Extending the Extension

A Study into the Synthesis of Spatiality and Embodied Carbon in Future Alterations of Suburban Dublin.

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Abstract

Semi-detached houses became a significant component of the housing stock in the suburbs of Dublin, Ireland during the 1960s. However, the new generation of occupants harbour a desire to modify these houses as a manifestation of their family's identity, desires, or daily routine to make them their homes. There is already a significant body of research into the material alteration of houses and their motives, however much of it predates the urgency of the climate crisis in which we find ourselves, thus there is no reference to the carbon further embedded into these homes by their occupants. The carbon impact of individual developments may seem minute relative to larger structures in cities around the world, but the multitude of constructions such as small back and return extensions on homes generates a surprisingly comparable figure annually.

This research paper investigates the alterations of a set of suburban houses in North County Dublin; the occupant's stories, motives for modifying, and their satisfaction. In parallel, the embodied carbon associated with these alterations is documented using the Inventory of Carbon and Energy (ICE) database. The research looks at the balance of the domestic value that these new spaces have provided to the homeowners, in comparison to the corresponding carbon data, and the effect that architects understanding the anthropological impetus behind an urge to alter could have on the communication of a more appropriate, carbon conscious design proposals to homeowners.

Keywords: Drawing, Sustainability, Embodied Carbon

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Introduction

The field of altering, reconfiguring, and extending dwellings is one that is thoroughly researched already. There are examples of sociologists studying the work of architects, such as Boudon's work on Le Corbusier's housing at Pessac (Boudon, 1966), as well as architects applying sociologists' theories to buildings to better understand the abstract concept of inhabitation (Pike & Scanlon, 2011). As Ray Lucas (2020, 45) puts it, 'home is a perpetually unfinished project and is constituted of what we do there'. Not only will how one uses certain spaces change as time goes on, thus changing the space itself, but new occupants will also result in a more extensive modification of the house. Be it new demands or new users, the 'continuum' (Lucas, 2020, 45) of spatial changes is often expressed through modification to the fabric of the home.

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In the introduction to 'On Altering Architecture' (2006, Pg. 1) Fred Scott spoke about the three fates of a building once completed; 'to remain unchanged, to be altered, or to be demolished.' It is not often one finds greenfield sites for a new build, nor for a house to remain untouched, and it is the least favoured course of action environmentally to demolish an existing structure. Developers may argue otherwise, as their business model and construction profits may take precedence over the sustainability of the built environment and complications that may occur from retaining buildings. However, according to the World Green Building Council in their report entitled 'Bringing Embodied Carbon Upfront' (2019, Pg. 16), 11% of global energy-related carbon emissions are from the materials and construction in buildings, so action must be taken. Similar to the anthropological and sociological studies of dwellings, there is plenty of research ongoing about the impact of embodied energy and carbon in the construction sector.

> *Ordinary people, on the other hand, do not concern themselves with looking at their houses, they are more concerned with living in them.*

- Phillipe Boudon, Lived-In Architecture: Le Corbusier's Pessac Revisited, 1966

Boudon's recognition of architecture's role differing in the life of those who design and those who occupy was seen as an early catalyst in this research to link why people alter aspects of their homes and the carbon repercussions of these decisions. Confining the research to a single housing type such as the semi-detached suburban house provided an adequate scope, whilst it would also limit the solutions provided for these extensions to certain widths, spans, and heights. In Boudon's words, 'standard components are letters, with those letters in a particular way, you have to spell out the name of your future house owners'.

The two strands of research could be simply defined as qualitative and quantitative. On one hand, the qualitative is something that architects are entirely conscious of through the design stage, in discussions with clients, identifying what they like about their homes and what they wish to improve. This part of the research takes the form of interviews with residents of the houses, and can thus be translated into drawings to express the cherished existing or speculative hopes, as it is in practice. On the other hand, the quantitative aspect of this study is the embodied carbon that remains after the design is finished and after the house has been occupied. These values are calculated using the ICE Database V1.6a, published by the University of Bath (Hammond & Jones, 2008), which, unlike the previous method, often happens in the post-occupancy stage in a professional setting. It is also important to record what is being removed during the process of these alterations. There can be a tendency to remove and forget the unwanted walls and doors as soon as possible, but if the materials are not correctly recycled, which was impossible due to the construction of these houses, their carbon impact must be considered. These methods separately are direct

recordings in their own right, but the balance will need to be struck in how they coalesce together into a drawing practice that can inform while designing.

The research in this paper aims to question how architects represent the spaces that homeowners hold dear with our knowledge of embodied carbon inefficiencies in a way that begins to discuss carbon, not as a malignant presence, but as a positive design constraint to be considered at an early stage. With this knowledge, what changes can be made, be it planning regulations or the iterative nature of design, that will incorporate the importance of embodied carbon and lifecycle flexibility, in particular with housing extensions as they occur often, consist of comparatively smaller financial fees, and contain a close relationship between the client and architect? Furthermore, how should fundamental changes to the designing of home alterations be communicated between all relevant stakeholders?

The Semi-Detached Typology

While the disconnect between designer and inhabitant is not always there, as the house or set of houses may not be 'designed' with an architectural ethos behind it, the observations on how people further developed their homes, and the suggestions as to why they made the decisions that they did in 'Le Pessac Revisited' were more pertinent for the research conducted in this paper. Like many parts of the western world, Ireland is in the midst of its housing crisis, whilst also seeing an alarming amount of its existing buildings falling further and further into dereliction and disrepair. The paper looks to focus on the renovation of a single dwelling at a time, as a means to understand this crisis at a microscopic scale. Furthermore, the size of an extension project is the most manageable for an architecture practice of a small scale, along with one-off houses, and would be how many small practices build their portfolio, especially in Ireland due to our procurement policy. Thus it is not only the housing typology that is common but the brief for the architect.

Figures 1 & 2 – Plan of Research Scope. Author's own.

Figure 3 – Elevations of streets in Research Scope, Author's own.

Figures 4 – Graphics showing the growth of semi-detached housing in suburban Dublin in the 1960's and 1970's. From J. Murphy's *The Semi-detached house: its place in suburban housing* (1977).

As mentioned previously the semi-detached housing stock that is focused on in this study surrounds due to its prominence in the development of Dublin suburbs. However, due to their more recent construction, the reflection and research surrounding them may not be as substantial as other, more documented typologies such as the Georgian terrace. Research compiled by James D. Murphy (1977) about the housing type's rise to prominence in suburban construction in Dublin, has helped identify similarities between the houses in this study and a wider context of Dublin housing estates built at the same time. Firstly, there is a clear indication from Figures 4, that significant growth in semi-detached housin g occurred in the period between 1965 and 1974. Many were built using nine-inch concrete blocks as the forms of houses in Portmarnock correspond to those depicted in Figure 7. The detail was taken from first accounts from discussions with one of the occupants of the houses, as well as the establishment of a quarry at the top of the road. Furthermore, Murphy conducted this study as a Cement-Roadstone housing research fellow.

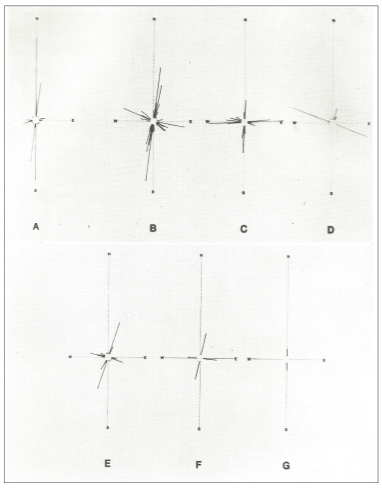


Figure 5 – Orientation of Dublin housing. From J. Murphy's *The Semi-detached house: its place in suburban housing* (1977).

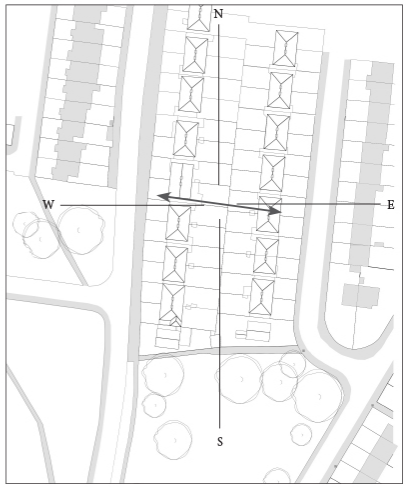


Figure 6 – Orientation of housing in research scope. Author's own.

When surveying ten building firms between 1973 and 1975, Murphy found that 70% of the houses these firms were producing were semi-detached (1977,40). Regarding plot ratio, Murphy states that houses built since 1960 vary between 1:3.5 and 1:4.3 (1977, 30) which would be outside of the average ratio on this study's houses of 1:2.2. This discrepancy could be due to the extensions built since, however. When discussing orientation (1977, 48), Murphy suggested there was very little consideration given, even in larger housing estates. While in Figure 5, the diagram denoted 'F', identified as an estate of similar scale and orientation to the houses in this study (see Figure 6), Murphy emphasizes that, overall, there is a 'lack of concern for orientation in the layout and design of the most common housing type [semi-detached] being built for the private sector.'

The houses that were studied for the early stages of research last year were clustered around these two parallel streets in North County Dublin. These houses were chosen not only because of their type but also because semi-detached housing type is common in the city of Dublin and surrounding areas, but also as there is an abundance of alterations built on this specific road, be it through planning or through exemption. The rows of houses back onto each other, either east or west facing, allowing for south light to pour into the back gardens, with one road enjoying the morning sun whilst the other receives it in the late evening. The standard semi-detached houses were initially built with carports that allowed vehicles to drive through into the back garden. Each of the houses highlighted has converted these carports in the '70s and '80s as the first step in the renovation as the primary structure was already built and one was not adding to the footprint of the house, be it as a more modern garage or integrated into the domestic spaces.

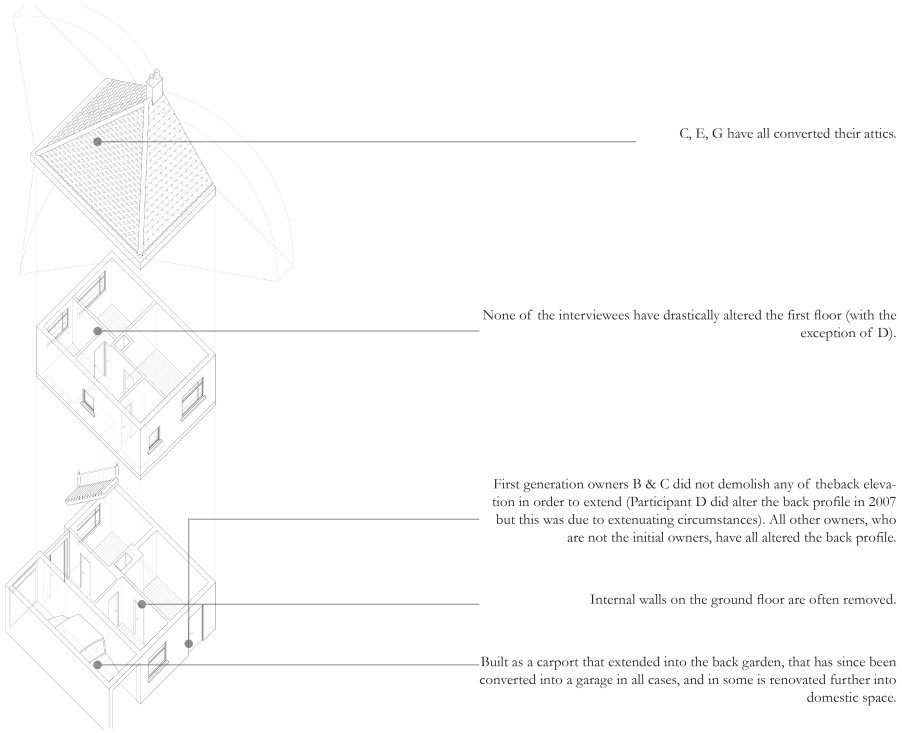


Figure 7 – Axonometric showing the standard construction of homes within the research scope. Author's own.

Habitus

The work of French social theorist Pierre Bourdieu was first introduced into my research through the essay by Pike, Scanlon, et al. regarding the social anthropology of the Dublin extension and its relevance to 'Habitus', Bourdieu's theory regarding socially ingrained dispositions, and how they arise. Pike and Scanlon's description of a house extension is not just as an extrusion of space and matter, but 'invariably a more invasive procedure' (2011, 318);

> *The extension can involve as much demolition as it does construction, clearing away old structures. Previous 'ad-hoc' extensions, and removals of walls to connect the new and the old. Normally, the addition of an extension to a dwelling can bring about the reconfiguration of a life pattern by introducing new spatial arrangements and elements that modify relationships between existing ones.*

The use of the term project, not just as a noun but as a verb, by Pike and Scanlon to define an architect's work as 'an intense speculation of a very precise nature' was of particular interest to me, and I began to see that it may not be just intense speculation, but intense observation as well, through the houses around me. Whilst this essay focused on the architect's role in projecting a social scenario within a domestic setting, I felt my role may be to hear and observe the existing settings, and project on the more quantifiable aspects of the houses in my research.

Bourdieu's theory of Habitus was heavily influenced by the writing of German art historian Erwin Panofsky, for whom Bourdieu wrote a postface in Panofsky's book 'Gothic Architecture and Scholasticism' when translating it into French. Within this book, Panofsky outlines the radical shift in educational and professional culture during the period, and how that manifested itself in its architecture. As Panofsky says (1957, 29-30), 'The men of the twelfth and thirteenth centuries attempted a task not yet clearly envisaged by their forerunner….. the task of writing a permanent peace treaty between faith and reason.' It could be suggested that to achieve an architecture responsive to the climate emergency, how we are trained as architects needs to consider the balance of the quantities of specifically embodied carbon with the quality of space we wish to create.

Ultimately, this variation leads to a large set of alterations that are not fully documented, which could result in considerable incomplete calculations of embodied carbon at a city-wide scale.

Bourdieu's other theories of 'the anatomy of taste' and the fraction of production between two fields, (Webster, 2011, 45), (which discuss restricted production, and those large-scale production, were also of interest to me as I began searching through local authority websites to identify what public information I could obtain on other extensions. This was not meant as a critique of class, as Bourdieu went on to research , but more to understand what information was available to whom on the extent of alterations occurring in each house. While some house owners apply for planning, others ensure that they do not impinge past the regulations that allow exemption from planning permission. Others employ architects (who could be seen as those within the 'restricted production' field) to draw their alterations, whilst others have the capabilities themselves or have an acquaintance that is willing to draw up the works for a builder. Ultimately, this variation leads to a large set of alterations that are not fully documented, which could result in considerable incomplete calculations of embodied carbon at a city-wide scale.

Regulations

In Reinier De Graaf's short essay 'His Architect' (2017, 334-335), he examines the individual architect, one who views architecture as purely a tool for capital; he sees 'not composition or ideology but profit' as the most important thing. One particular quote stands out;

> *People say the developer's methods are unlawful, but that is not the way he [the architect] sees it. To him, his methods are just about using the law to his best possible advantage. The law is not a moral code but an instrument with which to organise his labour; the residual space left over by the law is just as much part of the law as the articles of law.*

Whilst this piece by de Graaf seems excessively nefarious, surely if that mentality of using one's understanding of law as an architect to benefit your own means exists, it can be used in more benign or considered ways. If the social ideals of a Modernist era are no longer achievable as de Graaf has suggested in much of his writings, most notably his article 'Architecture is a Tool for Capitol…', yet we continue to use rhetoric from that generation in an entirely different social structure for conflicting intentions, then changes need to be made to how we view ourselves as architects, but more importantly how we view our relationship with the public and the projects with which we involve ourselves. With the climate crisis emerging as the dominant issue across the world, how do architects intend to implement their regulatory knowledge, or what changes should be made? If so, what impact would regulatory changes have on how housing extensions are designed and built?

This 'quota' of carbon is, unlike capital, not something to make an investment in, it is not something that gains interest, it's not something individually owned but a part of a wider budget with which collectively we are all responsible.

An important regulation within the Irish planning system that is frequently used is that, if an extension to the back of a house is under 40m^2, it does not require planning permission (see Figure 8). The Central Statistics Office in Ireland stated that in the year 2019 before COVID, there were 12,348 applications submitted across the country for house alterations or extensions. Assuming each of these is the minimum 40m^2 in size, and using the median embodied carbon of family homes from *Benchmarking the Embodied Carbon of Buildings* (Simonen, K., Rodriguez, B.X. and De Wolf, C., 2017) which is 193kgCe/m^2, the figure for all extensions lodged for planning in 2019 would be approximately 189,655,000kgCe. When comparing that to large office buildings, the average figure of 399kgCe/m^2 is used from the same publication, and that much Carbon would equate to approximately 18 6-storey office buildings, each 12,750m^2. To put that in context, Dublin City has the maximum height of a building is between

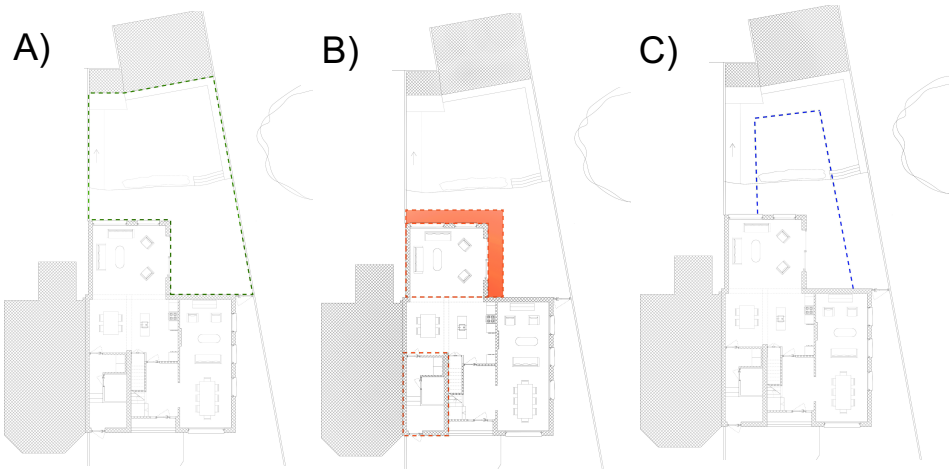


Figure 8 – The Exemptions of a back extension in Ireland. A) shows this area, the private open space, cannot be reduced to under 25m^2 . B) shows the 40m^2 that you must keep under (shaded area is the further area this extension could have used). You also cannot build more than 12 m^2 on the first floor or above. C) shows the 2m line away from the boundary that you cannot up to. An exempted extension cannot exceed the height of the house. Author's Own.

16m and 28m, depending on location (Dublin City Council, 2016). Taking the median of 23m and a floor-to-floor height of 3.5m, the number of housing alterations could be the equivalent of 4 landmark buildings in the city centre in a year. As an aside, the number of alterations stated in this example is only those that are required to submit a planning application. There is currently no true estimation of the number of extensions being built around the country of Ireland, let alone tracking the embodied carbon figures as done in this research paper.

The abstract nature of discussions around new systems and frameworks required for a more sustainable future is a struggle that can lead to a sense of despair. However, if we analyse the capital aspect of these projects and how they can dictate the spatial and aesthetic quality of home alterations, treating the limitation of carbon as one might with a financial budget can help us envisage how we might approach future design briefs.

Pier Vittorio Aureli outlines the unhealthy obsession with capital and growth in his piece 'Less is Enough: On Architecture and Asceticism' (2013). Aureli tracks the religious intentions of asceticism from early monastic practices, to its current appropriation in our society as 'the incessant optimisation of the productive process towards a situation in which less capital investment equals more capital accumulation'. The book highlights the issue with the concept of 'less is more' in an era that thrives on growth; constantly driving down the investment to increase profit, and how this manifests itself in construction.

This change in approach to architecture came after the economic crash in 2008, not only are architects doing more work for less money, but the 'less is more' attitude adopted by homeowners, results in architects becoming more creative when tasked with a smaller budget. However, what if a budget of capital for a plot of land was replaced with a budget for carbon? This 'quota' of carbon is, unlike capital, not something to make an investment in, it is not something that gains interest, it's not something individually *owned* but a part of a wider budget with which collectively we are all responsible. Furthermore, limiting Carbon requires the same creativity as a strict financial budget would and there are many projects that have proven this.

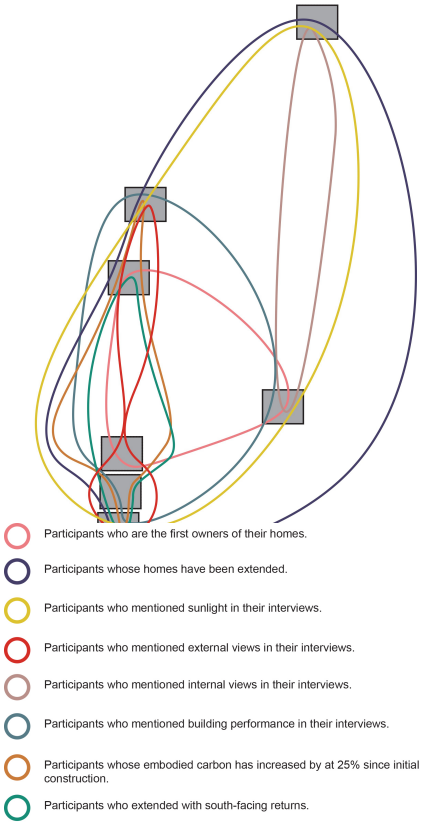


Figure 9 – Diagram expressing the common threads of the occupants and their home alterations across the research scope. Author's Own.

Methods

This research aimed to emulate both the quantitative and qualitative aspects of integrating embodied carbon into the renovation of people's homes. To achieve this, interviews were conducted with seven occupants on the two roads highlighted earlier, who had either altered or extended their homes in some way. The interviews were semi-structured, with three main questions, regarding the condition of the house when the participants arrived, what they changed, and what else they might change in the future. There were also a few short questions that were inspired by a quote from Leon van Schaik and Nigel Bertram's 'Suburbia Reimagined; Ageing and Increasing Populations in the Low-Rise City' (2018, 24), regarding our housing precedents for their research on suburbs, predominantly in Melbourne, Australia;

> *As we map out a path of best practice, twisting between that which should be avoided and that which we aspire, we - in the ancient but constantly renewed triad of our profession - draw on precedents that we must judge for their suitability for purpose, their durability and their potential for beauty – that meaningful correspondence of parts and the whole.*

These other three questions aimed to address to purpose, durability and beauty of each house through the eyes of their owners; Which is the space that is used the most, which space has been changed the least, and which space gives the occupant the most joy. Using the interviews and site photographs, observational drawings were produced, where the emphasis was placed on the areas described in the most detail by the interviewees; their favourite spaces, where they spend the most amount of time, as well as certain technical anomalies or flaws of the construction of the house that came up in conversation.

The data generated through the previously mentioned inquiry process took the form of audio recordings of the interviews with participants as well as corresponding images of aspects of the homes raised during the interview. As the primary researcher, I take the responsibility of making sure that all data was collected and managed appropriately, for the safety of my participants and to ensure transparency of this research and the anonymity of the participants. Research data was recorded on a smartphone and a camera (in .wav and .jpg formats respectively), which after their collection was uploaded directly onto a password-protected encrypted 'Microsoft OneDrive' cloud system provided by the university, that no one else can access, and complies with all GRPR regulations. After this, the original recordings and images were deleted from the smartphone and camera respectively.

The next step was to calculate the embodied carbon of each house. Site surveys were taken of each of the houses, and cross-referenced with any drawings found

on planning portals before being drawn in CAD. The original structure of the houses which was verified by many occupants, some of whom are the first occupants and were present for the original construction was initially calculated. Each material was identified in the ICE v1.6 Database, as were their corresponding embodied carbon, given in kgCO2/m3. Through the plans and elevations produced, volumes of materials were calculated before being multiplied by the figure provided in the database. After the entire existing structure's embodied carbon was calculated, and separated into each floor, the process was repeated for the removal and addition due to any alterations. For example, one house's area was initially 134m^2 and was increased to 156m^2. The final figures of each, existing and altered, were divided by their respective areas to find the embodied carbon per squared metre, the contrast in the two figures as well as identifying the highest contributors to these numbers.

Observations were initially drawn between different interviews, identifying common strands, along with the comparison of carbon figures, which is gauged by the increase of the house's embodied carbon per square metre. The research then developed into the next stage, which involved synthesising the previously collated quantitative and qualitative information. The commonalities of these alterations and their carbon impacts are then combined using different forms of drawing techniques. These drawing practices seek to express the impact that the excessive carbon consumption of these extensions by affecting them spatially.

	Embodied Energy	Embodied Carbon
Ground Floor	169,430 MJ	15,429 kgCO2
First Floor	161,290 MJ	13,181 kgCO2
Roof	30,152 MJ	2,923 kgCO2
Additions	151,429 MJ	12,970 kgCO2
Removals	34,911 MJ	2,102 kgCO2

	Embodied Energy	Embodied Carbon
House Before	360,871 MJ	31,534 kgCO2
House After	512,300 MJ	44,504 kgCO2
Percentage Increase Before and After	41.96%	41.13%
Percentage Removed	9.67%	6.66%
Embodied Carbon Before		235 kgCO2e/m2
Embodied Carbon After		285 kgCO2e/m2

Figure 10 – Example of the Embodied Energy and Carbon calculation of a house before and after its extension. Author's Own.

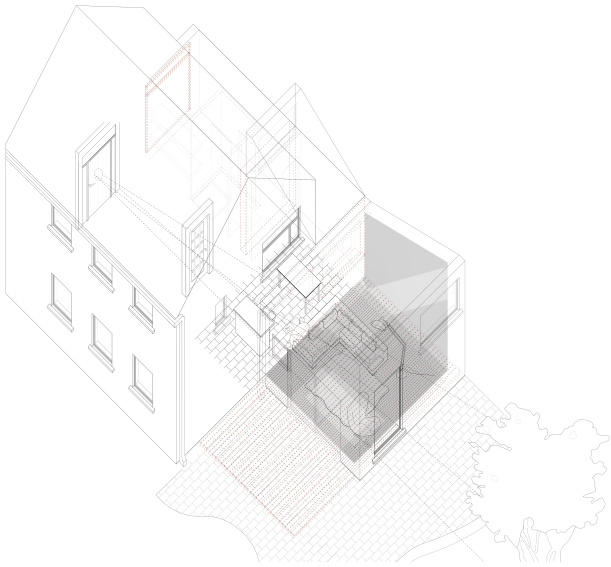


Figure 11 – Observational drawing of the same house referenced in Fig. 10, outlining the importance of sunlight to the occupant in the new extension. Author's Own.

Observations

One participating house and its occupants were taken as an exemplar to test the process of the qualitative methods of interviewing and observational drawing. For these residents, natural light was a predominant factor in the new extension, as in their words, 'when we came home in the evening the back room was pitch black'. The extension, built in 2010, brought the under-used deck in the back garden into the house as a new living space, with the garage converted into a new utility space. A large steel beam was placed across the width of the extension, to keep the extension completely open and allow light to flood into the space.

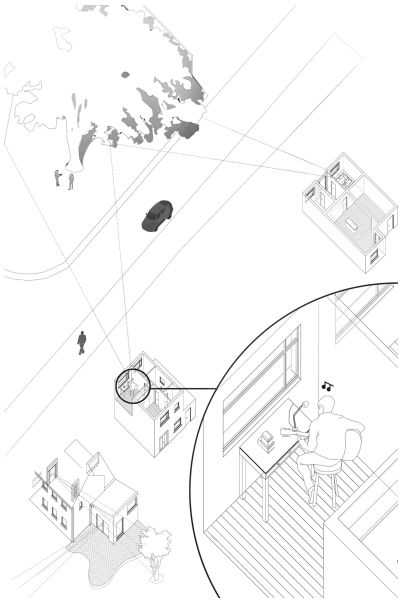


Figure 12 – Wider observational drawing regarding views toward nature. Author's own.

As an aside, the other interviews began to show certain patterns of affection for light as well as views towards nature, which is much more common in the suburbs than in the city centre. One participant noted how, while it was the previous owner who built the extension, they had since altered the ground floor internally. She noted that the extension, which was built against the right of the boundary line, meaning that the south light is not optimised, and if she were to redo it, she would flip the house's footprint. Another member of that house identified the front room as his favourite as it was cooler than the extended living space, and had a great view of the large oak tree across the road. This tree was also mentioned by another participant when discussing his favourite space, as he likes recording songs with his guitar in his room looking out at the tree. With another participant, they enjoy the vista of the Snowy Mespil tree in their back garden from the front door.

After replaying the recorded interviews and observing all the pictures taken from each house visit, the process of observational drawing began. For example, in Figure 11, the house mentioned at the start of this was drawn, referencing the dual aspect windows which receive light, the view from the front door to the tree outside in the back garden, as well as the structural steel beam, which has provided the span for the occupants to enjoy these spaces. However, as with any steel member, this beam had an enormous carbon value, and combined with the removal of the back wall and a considerable amount of glass for clerestory windows, this extension increased the embodied carbon of the building per square metre significantly (see Figure 11). The spaces for the participants who highlighted the large tree as their favourite were drawn together to show proximity (Figure 12), and curiously were located in rooms that were not materially altered in any extension.

As discussed, views outwards and sunlight were two topics mentioned by multiple participants. The position occupied in the places that gave them joy also indicated where value is recognised in these homes (Figure 13). Another occupant chose the same position in their extension as mentioned previously, looking out towards their back garden. In this case, she had her chair behind the wall, 'hidden from everyone else, and I can just read my book'. There were contrasting positions too though, someone else emphasised the importance of being in the 'middle of everything', even if it meant he couldn't view the television properly, as he enjoyed both the western light entering in the evening as well as the conversation he could have with his family. Similarly, a different homeowner identified the

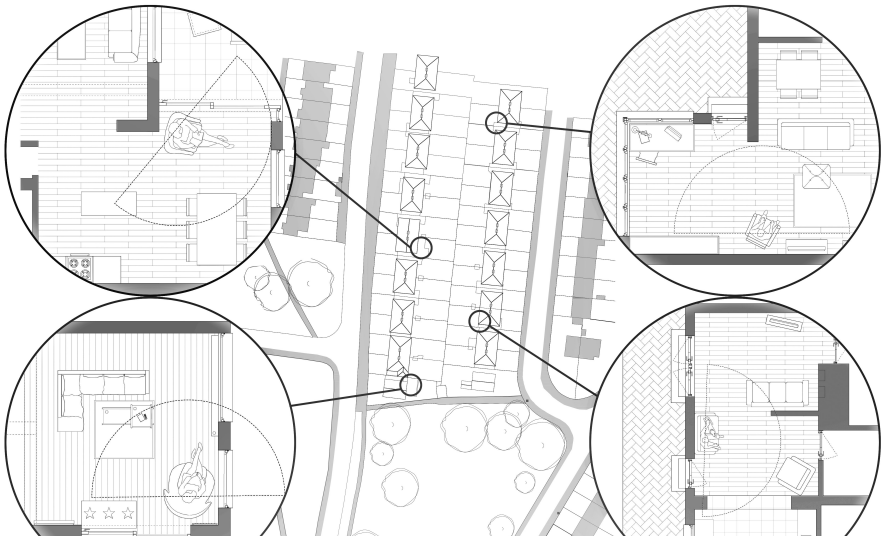
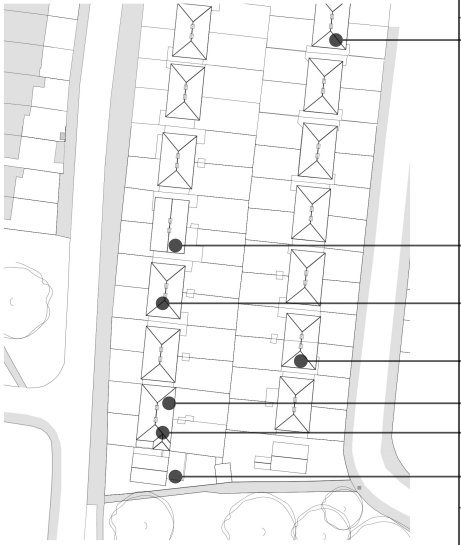


Figure 13 – Plan showing the favourite places of occupants in their homes within the research scope. Author's own.

comfort of his favourite couch and enjoyed the proximity to his family in the open-plan kitchen where the radio would be playing. The key difference with this case was that he was one of two who has not extended the living space into the back garden, thus his view was back towards the rest of the house.

As research progressed, the discussion focused more on the final three questions; the three spaces of purpose, durability and beauty as told by the occupants. These questions were far more introspective and unearthed details that could tell more about the greater culture of suburban Dublin. Firstly, there were two participants that have not extended past the existing footprint of their home and didn't indicate any urge to change that, as they were very content with their current homes. This is reflected in the results, with the additions in the interior of the two houses equating to an increase of 2.6% and 3.3%. However, these two residents were also both the first and only owners, one even recalled speaking to the original builder of the houses as they played for the same local sports team. This suggests the need to project their lives onto the structures would not be present, as the houses have been essentially built for them (see Figures 14 and 15).



House	Current kgCO2e/sqm.	% increase
F	253.4	24%
G	283.5	38%
D	330.7	61%
B	210.4	2%
C	211.8	3%
E	270.3	32%
A	285.0	41%
Average	263.6	28.7%

Figure 14 – Embodied Carbon Results. Author's Own.

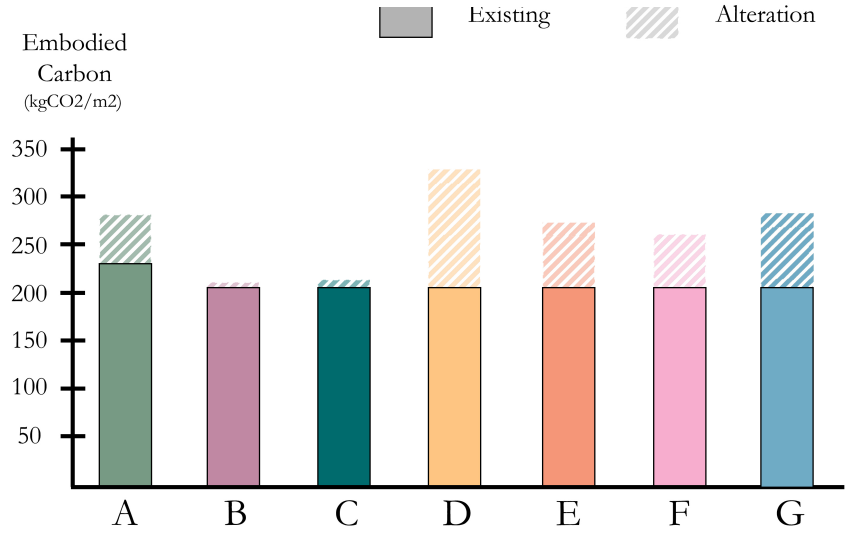


Figure 15 – Embodied Carbon Results Graph. Author's Own.

It was notable that many participants who had extended their homes identified a view out of the new space they had built, which begged the question; was the added space of the desired extension and time, money, endeavor, and carbon put into it worthwhile if it was not what was truly aspired for in the first place? The highlighted attraction to light and views suggests such aspects to be integrated far earlier into all design processes if they are not already, as their prevalence in these interviews suggest they would be appreciated by many occupants.

Drawing

So how would this impact the design process? Tests were done as part of this research on how to convey these spatial observations of extensions and their embodied carbon consequences, with the previous example house used as the initial test. The first test was referencing detailed sections from Atelier Bow-Wow, specifically *Graphic Anatomy* (2007), shown in Figure 16a. The desire was to project back the spatial quality as described through the interviews, and project forward the elements highlight in carbon data calculations as the highest contributing elements, proportionate to their contribution to the carbon increase of the house. For example, as shown in Figure 16b, all space behind the section line is projected back relative to the existing drawings, but the three elements identified as major carbon contributors (steel, glazing, and concrete slab construction) are projected forward past the section line by 11%, 7%, and 13% . This was to highlight that the steel member accounted for 11% of the extension's embodied carbon, the glazing 7% and the concrete 13%. However, in projecting one aspect in one direction and the other in the opposite direction, they were not impacting one another spatially.

Figure 16a – Perspective Section. From Atelier Bow-Wow's *Graphic Anatomy* (2007).

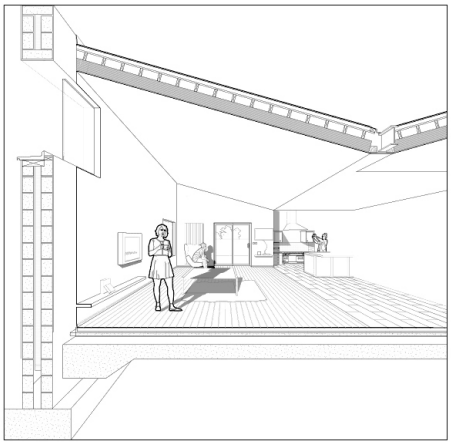


Figure 16b – Perspective Section Drawing expressing the wall, beam and foundations of House A. Author's own.

The second reference was a section by James Gowan highlighting the mechanical services of his East Hanningfield housing scheme (see Figure 17a). The representation of elements as some sort of 'kit of parts' (Montenegro, M. & Woodman, E., 2018, 64) and the colour coordination of different materials and construction systems. This led to the second test drawing (Figure 17b), one where the context of the room was removed, and only elements relative to either the interviews or carbon-heavy construction elements. The legibility of the drawing as an occupied space is lost, but it led to the decision to remove perspective from the drawing technique and focus on initially changing the proportionality of construction elements and then altering the section's spatial

quality and thus altering the moments identified by the occupants of the room (Figure 18).

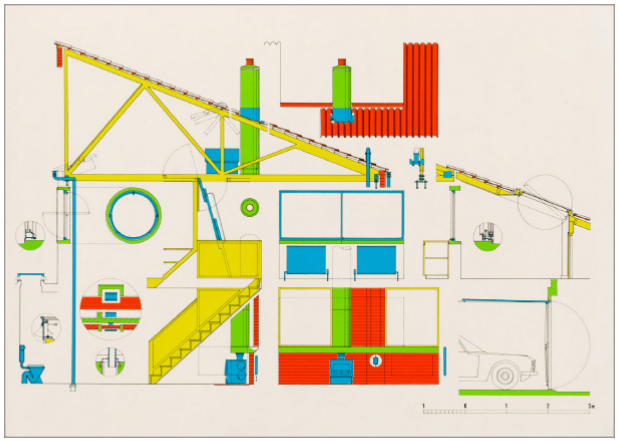


Figure 17a – 'Kit of parts' Section by James Gowan. From E. Woodman and M. Montenegro's *Housing and the City: Álvaro Siza and James Gowan* (2018).

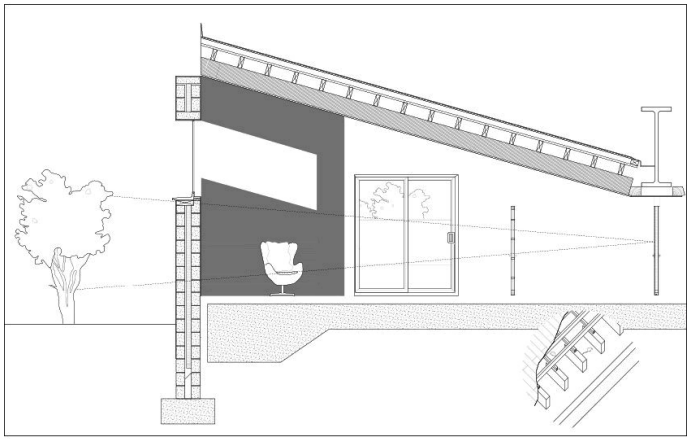


Figure 17b – 'Kit of parts' Section of House A. Author's own.

On reflection, the exercise of creating these images moved from an initial ambition of an ongoing drawing style that would facilitate a dialogue between architect and client. The original aim of this 'drawn conversation', to act as a hypothetical of the homeowner's specific scenario and the surreal impacts that carbon intensification can have evolved into something more abstract. However, this abstraction has resulted in the loss of the most important thing, which is the communication of an issue that is not visible on the surface yet requires our attention and scrutiny, and as shown in the examples above, is unique to each designer and client relationship.

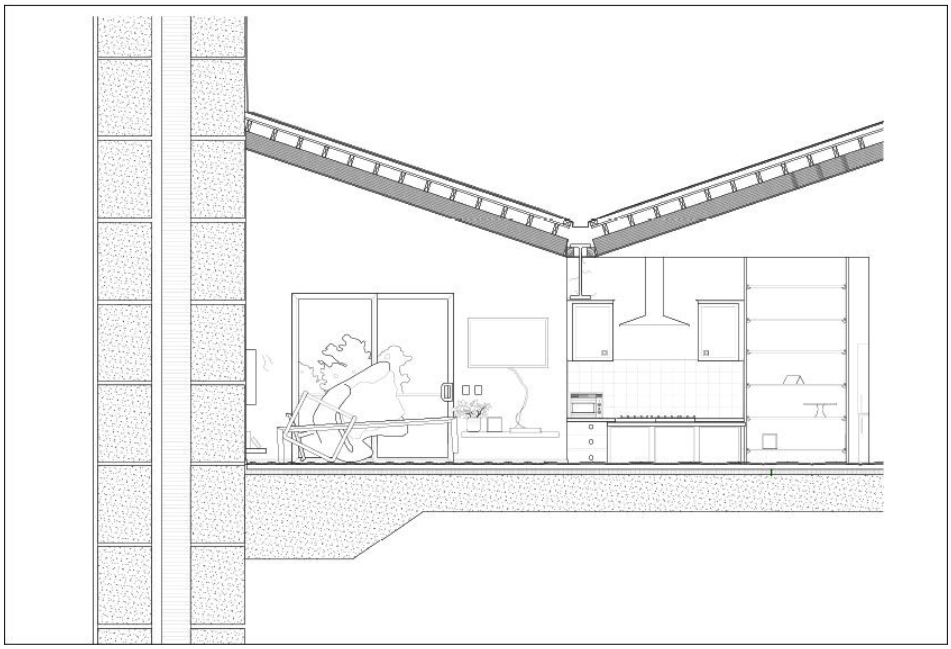


Figure 18 – Proportionate scale of House A . Author's own.

Conclusion

> *We cannot sustain our current modes of consumption and growth, and so to continue to use the word 'sustainability' holds out a false promise. In a way these reactions are understandable, but they are not acceptable. They are understandable because the climate and biodiversity emergencies demand systemic change, and this includes architecture and its value systems. The current approaches (technical, ethical, and cultural) are simply not capable of effecting the change required, and so tend to divert from it. But this is not acceptable, for the simple reason that climate emergencies are just that, and we all need to enact radical action as both citizens and experts. To do this, we need to break architecture's attraction to certain systems and values.*
>
> - Jeremy Till in *Architects after architecture*, by Harriss, H., Hyde, R., Marcaccio, R.(Eds.), 2020

Some of these rules are fixed, such as planning laws and budgets. Others require a level of skill in articulation from experts for the clients to interpret, such as a design proposal.

To achieve the change in architectural value systems that Till advocates, research like this study is required to initially understand the current value systems of citizens as well as the experts, before conveying the necessary shift. The technical aspects of this research, the carbon calculations, and the construction of extensions will not be acknowledged unless their cultural impact on broader society is communicated correctly. This communication comes from the experts, be they architects, local authorities, or policymakers, investing ethically into these urgent issues.

The integration of carbon into the early stages of construction is not difficult, as is shown in this research. After all, when discussing Bourdieu's theory of 'Habitus', which 'makes possible the production of an infinite number of practices, but limits the diversity of these practices,' Pike, Scanlon, et al. (2011, 334) outline the aforementioned rules of engagement applicable to home extensions, by which the system 'makes possible the free production of all thoughts, perceptions, and actions inherent in the particular conditions of its production.... and only those'. Some of these rules are fixed, such as planning laws and budgets. Others require a level of skill in articulation from experts for the clients to interpret, such as a design proposal. As the expert from the built environment, clients would employ from the earliest stage of design, it is the architect's duty to communicate the carbon footprint of their design proposal to them, often through drawings. The client's perception of this may only become pressing if a more explicit consequence appears, for example, the Building Energy Rating Certificates in Ireland have led homeowners to independently seek solutions to heat loss and renewable energy solutions for their homes. This is why a Carbon 'quota' or 'budget' for housing plots may lead to more awareness from clients. Adoption of this could facilitate a new 'Habitus' of carbon-conscious construction in the back gardens of suburban Dublin homes. In addition, the practice of drawing allows for focus on the dialogue between the two stakeholders, the homeowner, and the architect; with how the architect can communicate and incorporate the concept of specific quantities of embodied carbon, whilst also achieving the spatial qualities desired by the homeowners. It is important to highlight that the qualities identified by occupants in this Observations part of this research are not carbon-dependent. These aspects, such as natural light, views of nature, and connections with one another in their homes, can be achieved, and are encouraged when designing sustainably. If the design of new homes can be built with these factors at the forefront, to provide common qualities to begin with, then perhaps future unnecessary alterations and the subsequent carbon impact

In a society that is particularly individualised, where one is often asked to review their actions and responsibilities, it should be noted that this research aims not to focus on a single homeowner counting their footprint, or a carbon-conscious architect. Instead, it is about the system that encompasses both, along with the planning system they must adhere to, and the approach they take to communicating with one another. One conclusion coming from this research is that there needs to be more of an anthropological impetus in architecture regarding how people live to understand what it is they wish to modify and how to make the most appropriate and modest proposal.

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