Implementation of Passive House Standards in the UK, a Roadmap for the Local Authorities

Connor Minihane[1] and Arman Hashemi [1,*]

[1] Department of Architecture and Visual Arts, University of East London, London, E16 2RD, UK.
* Correspondence: a.hashemi@uel.ac.uk; Tel.: +44 20 8223 3233

Abstract: This paper aims to explore as to how the UK Government and local authorities can implement Passive House standards and legislations in a feasible and responsive approach. Existing literature on Passive House implementation in the UK, and its implications are explored followed by discussions on a questionnaire survey on the feasibility of mandatory and voluntary measures. Three effective approaches for immediate implementation are recommended: i) a gradual advancement of fabric-first legislation; ii) support mechanisms (with incentives) for voluntary design and construction; and iii) higher valuation for Passive Homes on the market. The research discusses the implications and barriers of mandatory and voluntary approaches to Passive House standards in the UK domestic market, paving a path for the UK Government officials to implement such approaches/suggestions into the infrastructure of the UK's construction industry.

Keywords: Passive House; EU Environmental Law; Brexit

1. Introduction

Heating accounts for around two thirds of the household energy used in the EU [1]. In 2018 alone, the total energy consumption in the UK increased by 1.1% [2]. These two forces of non-renewable energy consumption are ever more concerning in our global landscape of the 21st Century. The correlation between mass fossil fuel operations and rising global average temperatures is no longer the main subject of debate in the circles of the scientific community; rising sea temperatures, accelerating forest fires, ecological instability, melting icecaps/rising sea levels, pollution and more will soon become everyday reality if we, members of pertaining industries (Designers, law-makers, etc.) and citizens of the UK, refuse to play our part [3].

A post-Brexit UK welcomes a race of progressive energy efficiency laws in the domestic sector. Considering the UK were "a central driver of higher climate ambition within the EU", it is imperative the UK secure that same high ambition in the post-Brexit framework; the discipline of sustainable architecture plus the enforcement of environmentally responsive legislation will open its doors to advancement [4]. During the controversy of the UK Government's decision to scrap the Code for Sustainable Homes in 2015, the application of "Passivhaus as the minimum standard required by Building Regulations" was advocated to achieve "simple efficiency, instead of complex box ticking" [5]. The UK's domestic renewable energy policies have demonstrated to be somewhat advantageous compared to the rest of the world. The UK "has had more generous onshore wind subsidies than Germany" and it "introduced one of the world's highest feed-in-tariffs for residential PV in 2010", which resulted in the "rapid uptake of nearly 1 GW of domestic solar by 31 March 2012." [6]. In addition, the third quarter of 2019 in the UK witnessed for the first time, renewable energy operations producing "more electricity than fossil fuels" [7].

These findings assert a degree of confidence in renewable energy policies post-Brexit, therefore suggesting Passive House (Table 1) to be the golden answer for achieving low-to-zero energy design for the domestic sector. The defining characteristics and benefits of Passive House standards can be put into material perspective. According to the Passivhaus Trust, "an independent, non-profit organisation that provides leadership in the UK for the adoption of the Passivhaus standard", over 65,000 buildings have been "designed, built and tested" to Passive House standard worldwide [8].

The Passive House Database, as this research is conducted, have a record of 168 Passive House buildings in the UK alone [9].

Table 1. The criteria for Passive House.

Number:	Requirement:
1.	An annual heating and cooling demand of no more than 15kWh/m2 per year is achieved, or a maximum peak load of 10W/m2.
2.	Total energy consumption (being 'primary' energy: heating, lighting, hot water & power) must not exceed 120kWh/m2 per year.
3.	Air leakage must never exceed 0.6 air changes per hour, being at 50Pa test pressure.
4.	The thermal comfort of its occupant(s) must be achieved in all living areas throughout the entire year, with its temperatures never exceeding 250C for more than 10% of the hours in a given year.
Recommended:	The specific heat load of the dwelling's heating should not exceed 10W/m2 at its design temperature.

A trend in Passive House standard is clearly growing – globally; however, there are 22.6 million homes in the UK, so only 168 of the 22.6 million are low energy homes [10]. Assuming there are some low energy homes unaccounted for on the Passive House Database but, nevertheless, this is still just raindrops in an ocean. Passive House case studies have been incisively investigated, limited to domestic dwellings in the UK. Their key building features, being the consumption of "minimal energy for space heating or cooling, and result in high levels of occupant thermal comfort", all align with the following Passive House criteria according to [11].

Understandably, the above standards may complicate the average homeowner or the less-informed/lower-skilled Designer and Property Developer/Contractor/Builder (this will be explored in detail later in the report), so a critical analysis of its benefits come with merit to offset its challenges.

Table 2. The personality and benefits of Passive House.

Benefit:	Benefit Explained:
Reduced energy bills	Adopting a design which ensures high levels of insulation and air tightness dramatically loosens the need for traditional heating systems. Specifically to the UK, a dwelling built to Passive House standards – to its minimum requirements - would use just 23% of the energy of an equivalent dwelling constructed to comply with the 2006 UK Building Regulations for its spatial heating; 41% of energy used for primary energy; and 50% energy for hot water [12].
Enhanced thermal and human comfort	Thermal comfort is defined as "being established when heat released by the human body is in equilibrium with its heat production"; its thermal factors – air temperature, radiant temperature, air speed and air humidity – can achieve levels of comfort (in combination with one another) by the standards of Passive House [11].
Improved indoor air quality	Combining air tightness and mechanical ventilation systems allows internal humidity to be at an optimal level between 30-60%; moisture and "odour-rich air from kitchens and bathrooms is extracted, and fresh air introduced" into all spaces. Filtering systems also ensure pollen and other allergens are removed, making sure occupants with asthma are not vulnerable [11].
Improved acoustic insulation	Coupling a reduction in air leakage with the combination of high levels of insulation and effective glazing will result in efficient sound performance, exceeding standards required by current Building Regulations.
Minimised carbon/energy footprint	Although following only the minimum Passive House requirements still require some need of mechanical heating and cooling, a significant minimisation in energy consumption is still achieved. In turn, a dramatic reduction in demand on the national grid – if this is adopted on a legislated scale – will follow.

Financial return/investment	In addition to significant cost savings, the homeowner has the potential to also have financial returns: utilising renewable energy sources, such as PV panels for solar energy, can offset additional costs of energy consumed. Additionally, Passive Houses will always stand out on the housing market; in turn, an increase in market value will ensue.
Better quality design and construction; durability	By following the Passive House standards, i.e. reduced air leakage, high levels of insulation, etc., a minimisation of building defects will result allowing the building to be easier to maintain, easier to put back onto the market (i.e. for investment purposes) and – in general – a nicer home to live in.

On the other hand, traditional domestic dwellings greatly depend on non-renewable energy for consumption when weather conditions take a sporadic turn [2]. Figure 2 shows the correlation between average annual temperatures and domestic gas consumption. Average temperatures are recorded to be relatively stable between 2017 and 2018, and that on a temperature-adjusted basis gas consumption followed the same pattern – relatively stable. However, due to the 'Beast from the East' in 2018, that brought the average temperature in March down by 7° C [13], the overall gas consumption in 2018 increased. The quarterly changes in domestic gas consumption, as shown in Figure 3, reveals "the robust growth in gas consumption in the first quarter" induced by the cold spell that took place [2].

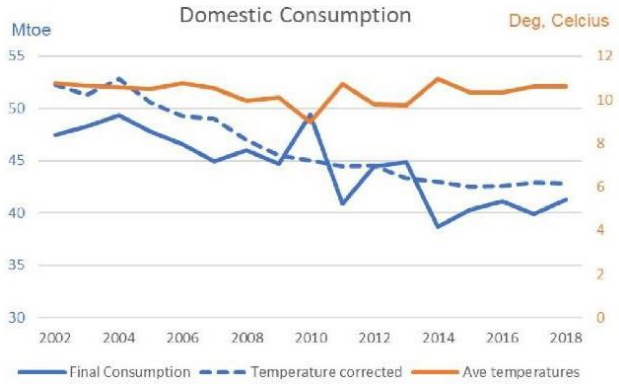

Figure 2. Domestic consumption of gas in correlation to average temperatures [2].

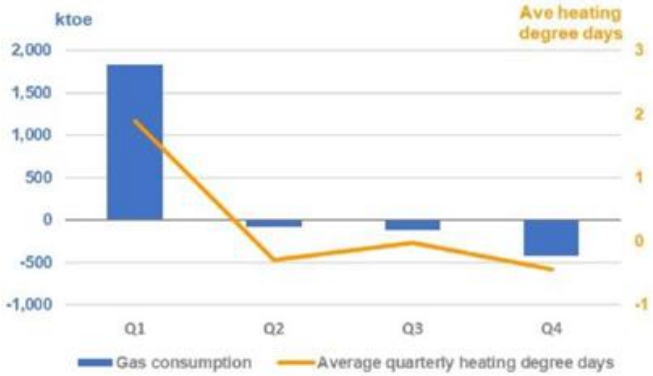

Figure 3. Quarterly domestic consumption of gas in correlation to average temperatures [2].

Considering the above, it would be relevant translating the same concerns of gas consumption to a Passive House in the UK. According to [14], a Passive House requires only 15 kWh of heating per sqm per year (15 kWh/m2a); and in the language of cost savings, for an average-sized UK home, that results in significant savings in gas consumption. Acknowledging the EU's proposed energy efficiency programmes and aspirations/targets must be explored to equip a post-Brexit UK with the energy efficiency programmes and aspirations/targets it needs to emulate – and exceed – those very same standards of low-to- zero energy for the domestic sector. The European Commission has recently enforced, under the Energy Performance of Buildings Directive, an EU policy on achieving

energy efficiency in all buildings, that "all new buildings must be nearly zero-energy buildings (NZEB) from 31 December 2020" [15]. Interestingly, in 2016, the "Commission developed guidelines for the promotion of nearly zero-energy buildings in order to ensure that by 2020, all new buildings are nearly zero-energy buildings"[16]; the enforcement of this nearly-zero energy policy was a result of the progress made through guidelines not matching up to the urgency of needing near-to-zero energy buildings. This is an effective response from the EU.

To add to this, The European Green Deal published in December 2019 outlines the EU's renewed approach to near-zero energy buildings (for all buildings). The one which stands out the most, in light of this research exploring a legislated approach to Passive House, states that the EU intend a "Strict enforcement of rules on energy performance of buildings" [17]. It seems the EU have learned a lesson from the relaxed approach of "guidelines" and are shifting to a "Strict enforcement of rules" to meet energy efficiency standards. Enforcement creates results, not guidelines. If a post-Brexit UK wants to lead the way in energy efficiency, effective legislation is needed – not 'effective' guidelines. If a post-Brexit UK adopt Passive House standards for new and existing domestic dwellings, a dramatic reduction in greenhouse gas emissions will take place.

The UK Government have put forward a proposal to improve the minimum standards for fabric performance in new domestic dwellings, a step in the right direction to achieve energy efficiency. The standards (Table 4) "are based on a statistical analysis of data used to produce the EPCs of all new homes built to 2013 Part L standards, and would remove "the worst performing 25% of each thermal element being currently built" in the UK [18]. The 2020 amendment of Part L UK Building Regulations suggest a "big step towards a fabric first approach" which focuses on designing dwellings with energy efficiency in mind from the very start, as well as to switch from CO2 to primary energy as the metric to assess its performance [19].

Evaluating these proposed standards with the criteria and benefits of Passive House in mind, as well as the dire need to reach to near-zero energy consumption in UK dwellings, these standards do not even come close. Indeed, while producing Part L revisions which acknowledge Passive House standards, will be heavily driven by the existing barriers and implications of its implementation on low-to-medium scale Designers, Contractors and Clients.

Table 4. The UK Government's proposed minimum standards for fabric performance in new dwellings; a 2020 revision to Part L UK Building Regulations [18].

External walls	**0.26 W/m2.K**
Party walls	0.20 W/m2.K
Floor	0.18 W/m2.K
Roof	0.16 W/m2.K
Windows	1.6 W/m2.K
Roof-lights	2.2 W/m2.K
Door	1.6 W/m2.K
Air permeability	8m3.K at 50Pa

2. Pathway to legislate Passive House in the UK

Passive House standards can result in complications for the average homeowner and for the less-informed/lower-skilled Designer and Property Developer/Contractor/Builder. This poses a profound issue, considering that self-employed jobs/small businesses "in the construction sector account for 37% of all jobs" in the UK [20]; this particular occupation of the sector will understandably follow the minimum guidelines of current Building Regulations (Approved Documents) to deliver the job on time with maximised profit. A hurdle such as this requires an immediate response: Pitts [21] argues that "the key to effective implementation in practice of more advanced standards is the need for designers (architects, engineers etc.) to have appropriate knowledge and skills, as well as motivation towards engaging with low energy design"; this analysis targets designers alone as, at the end of the day, contractors build what the designer designs. However, all professionals of the

industry must have an understanding of the science and technologies available to consult clients when and where necessary.

A twist to this plot is provided by [21], with his report concluding with evidence that "there has been a move towards the adoption of voluntary high level standards because of potential limitations with mandatory regulations" as well as the benefits that come from achieving high quality design, such as a dwelling achieving the Passive House certification or the BREEAM certification. Furthermore, [22] recognises that "local authorities, housing associations and individuals are motivated to create sustainable buildings" as it has "significant cost-saving and energy security" for years to come. To add to this optimism, another key obstruction to adopting Passive House in local regions – where the self-employed typically operate (i.e. building extensions in their local towns/Boroughs) – is simply "ignorance, but ignorance is slowly but surely coming to an end" [23].

Understanding the concerns raised above, in addition to the research of [24] concluding that "there is a lack of incentives for the building industry to adopt and implement low energy design strategies that are outlined in existing policies and guidance", there are effective methods of jumping successfully over these hurdles (Table 5).

Table 5. Proposed support mechanisms for enhancing the skills of the industry to move toward Passive House as the minimum standard.

Number of Method:	Method
1	The UK Government should advocate – with reiteration – their support of Passive House principles which "would help spread the good news" of its supreme energy efficiency capability [23]. This authoritative approach will definitely encourage the UK as a whole to follow PH standards.
2	In addition to the above, the UK Government can provide local authorities with Passive House programmes/initiatives/schemes to encourage small businesses and the self-employed to adopt Passive House principles. This could involve: • Reductions in taxes to encourage members to keep sustainability at the forefront of their operations, or; • Bonus schemes; • Provide training (for daytime and evening courses for flexible hours) – for free – on the available science and technologies which apply to Passive House. Those who complete the training (Designers, Builders, etc.) are awarded with a PH certification; • Provide financial incentives for clients/homeowners to employ PH certified Designers, Builders, etc., to • conduct their construction (the builder will possess the certificate)
3	To further encourage self-employed Designers, Builders, Contractors, Property Developers, etc. in the residential sector to undertake the training schemes, benefits when on the training could be provided to offset any financial losses, such as: • A reward payment; • Reimbursed transport payments (including petrol); • Free parking
4	Those who complete the training successfully could be rewarded with the following: • A loan to encourage small business set-ups; • Help with recruiting other skilled members who completed the training; • Connections to other skilled members in other disciplines (i.e. if you're a Designer, the training scheme could connect you with PH Property Developers, Engineers, etc.)

Below are produced revisions (Table 6 & 7) to the UK's proposed 2020 Part L regulations, adopting Passive House standards into its framework for: buildability; applicability; ensuring Designers obey Passive House standards from day one of designing; general guidance; to raise

awareness. These will be adopted into the Part L Approved Documents to ensure self- employed and lower-skilled members are aware of its implementation (Case studies & [11] used as guidance).

Table 6. Proposed minimum standards of fabric performance for Passive House standard.

External walls	**0.125 W/(m2K)**
Internal walls	0.14 W/(m2K)
Party walls	0.15 W/(m2K)
Floor	0.125 W/(m2K)
Roof	0.125 W/(m2K)
Doors	0.7 W/(m2K
Windows/Glazing (all triple glazed)	0.75 W/(m2K)
Air permeability/tightness	n50 = 0.55/h; or < 0.55 ACH@50

Table 7. Proposed construction guidelines for Passive House standard.

Highly insulated thermal envelope	Follow fabric standards in Table 7.
High performance triple glazing	Building Inspector to check and approve all glazing to ensure standards are met before final approval/certification.
Continuous air sealed layer/vapour barrier	Building Inspector to be advised of all air sealed layer locations to identify, check and approve its continuity.
Heat recovery ventilation	Building Inspector to check the heat recovery ventilation system is manufactured and installed to Passive House standard
Elimination of thermal bridges/cold spots	• Building Control to approve construction drawings/details to ensure no thermal bridges; • Building Inspector to assess any thermal bridges in construction; building approval/certification is provided when this is confirmed

Understanding the significance of a legislated approach to Passive House – and its potential hurdles and implications – is one thing, but physically applying it to the existing UK regulatory frameworks for real change is another thing entirely.

2. Research Methods

The methodology of this investigation, for the collection and appraisal of relevant research information, will follow a combination of both 'qualitative: primary evidence' and 'qualitative: secondary evidence'. This will allow the paper to achieve not only credible results but - as equally important – to collect a wide range of viewpoints to understand its various dimensions. In addition, the two methods of approach will complement one another throughout the research.

The structural framework of this research is constructed of conducting interviews and producing and handing out questionnaires, specifically targeting members of the construction industry who operate in the domestic sector (both new-build & existing dwellings). Such members will primarily be Designers, as energy efficiency/Passive House awareness always starts with the Designer/Design Consultant. In addition, other members of the industry (or pertaining industries, i.e. Real Estate) will be subject to the discussion/questionnaires; members such as: self-employed and small-scale contractors, property developers and builders as well as law-makers/local authorities and building authorities (i.e. a Building Inspector who operates in local Boroughs). This is to understand if a legislated approach to Passive House in all residential dwellings (but only mandatory for proposed alterations to an existing building), in their view, is the right way forward for the UK and

its industries. This paper also delves into research already carried out on Passive House, looking into mandatory approaches and voluntary approaches boosted by incentives in the domestic sector. This will shift its focus, limited to the UK, on its barriers, potential implications (such as costs, freezing productivity in industries, etc.) and on what would be the best approach for implementation. This will, in turn, help structure the questionnaires and interviews more effectively (the goal is to add to existing research to find an answer, not take a step back). A total number of 28 individuals participated in the research. Descriptive data analysis was applied using frequency and percentage to report the results of the questionnaire.

3. Results and Discussion

The first half of this research paper, explored the potential barriers and implications of legislating Passive House and, flipping the coin, entertaining the idea of having a voluntary approach energised by incentives and additional support mechanisms. Irrespective of approach (and each approach will be appraised based on the data provided), feasibility – and its ease of incorporation – is what is imperative. The findings of the previous paper concurred on two barriers of effective UK Passive House implementation: ignorance/lack of awareness and lack of training/skill amongst the majority of the construction market – the self-employed. To steer an industry towards low energy design (limited to the domestic sector), enforced by advanced design & construction standards (adopting the Passive House principle; Table 6 & 7), ensuring the majority of its employees (the market itself being the ultimate employer) have the appropriate knowledge and skills to move the industry forward is the golden rule for this research to draw on noteworthy conclusions.

A questionnaire was designed to incorporate both collective answers for general questions (i.e. "Are you familiar with the term 'Passive House'?") as well as individual answers for specific questions (i.e. "Should there be better energy consumption standards in domestic buildings?" & "Would the legislation of Passive House standards harm your role and your job security in the industry?"). This allowed the data to be filtered out, ensuring the implications and barriers of a certain member of the industry can be addressed– and tackled – and not generalise the entire findings for one outcome.

Q1 of the questionnaire (Figure 4) asked the participants if they were aware of the term 'Passive House'. From the total 28 of participants: all (16/16) of the academic/young Designers said 'yes'; the only Quantity Surveyor participant said 'yes' (1/1); just one-third (1/3) of the Self- employed Contractors said 'yes'; just one-third (1/3) of the Property Developers said 'yes'; the only Design Consultant participant said 'yes' (1/1); and, not one person (0/4) of the Self- employed Tradesmen said 'yes'. This data shows quite an even split between those who design (or part of it) and those who build (or are part of it): the Academic/young Designers, Quantity Surveyor and Design Consultant were all aware of PH; and, out of all of the Self- employed Contractors, Self-employed Tradesmen and Property Developers only 2/10 were aware of PH. This clearly emphasises on the difference of awareness between those who design and those who build; this gap needs to be overcome. More alarmingly, not a single participant of the Self-employed Tradesmen knew of PH. If, say, one were a Plumber, technologies such as Heat Recovery Ventilation Systems are one of the 5 main factors of PH design and construction (Table 7) and, evidently, this would not be considered in the self- employed field.

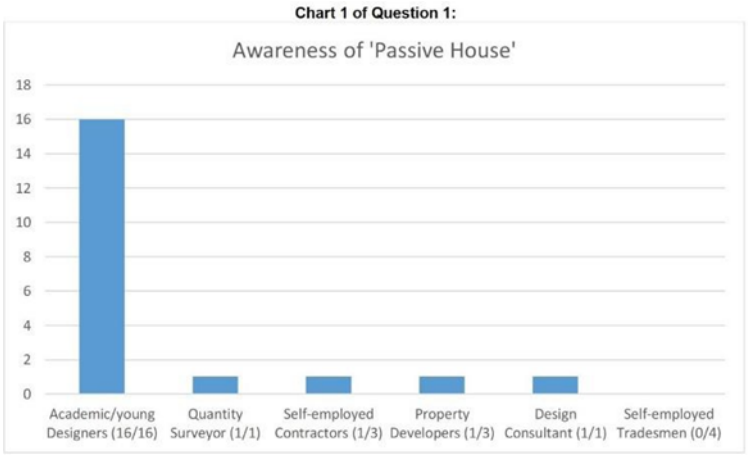

Figure 4. Question 1: 'Awareness of Passive House'.

Q2 of the questionnaire (Figure 5) asked participants if they were satisfied with the natural ventilation via prevailing wind orientation – during all seasons – in their domestic building. From the total of 28 participants: 10/28 said 'yes'; 7/28 said 'no'; and 11/28 said 'sometimes'. The goal here is to see how the participant would appraise the passive architectural design of their own home; entirely depending on the building's wind orientation, location and local climate (of the UK), 18/28 of the participants are not entirely satisfied with natural cooling (no mechanical systems).

Q3 (Figure 5) of the questionnaire asked participants if they were satisfied with the natural heating via solar gain – during all seasons – in their domestic building. From the total of 28 participants: just only 1 person said 'yes'; a staggering 23/28 said 'no'; and 4/28 said 'sometimes'. The goal here is to, again, see how the participant would appraise the passive architectural design of their own home; entirely depending on the building's solar orientation, thermal performance (i.e. materials that retain and emit heat), location and local climate (of the UK), it is, again, interesting to see that just one person out of 28 are entirely satisfied with the natural heating (no mechanical systems).

The result offers a correlation between insufficient ventilation and insufficient heating in UK domestic dwellings: in the absence of mechanical systems (air-con & boilers), the comfort of UK occupants are unsatisfied. This is down to both the inadequate design of typical dwelling models built in the UK, and, in turn, its incompatibility to the UK climate (i.e. the UK experience colder winters than the average European country, meaning occupants depend more on mechanical heating than, say, an occupant in Italy). This data shakes the shoulders of Designers, especially Passive House advocates, and should therefore shake the shoulders of Contractors/Builders too. If people are not satisfied/comfortable in anti-Passive House dwellings, why should we continue to design and build them?

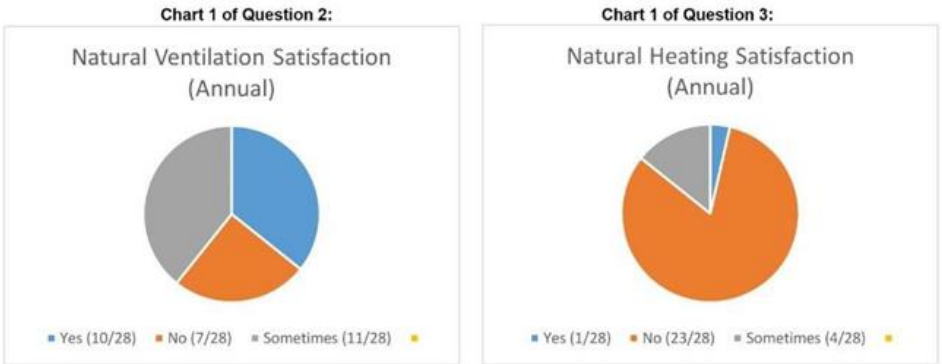

Figure 5. Question 2: 'Natural Ventilation Satisfaction (Annual)' & Question 3: 'Natural Heating Satisfaction (Annual)'.

Q4 (Figure 6); From the total 28 of participants: all (16/16) of the academic/young Designers said 'yes'; the only Quantity Surveyor participant said 'yes' (1/1); two-thirds (2/3) of the Self- employed Contractors said 'yes'; all (3/3) of the Property Developers said 'yes'; the only Design Consultant participant said 'yes' (1/1); and, half (2/4) of the Self-employed Tradesmen participants said 'yes'. If we contrast this to Figure 1 of Q1, 'Awareness of Passive House', this is a big improvement all round. Limiting our focus to just Self-employed Contractors, Property Developers & Self-employed Tradesmen, we've gone from only 2/10 of them being aware of PH to now 7/10 accepting that the UK's domestic sector should be regulated by stricter energy consumption requirements. The recorded data in Q4 reveals a total of 3/28 participants not accepting the need for stricter regulation on energy consumption in domestic dwellings. The questionnaire provided the option for participants to explain their reasoning, if desired. 1 out of the 3 of these participants, a Self-employed Contractor, offered a reasoning: "If stricter energy consumption standards are put in place in the UK domestic sector, average home-buyers & builders are the ones who might suffer. This could have a knock-on effect, making homes more expensive to build and buy, therefore causing less homes being built and thus failing to meet the already high demand of housing." As explored previously, it is actually a common misconception of low-energy design to be more expensive than our current domestic models; sure, it requires the skill and utilisation of modern technologies (i.e. Ecotect, a daylight simulation software) but the costs of materials, plant and labour for construction offers no additional burden to project budget concerns. Concluding this, the importance of PH awareness – specifically its environmental and financial advantages/offsets – are in dire need of reiteration amongst the self-employed sector.

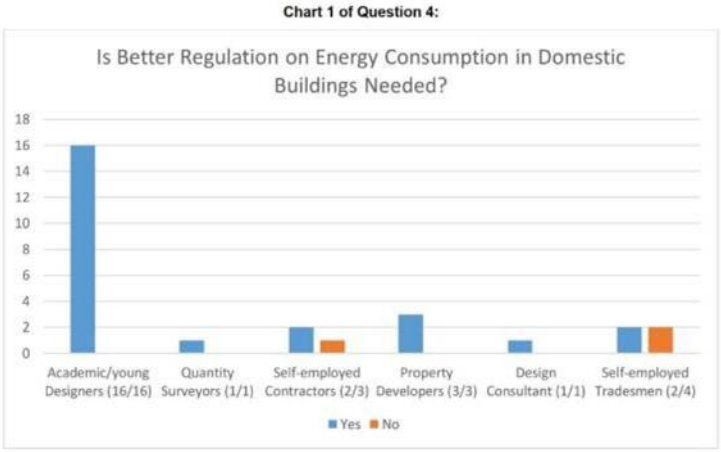

Figure 6. Question 4: 'Is Better Regulation on Energy Consumption in Domestic Buildings Needed?'

Q5 (Figure 7); The question presented the UK Government's 2020 proposal to Part L, this time acknowledging a fabric-first approach (i.e. lower u-values/greater thermal performance materials and lower air permeability/air loss). These are the main fundamentals of Passive House design, so putting forward these proposals to the participants allowed the research data to naturally evolve. From the total 28 of participants: all 28 participants said 'yes', accepting the fabric-first approach as the right approach to energy efficiency in domestic dwellings. No participants offered an additional reasoning. Knowing these participants don't represent the entirety of their role (i.e one self- employed Plumber doesn't speak for all self-employed Plumbers), it is hopeful to see all participating members to understand the key to enhanced energy standards is indeed utilising high thermal-performing materials. Contrasting this to Q4, having 3 participants not accepting stricter regulation/enforcement on higher energy standards, it is interesting to see these same 3 accepting effective fabrics to be the way forward for low-energy design; maybe this is because they are aware such materials exist on the market, but are not required to use them in their projects?

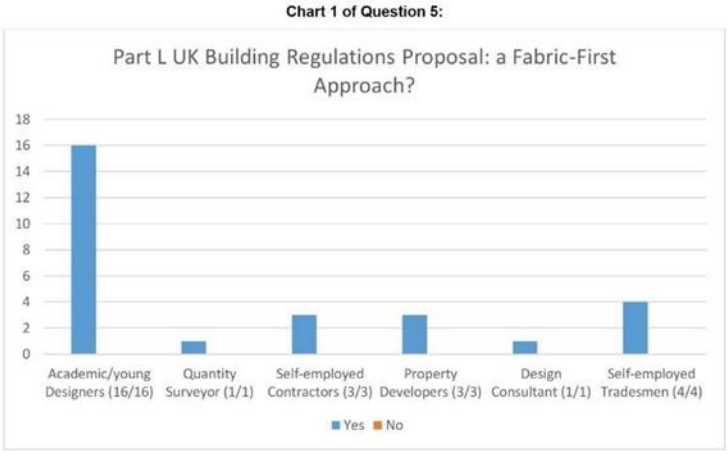

Figure 7. Question 5: 'Part L UK Building Regulations Proposal: a Fabric First Approach?'

Figure 8, Q5; continuing on from the UK Government's 2020 proposal to Part L requirements, the objective here is to see which participants from their respective roles believe the proposed standards are effective how they are, should be more effective (lower u-values etc.) or should be more relaxed (higher u-values etc.). From the total 28 of participants: 5 (5/16) Academic/young Designers said 'yes' & 11 (11/16) said they should be stricter; the one Quantity Surveyor (1/1) said 'yes, spot on' (not wanting them any other way); all 3 (3/3) of the Self-employed Contractors said 'yes'; 2 (2/3) Property Developers said 'yes' with 1 (1/3) actually wanting the proposals to be more relaxed/worse performing; the one Design Consultant (1/1) said 'yes'; and 3 (3/4) of the Self-employed Tradesmen said 'yes' with 1 (1/4) wanting stricter standards. This seems to offer quite a mixed bag of results here: everyone agreed with the fabric- first approach, accepting that the way to minimise energy consumption in the domestic sector is by using superior fabrics. However, not everyone agrees with the fabric standards put forward by the UK Government, from all different angles. When the participants were asked for their reasoning: the 11 Academic/young Designers & the 1 Self-employed Tradesmen supporting stricter standards believe the UK's domestic sector should be more in-line with Passive House criteria, but this should be a gradual progress (however, these proposals still fail to take us to the starting line); and, the 1 Property Developer opposing both the 2020 proposals as well as enhanced revisions believe such proposals can deter future Property Developers away from the market, expressing that this could be "intimidating" for such members to continue the building game. A somewhat valid reason in a sense, but reality begs to differ: support mechanisms, such as training and financial incentives, could relax such intimidation and strengthen the skills of the self-employed to build low-energy designed homes.

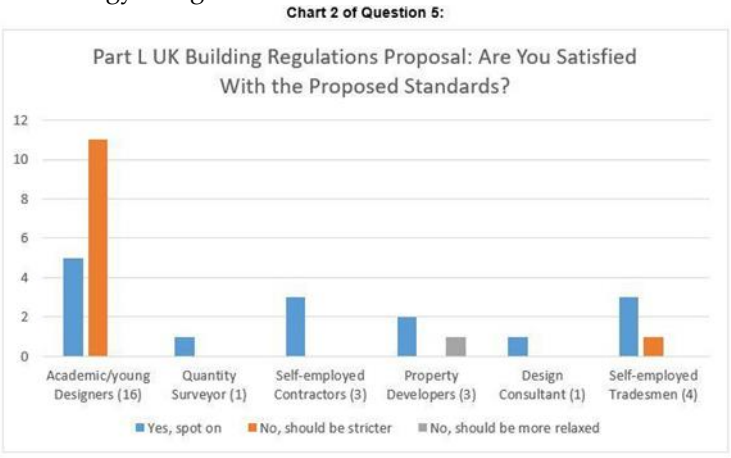

Figure 8. Question 5: 'Are You Satisfied With the Proposed Standards?'

Figure 9, Q6; from research conducted on Passive House criteria, specifically the u-values and air tightness spec required to be classed as a 'Passive House', this paper produced proposals of its

own – exceeding the minimum Passive House requirements to aim for greater energy-efficiency outcomes (revisit Table 6). The questionnaire was the best opportunity to test the water; is it feasible? Would you welcome its enforcement? 11 (11/16) Academic/young Designers said 'yes' & 5 (5/16) said 'no'; the one Quantity Surveyor (1/1) said 'no'; all 3 (3/3) of the Self-employed Contractors said 'no'; one-third (1/3) of Property Developers said 'yes' with two-thirds (2/3) saying 'no'; the one Design Consultant (1/1) said 'yes'; and one-fourth (1/4) of the Self-employed Tradesmen said 'yes' with three-fourths (3/4) not accepting the legislation of stricter fabric performance. For the same reasons expressed in Q5, those who did not accept its legislation feared one of the following: it was not a gradual progression, meaning it's a big leap of change to demand sectors to comply to; and, others were intimidated by the change, meaning they fear the demanded enhancement of their skills and knowledge in the construction of low-energy design homes. Also, notice how there is 1 Property Developer who changed their mind (in Figure 8 of Q5, 2 Property Developers accepted the UK Government's proposals as they were and not desiring anything stricter, and 1 wanted them more relaxed. Now, after putting forward stricter requirements, one of these 3 Property Developers now accepts stricter standards). Unfortunately, no reason for the change of heart was provided, but the research assumes that one valued its proposal as feasible the way they operate.

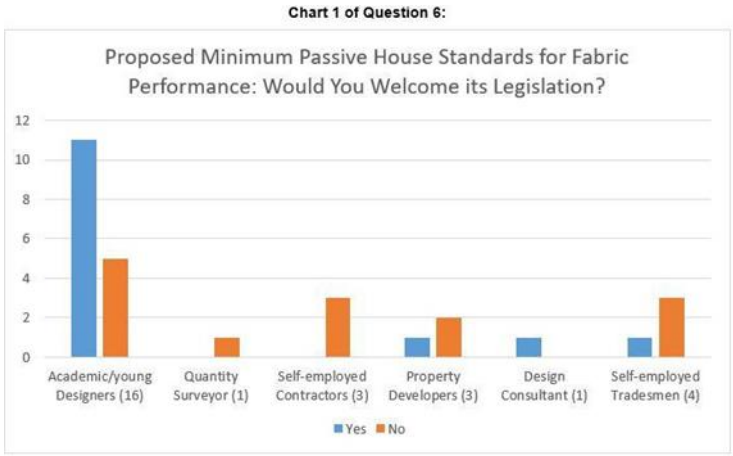

Figure 9. Question 6: 'Proposed Minimum Passive House Standards for Fabric Performance: Would You Welcome its Legislation?'

Figure 10, Q7; Support mechanisms for the self-employed – and all who require them – were proposed (Table 5), some supported by Government and some supported by local authorities. The suggestions respond to the lack of incentives and skills available to achieve Passive House standards amongst the self-employed in the UK industry, equipping them with the training required (once passed, they are 'PH qualified') and – in a sense – creating a hub/safe haven to expand their employment with other trained members (i.e. pairing a PH qualified Self- employed Contractor with a PH qualified Designer). The participants unanimously supported the proposed mechanisms. This data tells the research that all participants would in fact accept training – provided they were supported and incentivised – to become PH qualified. A few participants noted that, although these proposals have their support, it is also entirely dependent on the volume of funding catered by the UK Government (i.e. if insufficient funds were allocated, the scheme would not be sustainable).

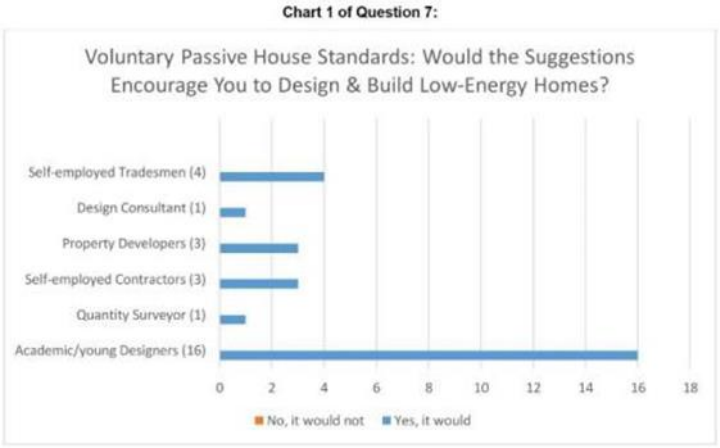

Figure 10. Question 7: 'Voluntary Passive House Standards: Would the Suggestions Encourage You to Design & Build Low-Energy Homes?'

Figure 11, Q8; The data recorded here conflicts with the assumption that each respective role of the industry holds their own opinions; this data shows each and every participant to have their own opinions, irrespective of their position. As you can see: 14/16 of Academic/young Designers, the one Quantity Surveyor, 2/3 of Self-employed Contractors, 2/3 of Property Developers & 3/4 of Self-employed Tradesmen all believe the post-Brexit economy is not an excuse to not go ahead with legislating Passive House; 2/16 of Academic/young Designers, 1/3 of Self-employed Contractors & 1/3 of Property Developers all believe it is an excuse but change such as this exceeds any other importance; remaining, 1/4 of Self-employed Tradesmen believe the post-Brexit economy has nothing to do with it but still does not want a legislative Passive House.

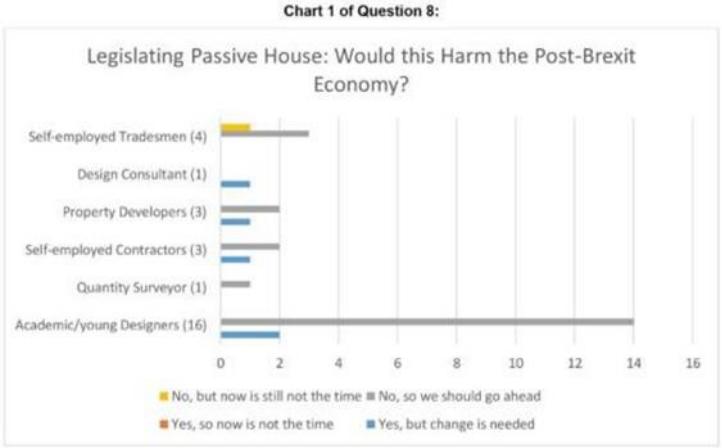

Figure 11. Question 8: 'Legislating Passive House: Would this Harm the Post-Brexit Economy?'

Figure 12, Q9. This follows on from the proposal of support-mechanisms (Figure 1 of Q7), this time asking the participant if it would harm the post-Brexit economy. The participants unanimously agreed on 'no, so we should go ahead'. This is an interesting contrast to the legislative approach to Passive House, revealing a commonality of the participants when it comes to a non-legislative/voluntary approach to Passive House standards.

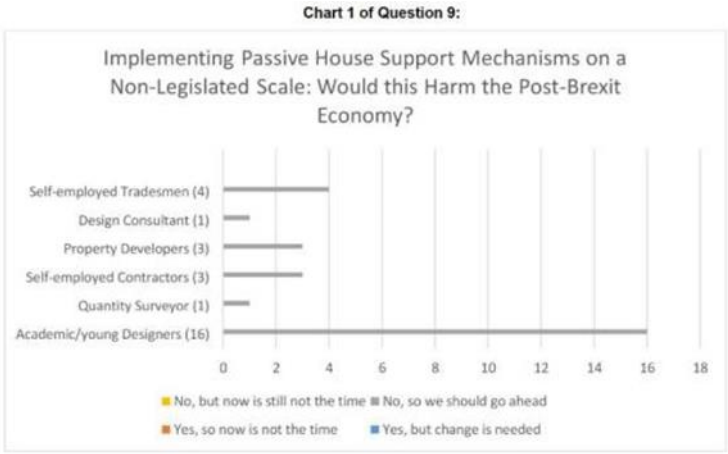

Figure 12. Question 9: 'Implementing Passive House Support Mechanisms on a Non-Legislated Scale: Would this Harm the Post-Brexit Economy?'

Figure 13, Q10. This question was posed to participants to understand if the legislation of Passive House would render their role obsolete – or make it too difficult to be profitable. From the 28 participants: all (16/16) Academic/young Designers said 'no, so we should go ahead'; the one Quantity Surveyor said 'no, so we should go ahead'; one-third of Self-employed Contractors said 'no, we should go ahead' with the remaining two-thirds accepting their job will be challenged, but the change is more important; one-third of Property Developers accept their job is on the line but change is dire, and two-thirds believe the legislation should go ahead; the one Design Consultant said 'no, so we should go ahead'; and, 2/4 of Self- employed Tradesmen admit their job will also be challenged but change is paramount, 1/4 stated that their job would not be challenged and thus legislation should happen, and 1/4 stated their job security will be affected and so does not accept its legislation.

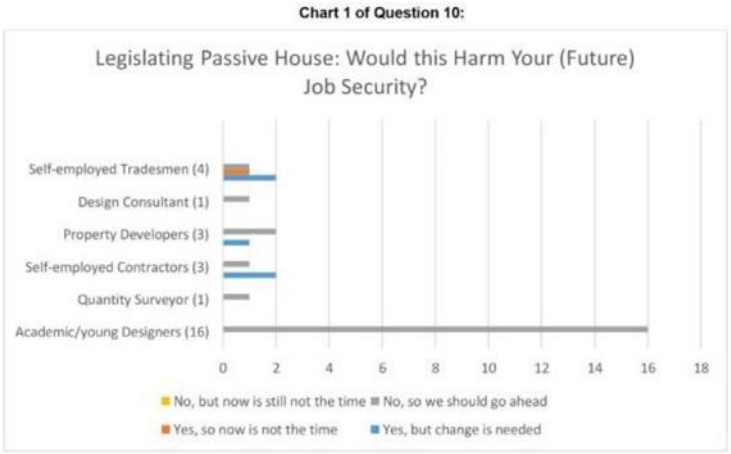

Figure 13. Question 10: 'Legislating Passive House: Would this Harm Your (Future) Job Security?

Figure 14, Q11. Following on from Figure 1 of Q9, this question was put forward to participants with the objective of understanding if the implementation of the proposed support mechanisms (Table 5) would harm their job security. Reminding this investigation that financial offsets were incorporated (ensuring participants enrolled on the programme would not be subject to financial loss), with the addition of expanded employment opportunities as well as future incentives, all 28 of the participants unanimously agreed that such implementations would not impair their role/employment. However, there was a commonality between those who are self-employed: although they all agreed (3/3 of Self-employed Contractors & 4/4 of Self-employed Tradesmen), they all noted that this acceptance was subject to one very important condition: exactly the same response as Figure 10 (Q7) – as long as adequate funding was consistently provided by The UK Government, and its local authorities, to sustain the programme and its benefits.

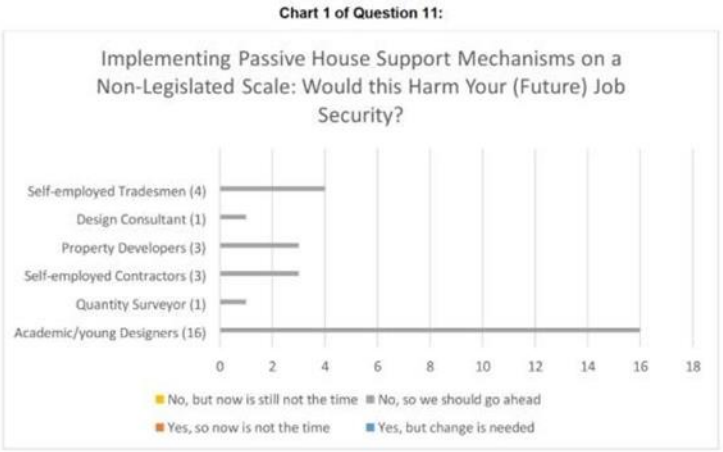

Figure 14. Question 11: 'Implementing Passive House Support Mechanisms on a Non-Legislated Scale: Would this Harm Your (Future) Job Security?'

The data recorded from Figure 10 (Q7) to Figure 14 (Q11) revealed an interesting response to the proposal of mandatory and voluntary approaches to Passive House in the UK. The research obtained through its 'qualitative: secondary evidence' explored The European Commission's response to zero-energy policy; having enforced only guidelines to meet energy-efficiency aspirations in the new-build sector of construction, and having those guidelines paired with a miserable outcome, The European Commission then responded with the enforcement, under the Energy Performance of Buildings Directive, of zero-energy legislation applicable to all new buildings from 31st December 2020. The research paper evolved from this understanding, assuming dire change – such as low-to-zero-energy homes (Passive House being the golden rule for such an approach) – can only be met by dire action: the enforcement of its legislation.

As it turns out, this is not the case. The 'qualitative: primary evidence' of this paper dramatically conflicts with its prior understanding; the voluntary approach to Passive House incorporation, propped up by the proposed support mechanisms, was met with profound positivity – almost the complete antithetical response to a mandatory legislative approach. Understandably, the self-employed members were concerned with their job security if such mechanisms were implemented (a voluntary approach) – however, such concerns would all be relaxed provided the UK Government cater the appropriate funding. In addition, some participants believed the UK's post-Brexit economy would worsen the landscape if Passive House standards were legislated, whereas not a single participant believed this would be the case if support mechanisms (again, a voluntary approach) were implemented into the UK's regulatory framework of the domestic sector.

On the other hand, however, it is imperative for this research to greatly consider its limitation (the COVID-19 outbreak) on not allowing the paper to fully conclude on such an outcome; the research, unfortunately, did not sit-down with other members of the industry to which this research question undoubtedly pertains to: members of local authorities (law- makers), Town Planners, Building Inspectors, Clients, etc. However, as previously concluded,

Self-employed members are far more at risk to such mandatory or voluntary implementations and, thus, considering their collective responses were positive, it is safe for this research to assume that a voluntary approach to Passive House with the proposed support mechanisms will steer the UK and its industries towards low-energy design homes. Q12 of the questionnaire concluded by asking participants if they have any recommendations on how to combat the energy-efficiency concerns in the domestic sector of the UK. Table 8 documents their recommendations.

Table 8. Recommendations of Participants.

Number:	Recommendation:
1.	The participants, specifically being the Academic/young Designers, Self-employed Contractors & Property Developers, noted that the approach to Passive House standards should be an approach with gradual ease and gradual progression. The reason for their recommendation comes with concerns that a sudden shape-up of standards – standards of which are far more superior than employees of its market are familiar with – can be intimidating, causing less attraction to domestic design and construction and, in turn, causing a detrimental disruption to the productivity of its market. This has been noted with utmost consideration and will play a great part to the ultimate conclusion of this research. ***Gradual change + gradual productivity/confidence = a gradual, yet effective, approach to Passive House standards. Noted.***
2.	The participants, specifically the Self-employed Tradesmen & Self-employed Contractors, recommended that, although the proposed support mechanisms of the voluntary approach to Passive House has their full support, it is entirely dependent on the fact that it has the full support and funding of the UK Government and its local authorities. Failing to entirely support the programme, and failing to ensure the sufficient funding required consistently, will cause the programme to collapse and, thus, disrupt the employment of the members concerned. ***Consistent UK Government & local authority support is paramount for the success of this operation. Noted.***
3.	The third and final recommendation from the participants is universal across the board; not a particular member/role of the industry put this forward, but rather some of each. This recommendation regards ensuring Passive House homes are more profitable on the market than those of traditionally designed and built homes (i.e those built to UK Building Regulations 2013 standards for example). Ensuring PH homes are more profitable on the market provides the following chain reaction: more Contractors, Property Developers, Builders etc. will shift their efforts to building PH homes if they're more profitable, meaning this is where the demand will be; Designers will design more (or exclusively) PH homes as this is where the demand is (more Contractors etc. are incentivised to build them); if PH homes are more of an investment than traditional domestic units, more people will want to buy PH homes and sell them (in the future), putting them back on the market; if more people are willing to buy PH homes (due to the demand and investment opportunity), the Real Estate industry will focus on PH homes as there are more opportunities for greater commission. Inevitably, a greater investment opportunity in property will induce more homes to be built (sustaining the need for more housing) and this will also result in the traditional built homes being refurbished to PH standards (as there will be a limited number of new build opportunities; i.e. land). ***Ensure PH homes are more profitable on the housing market than non-PH homes. Noted.***

4. Conclusion

The results of this paper reveal significant conflictions in two pieces of research offered when it comes to understanding the most effective approach. The European Commission's learning process, from implementing energy-efficiency guidelines to enforcing energy- efficiency policies was translated into a 'guidelines do not induce change, but enforcement/legislation does' approach. Fast forward to this paper's own data recordings and discussions, shifting its focus to those who know best: members of its industry, the response directly contrasts what was previously understood; enforcement of Passive House standards will deter its self-employed members (and others, such as Property Developers for example) from the more-advanced design and construction game.

A voluntary approach, however, paired with the proposed support mechanisms and its incentives will be the necessary – and trustworthy – force needed to push the UK's market into the right direction. On this note, the research paper has reached the following conclusion: *first*, the UK Government should gradually enforce (with legislation) stricter energy consumption standards in

the domestic sector (turning to a fabric-first approach), ensuring there is no 'big-leap' from one standard to another as this could disrupt the productivity and confidence of the market; *second*, the UK Government, and its local authorities, should implement the support-mechanisms proposed for members of the industry to become Passive House qualified (and profit from it) and encourage those to follow stricter Passive House standards; *third*, the UK Government and its local authorities should work closely with the Real Estate agencies of the UK, ensuring PH homes are valued more (relative to its size, location, etc.) than its traditionally-designed counterparts.

As a result from implementing the above recommendations, there would be no harm caused to members of its market, and productivity will be sustained with gradual progress, whilst revolutionising the UK's approach to low energy design homes in the process.

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Conflicts of Interest: The authors declare no conflict of interest.

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