carbon and/or Building Energy Rating (BER)?

In terms of the home buyers' attitude to carbon, Estate Agent 1 summarised their view of the situation: *"Of course, we want to buy organic if you could afford it, but if you can't, you can't."*, implying that a higher cost is associated with a lower carbon home. With regards to how this information is portrayed to the market they stated, *"It is less carbon footprint and more around community and diversity and biodiversity. There's a total acknowledgement in terms of the climate crisis, but we're not selling houses on the basis of the climate crisis."*

On the matter of BER ratings, Estate Agent 1 discussed the low impact from a cost perspective of different A ratings. *"When BER came in, there was a differentiation, and we'd be asked, and we're still asked, the difference between an A3 and an A1 or an A1 and an NZEB. To achieve those levels is really, really hard. It's nice to have, but it doesn't drive the value."*

Table 5. Indicative annual CO2 emissions and running costs for different rating bands for space and water heating. BER indicative annual CO2 emissions and running costs for different rating bands for space and water heating. Available at: https://www.seai.ie/publications/Your-Guide-to-Building-Energy-Rating.pdf

Rating	2 Bed Apartment		3 Bed Semi-D		4 Bed Semi-D		Detached House		Large house	
	Area (m^2)	75	Area (m^2)	100	Area (m^2)	150	Area (m^2)	200	Area (m^2)	300
	Tonnes CO_2	Cost (€)	Tonnes CO_2	Cost (€)	Tonnes CO_2	Cost (€)	Tonnes CO_2	Cost (€)	Tonnes CO_2	Cost (€)
A1	0.4	€140	0.5	€190	0.8	€280	1.1	€400	1.6	€600
A2	0.8	€280	1.1	€380	1.6	€560	2.2	€800	3.2	€1,100
A3	1	€350	1.4	€470	2	€700	2.7	€900	4.1	€1,400
B1	1.3	€440	1.7	€590	2.5	€900	3.4	€1,200	5	€1,800
B2	1.6	€570	2.2	€800	3.3	€1,100	4.3	€1,500	6.5	€2,300
B3	2	€700	2.7	€900	4	€1,400	5.3	€1,900	8	€2,800
C1	2.4	€800	3.1	€1,100	4.7	€1,600	6.3	€2,200	9.4	€3,300
C2	2.8	€1,000	3.7	€1,300	5.5	€1,900	7.4	€2,600	11	€3,900
C3	3.2	€1,100	4.2	€1,500	6.3	€2,200	8.4	€2,900	12.7	€4,400
D1	3.7	€1,300	5	€1,700	7.5	€2,600	10	€3,500	14.9	€5,200
D2	4.4	€1,500	5.8	€2,000	8.8	€3,100	11.7	€4,100	17.5	€6,100
E1	5	€1,800	6.7	€2,300	10.1	€3,500	13.4	€4,700	20.1	€7,000
E2	5.7	€2,000	7.6	€2,600	11.4	€4,000	15.1	€5,300	22.7	€7,900
F	6.8	€2,400	9.1	€3,200	13.6	€4,700	18.2	€6,300	27.2	€9,500
G	8.5	€3,000	11.3	€4,000	17	€5,900	22.7	€7,900	34	€11,900

This question was not discussed with other interviewees in any detail; however, Developer 3 noted that *"millennials are very much invested in sustainable development and a reduction of carbon."*

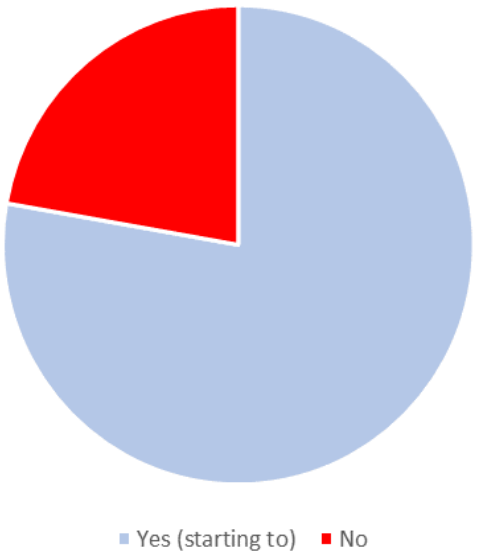

Figure 5: Industry expert responses to whether embodied carbon associated with developments is currently counted?

2.3 The Future

Finally, respondents were asked how they see these housing developments evolving by 2030.

The use of more **modern methods of construction** (MMC) was the most noted response to this question. Reasons noted for employing MMC included a diminishing labour force and the streamlining of the construction process. The ability to measure carbon was a secondary benefit of this approach. On MMC, QS 1 stated, *"I think the catalyst of carbon, the greater accuracy, and the reduction in waste… It brings a cost benefit as well because of the efficiency, so it's a win-win. Higher quality, lower carbon, lower cost, quicker. It needs the economies of scale."* Developer 4 stated, *"We are trying to get our standardisation in place and then the next element of that would be to pursue a lot more MMC, which will hopefully improve the embodied carbon within the projects as well."*

Issues with **the certification** of new materials (such as more natural insulation or alternatives to brick cladding) are limiting options for innovation. Developers 1 and 3 spoke of the lengthy timelines and high costs involved in this process. Developer 1 noted that the *"The certification process is so slow and so costly, we're looking at 18 months to get something approved, and then it is going to cost €60-70,000. So, people decide to just keep going as we are… it is a big restriction on how much innovation we can actually put into the homes."* While Developer 3 stated, *"certification could take you three to five years, it's quite constrained at the moment just to get one material certified in Ireland through the NSAI certification process."*

Developer 3 also noted the need to increase **density**. *"We need to increase density. At the moment it's 30 to 50, now that's changing to 40 to 80. I'd be cautious about going up to the 80. If we create a model where we apply these changes that we are saying we're still going to increase our densities by 10 units per hectare… You can't have a low-density housing scheme and then a very high-density scheme right beside it in an area*

where there's no public transport." Developer 1 also referred to a reduction in dwelling sizes. They stated, *"It's also about reducing the size of our homes because the size of our homes in Ireland is crazy compared to the rest of Europe. So, if we can reduce that, then we're reducing materials but yet giving people the same functionality in the home."*

Developer 2 focused on operational carbon, stating that **energy efficiency** is where they see the largest impact, *"the biggest dial turner that I can see now, based on what we know today, is energy efficiency."* Developer 5 also noted their attempt at addressing this issue: *"We have been unable to do anything in terms of district heating to date, not for the lack of asking the question on our side.",* while Developer 1 noted, *"We are definitely looking at more terraced houses because you can have more energy-efficient homes as they don't have as many exposed facades to lose heat through; that's something we're actively looking at."*

2.3.1 Limitations and Assumptions of the Study

It is accepted that a larger sample size would be beneficial in validating these findings. Five of the ten interviewees represented developers, and therefore, it would be useful to expand the selection to include additional Approved Housing Bodies, Quantity Surveyors and Architects.

2.3.2 Conclusion & Next Steps

Following these interviews, some of the participants shared information on their most viable recently completed housing developments, which we have analysed in the 'Embodied Carbon Impact of Urban Sprawl' section of this report. It is hoped that these discussions are the beginning of an ongoing collaboration with those who have taken part. Please refer to the Guidance Document in Appendix 1 for a series of recommendations informed by these conversations and the embodied carbon calculations noted above.

We wish to warmly thank those who participated.

3 Embodied Carbon Impact of Urban Sprawl

3.1 Whole Life Carbon Assessment - Scope, methodology & results

3.1.1 Scope of the Study

The results presented here are for a recently built, low-rise suburban development. We chose to look at the typology that was identified as viable by developers during the interviews undertaken during the research. This development was chosen as it represented a typical condition in current Irish private sector housing production, where relatively low-density, semi-detached and terraced house types are supplemented with duplexes and apartment buildings to bring up the density, in this case to an overall figure of 50 dwellings per hectare. Two building types have been analysed, a semi-detached house and a duplex apartment building. For comparison purposes, a semi-detached house in a second project of a similar type was analysed.

An innovative aspect of this study is that in addition to estimating the carbon emissions associated with the construction of the dwellings, external areas and infrastructure have also been assessed. While there are limited studies available on the carbon impact of different residential typologies, to date there are few existing studies that include construction outside of the building envelope. These areas include roads and footpaths, green areas such as swales, and the various infrastructures that serve the dwellings, such as foul and surface water, public lighting, electricity supply and telecoms. In order to assess the relative impact of these parts, separate assessments were made for the dwellings, their plot (front and back gardens), and external public areas and services. It is worth noting that in this type of development, it is common for new roads and infrastructure to be provided by the developer and for these to be later taken in charge by the Local Authority under the Planning and Development Act. This has no impact on the overall construction, as the specification of roads and services are regulated by national bodies such as Irish Water and Transport Infrastructure Ireland.

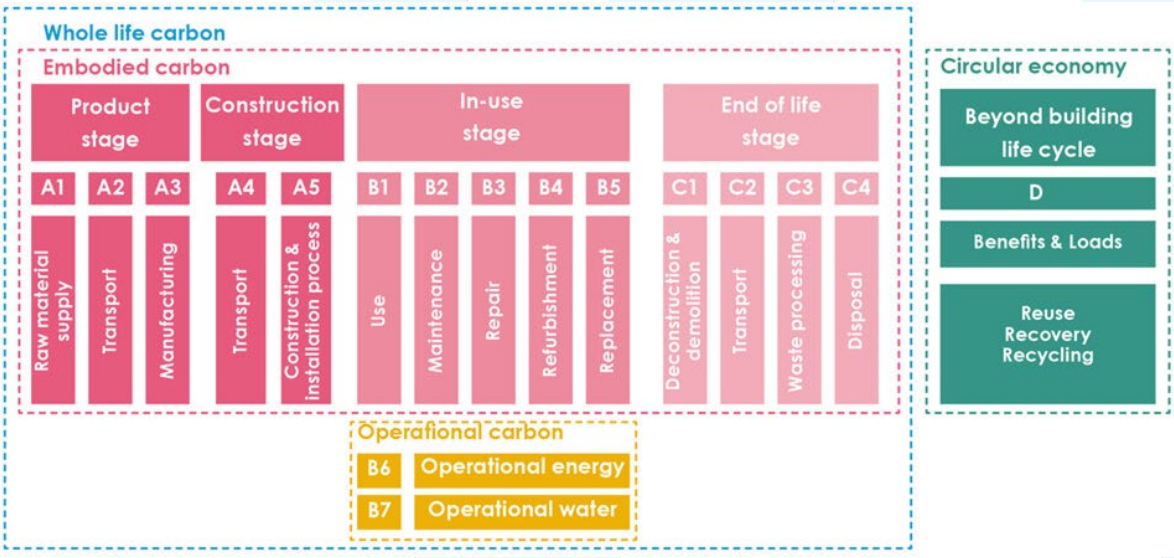

Figure 6: Embodied Carbon Primer Diagram (Source: LETI)

The

research has been carried out according to the EU Levels system Stage 2 'Detailed Design and Construction. The study mainly focused on life cycle stages A1-A5 that including the manufacture of materials, their transport to site and construction works. It was considered that insufficient data was available to allow for assessment of later stages, although it is worth noting that in residential construction life cycle stage B that deals with in-use carbon emissions, maintenance and replacement can have a high contribution due to domestic heating systems and appliances.

3.1.2 Methodology

As noted above, the study has calculated the embodied carbon impact of buildings, external areas and infrastructure as required by the scope of EU Levels. This is also in accordance with carbon accounting methodologies established by RICS in the UK, which are also referenced as part of the EU Levels Framework. A methodology was developed that breaks carbon assessment down according to categories of urban morphology, in this case separately measuring buildings, plots (front and back gardens), and external public areas. For each of these categories, drawings were prepared that estimated the surface areas of roadways, footpaths, and external landscaping. Separate drawings were also prepared that calculated the length of all service runs and connections, listed under the relevant type of infrastructure utility such as surface water, foul water, electricity supply etc. A siteworks Bill of Quantities (BoQ) was then prepared that quantified these external surfaces and services in a form that could be used for the embodied carbon assessment.

The results show that the external areas and their infrastructure form a significant part of the embodied carbon of residential construction. For the low-rise semi-detached dwellings, these represent an additional 32% of greenhouse gas (GHG) emissions. The research, therefore, suggests that if future policy requires a holistic carbon assessment of new housing developments, then the scope should go beyond the dwellings themselves to include the entire site and its infrastructure.

3.1.3 Limitations and Assumptions of the Study

Finding sufficient data to carry out detailed Life Cycle Assessments (LCA) proved difficult, and certain assumptions have had to be made as a result. It was not possible to obtain M&E services information for any of the projects, so information based on similar residential projects has been used from studies carried out by the Chartered Institute of Building Surveyors (CIBSE). Information on the internal finishes of the units was not provided, so these had to be estimated using standard specifications, referring to online estate agents' brochures for visual information. Bill of Quantities (BoQ), where provided were not sufficiently detailed to be useful, so this required the creation of BoQs for both buildings and siteworks elements.

The three LCA tools used for carrying out the LCAs of the study projects each had their advantages and disadvantages, briefly summarised as follows:

Carbon Designer for Ireland: This is a high-level tool, useful for initial appraisals of carbon efficiency at the early design stage. It does not allow for sufficient user input or customisation of construction elements suitable for residential construction to enable accurate studies to be completed.

OneClick LCA: Currently the industry-standard software used in Ireland and the UK. OneClick allows for much greater user input regarding building parameters and forms of construction and can provide more accurate results than Carbon Designer. It makes assumptions as to the nature of construction, and these assumptions are not always visible or editable by the user.

Upfront Tool: This is a detailed spreadsheet based in Excel that allows for complete control of the material quantities and characteristics to be entered. It therefore can provide results that are highly accurate. There is

significant work involved however in creating the quantities and these need to be estimated using a separate BoQ and sometimes separate drawings. In order to obtain a breakdown of the results by material or form of construction, information needs to be extracted using Pivot tables and converted into graphs and this is also time-consuming.

3.2 Whole Life Carbon Assessment - Results

3.2.1 Project 1: Semi-detached House

The first building studied was a semi-detached house, the most common dwelling type in the primary study development, known here as 'Project 1'. The embodied carbon for this type was measured at 366KgCO_2e/m^2, for life cycle stages A1-A5. Figure 7 breaks this result down by building element and material. As per Figure 7, significant carbon is expended on the ground floor, substructure, and external walls.

Project 1 - Semi-detached House - 366KgCO_2e/m^2

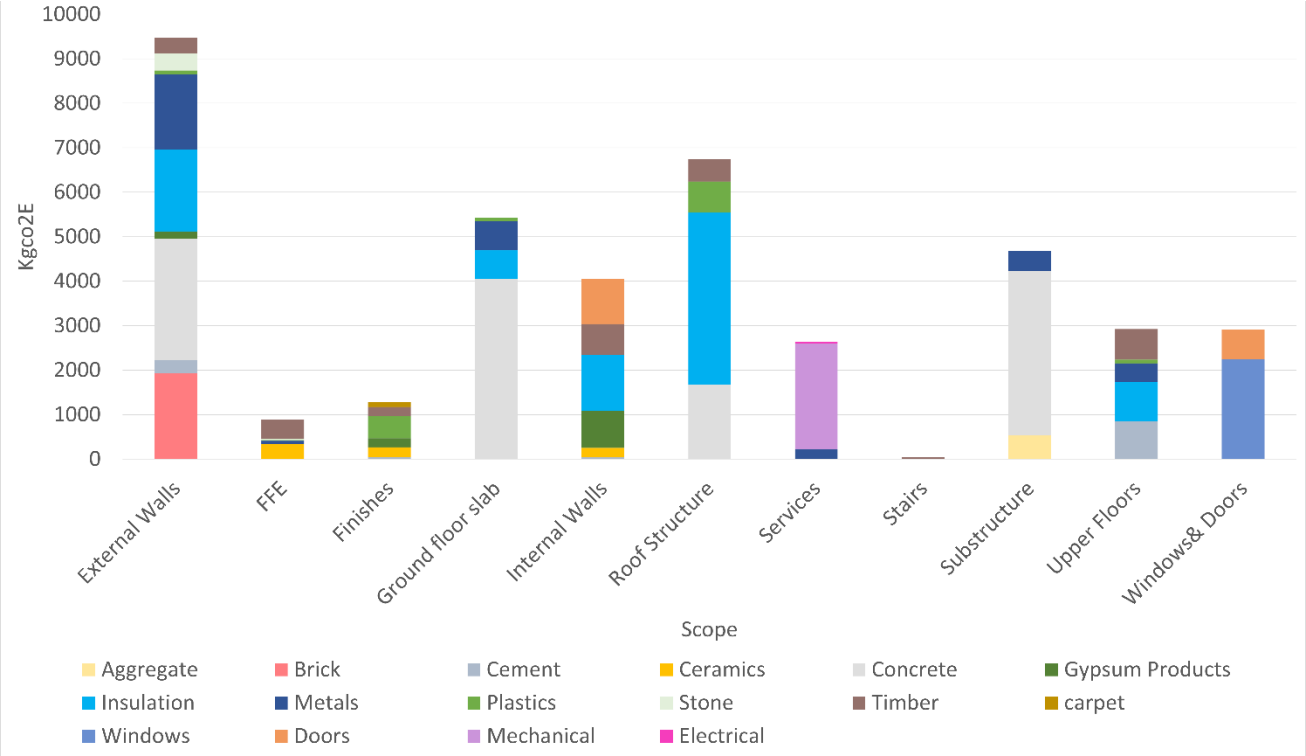

Figure 7: Breakdown of Results by Building Element: LCA Stages A1-A5

Concrete is the most carbon intensive material, closely followed by insulation, which is mostly of the PIR type. Given these results, we could question the logic of cladding timber frame buildings in rendered concrete blocks and brick, given the high relative contributions of these materials to the carbon count. The roof is also a significant source of carbon emissions, due to the concrete tile finish and the amount of material generally required to create the large volume of the pitch structure. This suggests that this house type could be made more carbon efficient either by providing a simpler structure, such as a low pitch for a flat roof or by providing for the possibility of future upward extension into the roof space. Note that the figure for services (M&E) is low as only stages A1-A5 were analysed. This figure would rise considerably if Stage B (in-use) carbon were included, as replacement cycles and refrigerant leakage for heat pumps can be considerable.

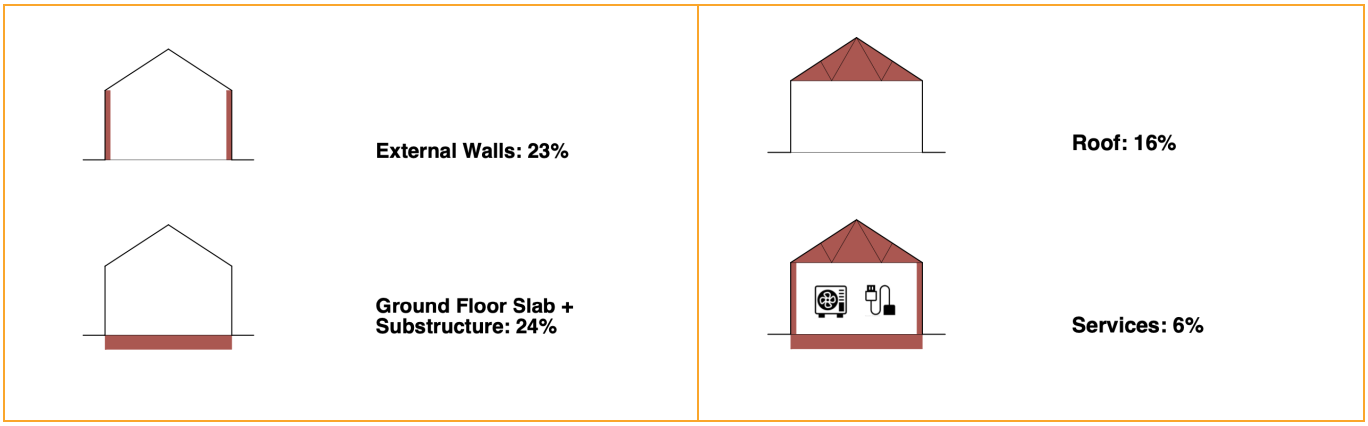

Figure 8: Carbon Hotspots of Semi-detached Dwelling

3.2.2 Project 1: Duplex Dwellings

The duplex dwelling has a higher figure of 435KgCO_2e/m^2. This is to be expected, as the ground floor unit and first floor slab of this building are built in concrete of various types. This is due to the requirements for fire separation between the stacked units as set out in Part B of the building regulations, resulting in concrete ground floor walls and a concrete first floor slab. Another contribution to the high external wall figure is the increased area of brickwork - a high carbon material. This is due to the fact that this dwelling type has no rear garden and has two street fronts, with a consequent planning requirement for brick on both sides. The external Part M compliant stairs also appear as a carbon hotspot, being made of in-situ concrete. Considering the modest contributions of the other materials seen in Figure 9, it is reasonable to assume that a potential timber frame version of this building would create significant carbon savings, if this could be safely certified under Part B.

Project 1 - Duplex - 435KgCO2e/m2

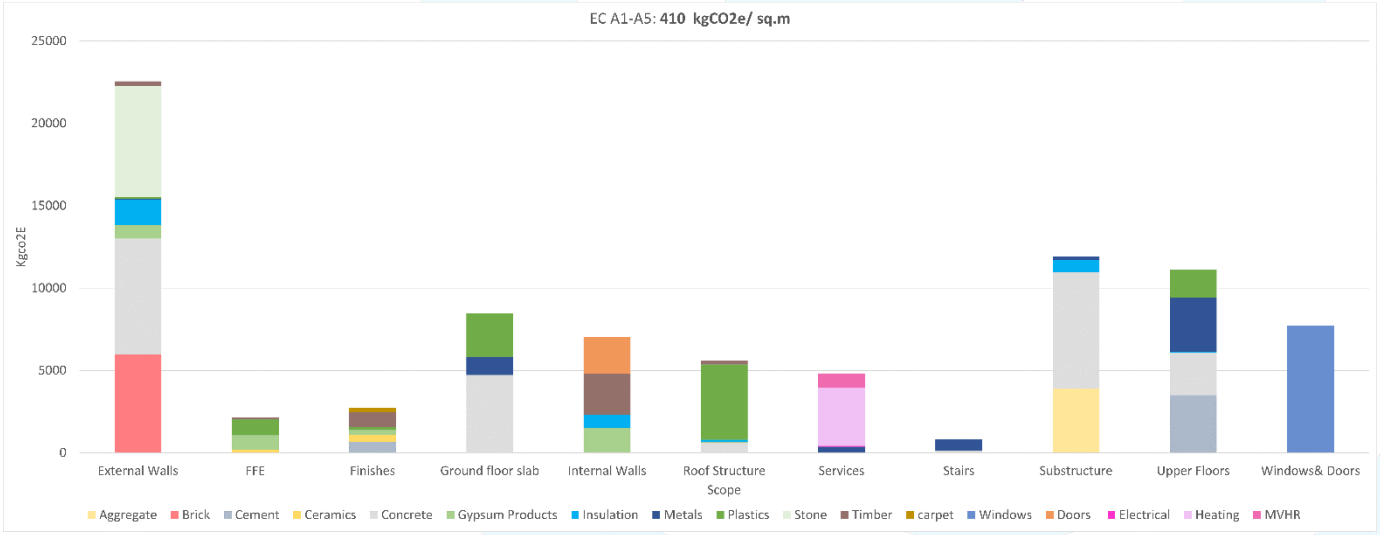

Figure 9: Breakdown of Results by Building Element: LCA Stages A1-A5

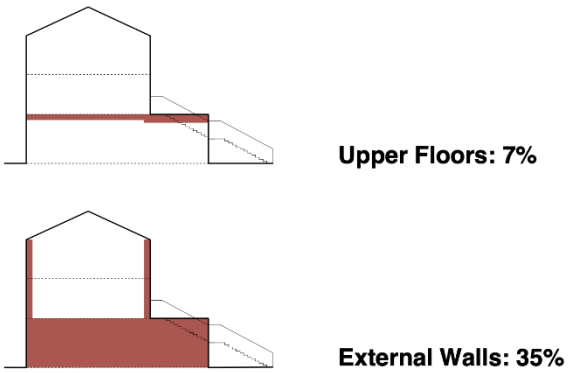

Figure 10: Carbon Hotspots of Duplex Dwellings

3.2.3 Project 1: External Areas and Infrastructure

For a typical semi-detached dwelling in Project 1, the external areas and infrastructure make up an additional 27% of the total embodied carbon of the dwelling, measured for life cycle stages A1-A5. This includes all areas external to the dwelling, and breaks down into 21% for the public areas, and 6% for external private areas. This is a significant part of the overall embodied carbon footprint of the development, and one that to date has not been counted in other studies of this type.

For the duplex dwelling, the external areas and infrastructure make up an additional 7% of the total embodied carbon. This is relatively less than for the semi-detached dwelling. This is due to the duplex dwelling being more efficient in terms of density therefore requiring less road, and more efficient to service, as the stacked dwellings can share service connections from the public infrastructure, rather than requiring individual connections for each dwelling.

Assessing the results for the external areas and infrastructure, it can be seen that the largest source of carbon is due to circulation areas such as roads and footpaths, with concrete and asphalt contributing the majority of emissions. Surface water infrastructure also appears as a significant carbon hotspot, and the high quantity of plastic visible in this result is largely due to two 100-metre-long attenuation tanks made from polypropylene that are buried along the western border of the site. Plastics are responsible for the largest emissions by material in the study, representing 330 tonnes of CO_2e, followed by concrete at 293 tonnes. Significant quantities of plastics are also found under the Sustainable Urban Drainage (SUDs) infrastructure. This refers to green areas such as swales or permeable paving for car parking that are designed to deal with surface water run-off. The large volumes of plastic are mostly due to PVC pipework that connects the underground drainage elements and brings the water to the large attenuation tanks referred to above. Figure 11 summarises these results.

Project 1 - External Areas and infrastructure - 8850KgCO$_2$e (per dwelling)

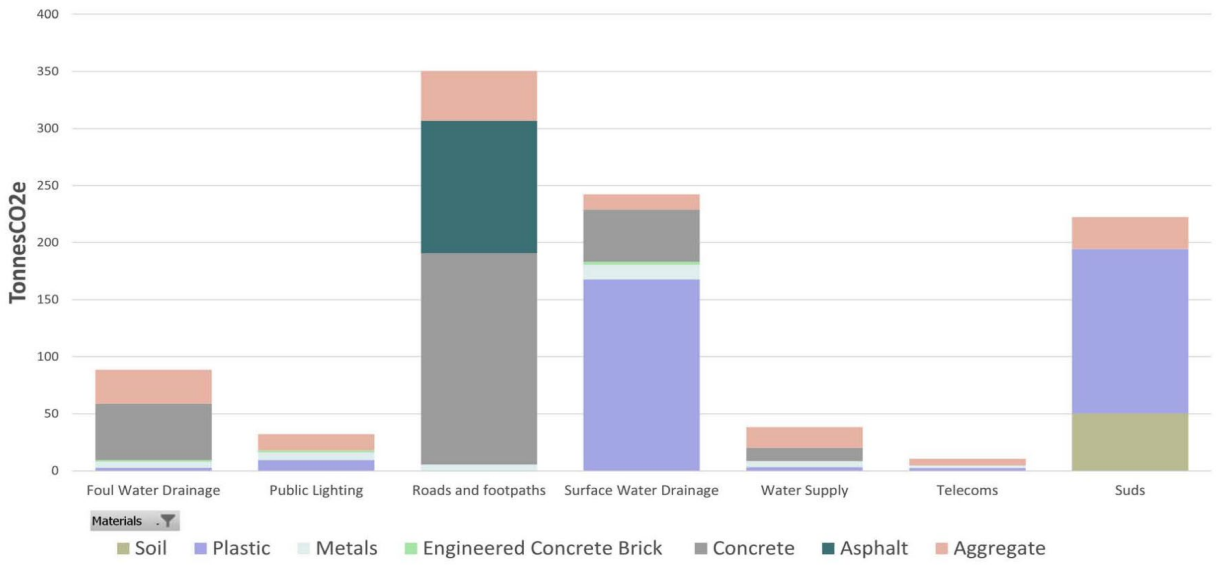

Figure 11: Carbon Hotspots of Duplex Dwellings

Semi-detached houses from a second project were analysed for comparison purposes (Figure 12). There were no duplexes or other denser dwelling types to compare, and data on the site-works was not available. The figures for this dwelling were slightly higher, largely due to higher specification of some items such as windows and external walls.

Project 2 - Semi-detached House - 401KgCO2e/m2

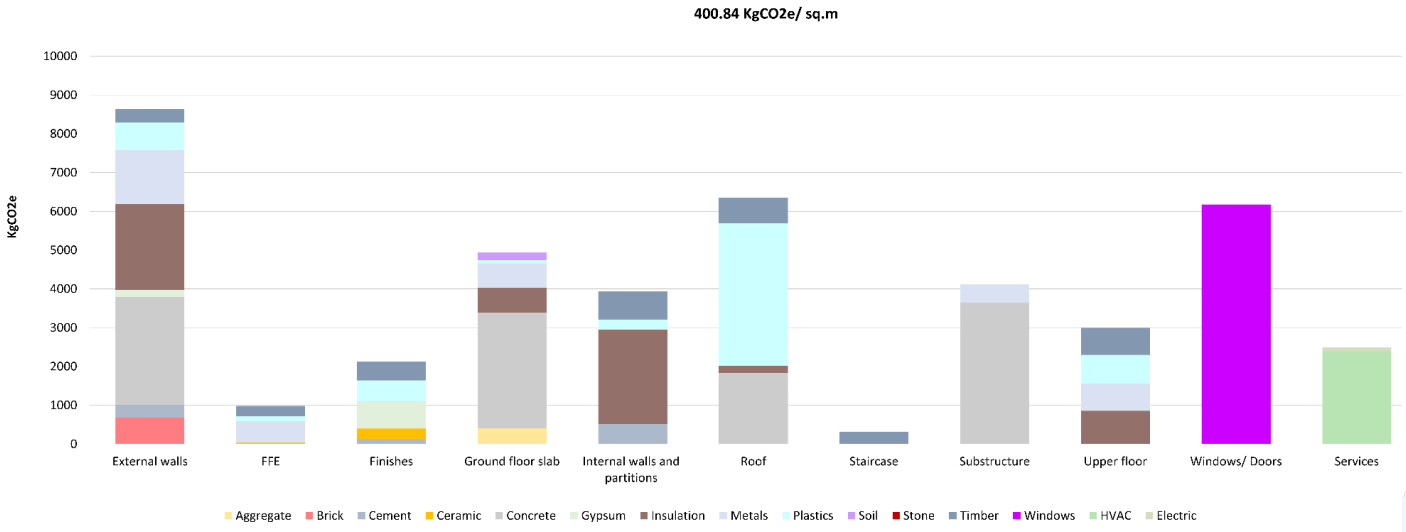

Figure 12: Breakdown of Results by Building Element: LCA Stages A1-A5

4 Learning from Case Studies

4.1 Low rise, medium density housing developments

We have selected a case study project to illustrate possibilities for achieving lower carbon in low-rise, medium-density contexts. Figure 13 and Figure 14 present the site plan and a part section for this case study project. Based upon the findings from the earlier Whole Life Carbon study in Chapter 3, features of the case study project which reduce the amount of embodied carbon required have been identified. These features are grouped according to the recommendations in our guidance document (Appendix 1).

4.1.1 Goldsmith Street, Norwich by Mikhail Riches Architects

Figure 13: Site Plan

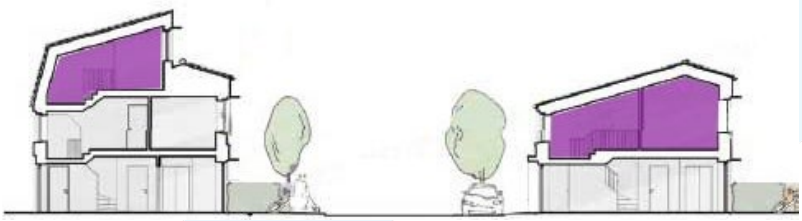

Figure 14: Part Section

4.1.2 How does it perform under our set of recommendations (Appendix 1)?

01 Site Location:
Brownfield inner city site (*previous housing demolished, which will have an associated carbon footprint)

02 Site Layout:
Efficient street layouts and access provision resulting from connecting to the existing adjoining network of streets.

03 Car Parking:
80 unassigned off-curtilage car parking spaces are provided for 105 homes (0.76 spaces per dwelling).
The quantity of drivable streets is reduced through the provision of pedestrian only access to the centre of the development.

Rear access is provided to approximately 66% of dwellings, which facilitates secure bicycle storage and location for bins.

04 Water Attenuation:
Connection into the existing system facilitated due to site location.

05a Envelope | Roofs: There are no uninhabited attic spaces. Roof profiles are designed to maximise habitable space.

05b Envelope | Walls: The quantity of external walls is reduced. All dwellings form terraces, which reduces the number of external walls.

06 Density: 82dph distributed evenly through 2-storey row housing and 3-storey end of row stacked flats. Each dwelling has its own front door at street level.

Operational carbon benefit: Blocks are orientated north-south, with 75% of habitable rooms aligned due south. Solar shading prevents overheating in summer. Roofs are canted at 15° to maximise solar gain and eliminate overshadowing between terraces, as noted by Hattie Hartman in the Architects Journal article “Mikhail Riches in Norwich: Passivhaus for the mass market”.

Table 6. Barriers to achieving this layout in Ireland.

Goldsmith Street	Irish context
Terraces are set out with a distance of 14 metres façade-to-façade and back-to-back dimensions.	Current regulations dictate 22 metres (however, the draft SCSG proposes a reduction to 16 metres).
3 stacked single-storey apartments with own door access bookend the terraces. - Accessed by TGD K staircases. - Constructed in timber frame.	TGD M staircase (rather than TGD K) is required to achieve TGD B compliance, resulting in much greater quantities of space required for circulation. Achieving compliance with TGD B is difficult.
Car parking ratio of <1 space per dwelling	Location dependent, reliant upon Local Authority implementation of recommended minimums.

It is recognised that not all issues are dealt with by this project, and it is, therefore an aspiration of the project that the compendium will grow over time. We have outlined the selection criteria in the table below and provided further information on two projects for further analysis.

Further reading and articles referenced:

Mikhail Riches in Norwich: Passivhaus for the mass market Architects' Journal
Achieving Passivhaus at Scale by David Moorcroft and James Turner
Stirling Work - The passive social housing scheme that won British architecture's top award Passive House+

Table 7. Case study selection criteria.

		Why?
Density	60-80 dph	RIAI document 35- 80 dph Developer interviews noted that they can achieve 50 dph
No. of storeys	4-6	https://www.londonfestivalofarchitecture.org/blog-post/high-density-low-rise-zero-carbon/
Location	Ireland & UK	UK - alignment with our TGD Accepted limitation of this study is the exclusion of European case studies.
Other	Referenced in Irish housing policy documentation	Projects that the Irish market is already familiar with.
No. of dwellings	Ideally >50 dwellings	Housing at scale- aligns with the business model of those interviewed/largest impact
Construction technique	Familiar construction method.	Easily replicated in the Irish market

Table 8.Selected Case Studies.

Project name	**Goldsmith Street**	**Abode at Great Kneighton**	**O'Devaney Gardens Phase I**
Image			
Density	82 dph	44 dph	77dph
No. & types of dwellings	105 homes Includes: 45 houses (40 x2B, 5 x 4B) 60 apartments (1 x 3b, 3 x 2B, 56 x 1B) All own entrance door at street level. All terraced.	First phase of a wider master plan of 2,250 homes 444 homes Includes: detached, semi-detached, terraced, maisonettes, apartments	56 homes Includes: 14 2-storey houses, apartments, duplexes & 3-storey houses, shared courtyard.
No. of storeys	2-3	2-5	2-4
Parking	80 spaces (73%)	680 spaces	

Location	Norwich, UK	Cambridge, UK	Dublin 7
Completion date	2019	2014	2023
Client	Norwich City Council	Countryside Properties UK	
Architect	Mikhail Riches	Proctor & Matthews	Dublin City Council
Main Contractor	RG Carter	Countryside Properties	PJ Carey (Contractors) Ltd.
Tenure	Social rent	40% affordable	Social
Other reasons for selection	Presented at IGBC Better Homes Conference 2022. Referenced by a number of participants in the semi-structured interview phase of this study.	Included as a precedent in the RIAI's Low Rise Medium Density Housing 2023 report. Referenced by 1 interviewee during this study.	Included as a precedent in the Draft Sustainable Compact Settlement Guidelines 2023.
Construction technique	Timber frame (off-site), brick & render outer leafs, pan tiled pitched roofs.	Structure unknown. Brick and timber cladding.	Cavity wall with brick outer leaf, zinc roofs
Site typology & landownership	Urban brownfield site (therefore connections to neighbouring developments more achievable than on edge-of-town greenfields sites.)	Sub-urban brownfield site former Clay Farm No permitted development rights at Abode, any change is controlled through planning.	Urban, brownfield
Further reading on the project	https://passivehouseplus.ie/magazine/new-build/stirling-work-the-passive-social-housing-scheme-that-won-british-architecture-s-top-award https://hdawards.org/scheme/goldsmith-street/ https://ukphc.org.uk/wp-content/uploads/2017/09/Achieving-Passivhaus-at-Scale-David-Moorcroft-Norwich-City-Council-James-Turner-Mikhail-Riches.pdf	https://www.proctorandmatthews.com/case-study/abode-great-kneighton http://www.distinctively-local.co.uk/storage/app/media/Distinctively-Local-Fnal-Report.pdf p.106	https://miesarch.com/work/5124#:~:text=O%20Devaney%20Gardens%20Regeneration%20Phase,density%20of77%20units%20per%20Hectare. http://www.dublincityarchitects.ie/odevaney-gardens-regeneration-phase-1-athnuachan-ghairdini-ui-dhuibheannaigh-ceim-1/

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Appendices

Appendix 01 - Guidance document

“Viable Homes: Guidelines for planners on the design and building of low carbon, low rise, medium density housing in Ireland” – download here

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