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The Effectiveness of Greenhouse Gas Emission Policies in Scottish Local Development Plans

Executive Summary

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University of Dundee, March 2016

Scottish Government commissioned ClimateXChange to assess the effectiveness of greenhouse gas emission reduction policies in Local Development Plans (LDPs) in promoting the uptake of Low and Zero-Carbon Generating Technologies (LZCGT).

Context

The Climate Change (Scotland) Act 2009[i] sets a target to reduce Scotland's greenhouse gas (GHG) emissions by 80 per cent by 2050[ii]. In addition, the Scottish Government has set a target for 100% of Scotland's demand for electricity to be met from renewable sources by 2020[iii].

More than 40% of Scotland's GHG emissions are a result of the heating, lighting and ventilation of buildings. A key tool in reducing this demand is the use of more efficient technology in all new buildings. Legislation now requires that all developments "… be designed to avoid a specified and rising proportion of the projected greenhouse gas emissions from their use, through the installation and operation of low and zero-carbon generating technologies" (Section 3F of the Town and Country Planning (Scotland) Act 1997, amended through the Climate Change (Scotland) Act 2009).

To date 14 Local Authorities have adopted specific Section 3F policies in their Local Development Plans since 2012. This study examined five of these authorities whose early implementation allows a sufficient set of applications for analysis. Examples of relevant technologies include hydro, wind, photovoltaics, solar thermal, biomass, all heat pumps and combined heat and power (CHP).

Key Findings

- The evidence shows **a modest increase in the uptake of LZCGT** since the policies were adopted, although the extent varies across the authorities studied. Whether this trend is a direct result of Section 3F policies or due to a number of external factors such as improvements in Building Standards legislation, the regional context, market influences and consumer preferences was impossible to determine in this study.
- The evidence suggests that from a local planning authority (LPA) perspective, Section 3F policies can be used to facilitate a more integrated approach to specific regional and local energy contexts, delivering larger CO_2 emissions reduction.
- All buildings included in the study met the CO_2 emissions reduction standard set out in building regulations. Compliance with the Section 3F policy requirement for new builds ranged from 35 - 98% across the five authorities studied. **The vast majority that did not comply were multi-domestic developments** (i.e. planning applications for more than one house), suggesting potential for improved compliance.

- The data suggests that **regional differences have a significant impact on the type and extent of LZCGT provision**, with remote areas and those without a gas connection demonstrating a relatively greater uptake than urban and grid-connected areas (i.e. gas grid).
- **All of the domestic buildings included in the sample complied with the 2010 energy standards emissions reduction target** in the Scottish Government's building regulations Technical Handbooks at the time of the study. However, only a limited proportion of the total sample (ranged across the authorities from 35% - 98%) complied with Section 3F policy and achieved this reduction through the installation and operation of LZCGT. Although far fewer in number, all the non-domestic buildings in the sample complied with the Section 3F policy.
- For dwellings, there is a significant correlation between both heat and electrical demand and dwelling size. Space heating dominates in terms of energy consumption and CO_2 emissions in all but the smallest and most energy efficient dwellings.
- By concentrating solely on the specification of LZCGT, current Section 3F policies might, arguably, be detrimental to design-led responses to CO_2 emissions reduction (e.g. demand reduction through energy conservation and passive design principles). The evidence suggests that scaled solutions such as district heating are not being supported. However, the potential should not be underestimated of Section 3F policies to promote awareness, support uptake of more sustainable buildings, and encourage the adoption of more innovative and efficient energy infrastructures.
- None of the policies studied implemented a reduction in CO_2 emissions beyond that already required under the Scottish building standards (Bronze Sustainability Level). Nor do they incentivise applicants to voluntarily meet higher emissions reduction targets.

The **evidence indicates that the Scottish building standards are driving the current reduction in CO_2 emissions, not Section 3F policies**. Although Section 3F policies are effective at raising awareness about the benefits of LZCGTs, there is potential for much more effective promotion of uptake in new buildings and, in particular in integrated solutions with specific local and regional drivers.

Current Practice and Factors Contributing to Effectiveness

Policy approach in specifying LZCGTs

There is general consensus among building design professionals that the most cost effective and long term approach to reducing CO_2 emissions is to reduce overall energy consumption through improved fabric efficiency and site specific passive design[iv] before considering the specification of LZCGT. We found that three of the five LDPs studied encourage this approach by linking the Section 3F policy requirement for LZCGT with other energy efficiency measures and passive design principles. A fourth authority goes further and exempts Passivhaus (http://www.passivhaus.org.uk/) from having to comply with the LZCGT policy due to its inherently very low energy consumption.

Incorporating LZCGT policy at the planning stage

Discussing energy efficiency and CO_2 emissions early in the design process has benefits: it promotes awareness of the requirement to design more sustainable buildings, and encourages the adoption of a more innovative and efficient energy infrastructure, including district heating and combined heat and power (CHP). The evidence suggests that the request for detailed technical data can be counterproductive at this early stage of the design process and is challenging for planners when judging the design and technological solutions offered.

Policy design

There is **significant variation in the compliance methodology, type and complexity of evidence requested** in the LZCGT policies studied. Simple, clearly defined, evidencing procedures appear to achieve higher levels of compliance. One Local Authority achieved 97% compliance at the planning stage with a simple tick box form.

Any policy is only as effective as the rigour with which it is implemented in practice. This study found that **only two of the five Local Authorities studied have procedures in place for non-compliance with policy** and impose suspensive planning conditions where no LZCGT is specified in the planning application. This study did not however investigate if the suspensive conditions were in themselves effective at securing LZCGT.

Delivering renewable energy

Regional influences have a significant impact on the type and extent of LZCGT provision, with remote and off-grid areas demonstrating a greater uptake of renewable technology than urban and grid-connected areas. The Scottish building standards recognise several technologies as LZCGTs. These include: hydro, wind, photovoltaics, solar thermal, biomass boilers/stoves, biogas, heat pumps, fuel cells and combined heat and power (CHP) fired by low emission sources. Most local authorities appear willing to expand this definition to include heat recovery devices and other innovative technologies. Efficient gas boilers and efficient appliances have a role to play in reducing GHG emissions, although they do not shift space and water heating away from non-renewable sources of energy, so inclusion of these as acceptable LZCGT undermines the ethos of the Section 3F policy.

All the policies studied actively encourage the use of scaled LZCGT (CHP and District Heating) but there was little evidence for this being strategically supported in practice.

The **issue of energy storage was absent in all Section 3F policies** with the exception of the inclusion of Fuel Cells as a LZCGT. There was little verification of energy storage provision in practice with the exception of hot water storage cylinders. Mechanical Ventilation Heat Recovery (MVHR) is considered fundamental to the Passivhaus concept, but is currently not sufficiently incentivised.

Delivering CO_2 emissions reduction

Of the five authorities studied, none currently impose requirement for CO_2 emissions reductions additional to that already legislated for in the Scottish building standards. There appears to be little desire in the building industry to meet higher aspirational CO_2 emissions targets, with 70% of domestic buildings simply aiming to comply with the 30% reduction target set in the Scottish building standards at the time of the study. Only 2 of the 482 dwellings (0.4%) returning building warrant data were carbon negative. It is clear that it is these Scottish building standards that are driving the current reduction in CO_2 emissions; not Section 3F policies. We recognise, however, that there are at least two further authorities who have incorporated policies into their plans, but which it was not possible to study as part of this research.

Methodology

The findings are based on a desk-based study taking a sample of planning applications with a heat and electrical demand that were submitted since the period that the specific Section 3F policies were adopted. Quantifiable data for heat demand, electrical demand, energy consumption, CO_2 emissions, and the distribution and contribution of specific LZCGTs was generated from data contained in SAP and SBEM reports. Overall effectiveness was judged in terms of the design of the policy, the application of the policy and the outcome in terms of uptake of LZCGT and achieved GHG reductions. Improvements made to the building standards regulations in 2015 were beyond the scope of this study and have not been considered.

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1 Context and Aims

Section 72 of the Climate Change (Scotland) Act 2009 requires local development plans (LDPs) to include policies to ensure 'that all new buildings avoid a specified and rising proportion of the projected greenhouse gas emissions from their use, calculated on the basis of the approved design and plans for the specific development, through the installation and operation of low and zero-carbon generating technologies.' Section 72 is enshrined in legislation as amendment Section 3F of the Town and Country Planning (Scotland) Act 1997, and will be referred to as Section 3F policies for the remainder of this report.

This report presents the findings of a desk based study commissioned by ClimateXChange, and completed by Architecture and Planning, School of Social Sciences, University of Dundee between June-November 2015. It sought to understand the effectiveness of these greenhouse gas (GHG) emission policies in terms of policy design, practical application and deliverables. To date, 14 local authorities have adopted specific Section 3F policies in their Local Development Plans. The research centred on the statistical analysis of planning and building warrant data (including SAP and SBEM Calculation) collected from five authorities that have implemented these policies through individual local plans in the period since 2012. The results have been anonymised for the purposes of this report, with authorities being identified by the letters A-E. The regional context and Section 3F policy typology are:

- Authority A: Accessible / Remote Rural[1] Umbrella Sustainability Policy[2]
- Authority B: Urban / Sub-Urban Standalone Policy
- Authority C: Accessible / Remote Rural Umbrella Sustainability Policy
- Authority D: Remote Rural Standalone Policy[3]
- Authority E: Urban / Accessible Rural Umbrella Sustainability Policy

We will first consider overall policy effectiveness, before reporting on the detailed analysis of the policies and their specific impact on the uptake of low and zero-carbon generating technologies (LZCGT) and the reduction of GHG emissions.

[1] Defined by Scottish government in: http://www.gov.scot/Topics/Statistics/About/Methodology/UrbanRuralClassification. We used a further definition: Sub-Urban - low density urban fringe housing developments. Therefore the classification would be (Urban -Settlements of 3,000 or more people; Sub-Urban- Fringe development to urban settlements; Accessible Rural - Settlements of less than 3,000 people and within 30 minutes' drive of a settlement of 10,000 or more; Remote Rural - Settlements of less than 3,000 people and with a drive time of over 30 minutes to a settlement of 10,000 or more.

[2] Where 3F policy is found in the Sustainability Policy.

[3] Where 3F policy is separate and not found in the Sustainability Policy.

2 Methodology

The findings of this research are based on a desk based study which took a sample of new build planning applications that were submitted to five Scottish local authorities in the period since they adopted policies in compliance with Section 3F. Data contained in Standard Assessment Procedure (SAP) and Simplified Building Energy Model (SBEM) reports submitted in respect to these applications at the building warrant stage of the developments produced quantifiable data for analysis (on heat demand, electrical demand, energy consumption, CO_2 emissions, and the distribution and contribution of specific LZCGTs). From this data we judged overall effectiveness in terms of the design of the policy, the application of the policy and the outcome in terms of performance values in each local authority.

For more detail regarding the methodology please refer to annex 1.

3 Summary of Findings

3.1 How effective is Section 3F Policy in facilitating LZCGT uptake and CO2 emissions reduction?

Section 3F policy clearly encourages the use of LZCGT in new builds, but the extent to which it directly influence uptake is unclear. The data suggests that regional differences have a significant impact on the type and extent of LZCGT provision with remote and off-grid (electricity and gas) areas demonstrating a relatively greater uptake than urban and grid-connected areas.

All of the domestic buildings included in the sample complied with the 2010 energy standards emissions reduction target legislated for in the Scottish Governments building regulations at the time of the study. However only 55% (range 35% - 98%) of the sample complied with Section 3F policy and achieved this reduction through the installation and operation of LZCGT. Although far fewer in number; all the non-domestic buildings in the sample complied with the policy.

The data also suggests that there is limited appetite in the building industry to meet higher aspirational CO_2 emissions targets, with 70% of domestic buildings simply aiming to comply with the 30% CO_2 emissions reduction target set by the current Scottish building standards (Figure 1). The current assessment procedure is formulated to show governmental compliance with CO_2 emissions reductions agreements in building regulations rather than demonstrate actual CO_2 emissions for reporting and monitoring purposes (Figure 2). In October 2015 new energy standards were introduced to deliver a further 21% aggregate reduction in CO2 emissions. While there is no prescription within building regulations for LZCGT, as energy standards continue to improve it is expected that renewable technologies are likely to form part of the solutions.

As current Section 3F policies only define how the CO_2 emissions targets set by energy standards in building regulations are met, rather than setting independent targets, it is the energy standards that are driving the current reduction in CO_2 emissions.

3.2 How effective is Section 3F Policy application in practice?

Challenges to the effectiveness of current Section 3F policies identified by the study relate mainly to the clarity of the policy, compliance methodologies, application and enforcement.

There are significant differences in the level of technical information required to demonstrate compliance in Local Development Plans studied. Several Section 3F policies request little or no technical information whilst others require detailed SAP or SBEM data that is unlikely to be available at such early stages in the design process. Nevertheless, planning permission for new buildings is not predicated on it being necessary to demonstrate structural and technical energy/emissions efficiency, as this is dealt with through the separate building standards and building warrant process. In Scotland the land use and appearance of the building is dealt with by the planning system, whereas the structural suitability and energy performance of a building is dealt with through the legislatively separate building warrant process. Whilst some councils in Scotland deal with the planning and building warrant applications at the same time, this is not mandatory and common practice is to achieve planning permission before seeking a building warrant.

There is also evidence that the additional Section 3F compliance information being requested, such as sustainability statements, are not routinely cross-referenced with planning documents e.g. drawings. Similarly there is a lack of transparency within the evidencing procedures in relation to compliance approvals of this information. Questions also arise as to whether planners have the detailed specialist knowledge needed to assess the appropriateness of the design and technical solutions offered.

Significant variations and inconsistencies in Section 3F policy descriptions, definitions, procedures and enforcement were identified across the different policies reviewed. Whilst not recommending standardised policies across Scotland, the evidence suggests there is potential to streamline procedures. This could avoid any time lost in initially finding the relevant policies and then understanding their implications, particularly for those practitioners who work across more than one planning area. Most Section 3F policies appear to be open to expanding the definition of LZCGT beyond that contained within the building regulations, which may encourage more innovative technical solutions. However, the inclusion of non-LZCGT within this definition (e.g. efficient gas boilers or efficient appliances) undermines the objectives of the Section 3F policy. LZCGT definitions are outlined in the Sullivan Report 20074 Appendix D[5], which contains a list of agreed technologies to be incorporated in policy. The only instance of technologies incorporating fossil fuels is in reference to "Community heat and power (CHP) or micro CHP using fossil fuels (gas, oil, coal)": I.e. scaled solutions rather than individual gas boilers. The Building Regulations (sec 7.1.3) refers to LZCGTs including: wind turbines, water turbines, heat pumps (all varieties), solar thermal panels, photovoltaic panels, combined heat and power units (fired by low emission sources), fuel cells, biomass boilers/stoves biomass boilers/stoves and biogas. A number of local development plans studied also actively encourage other approaches to reduce CO_2 emissions, such as passive design and energy efficiency measures.

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[4] http://www.gov.scot/Resource/Doc/217736/0092637.pdf

[5] A Low Carbon Building Standards Strategy For Scotland: Report of a panel appointed by Scottish Ministers Chaired by Lynne Sullivan, 2007. http://www.scotland.gov.uk/Resource/Doc/217736/0092637.pdf and http://www.gov.scot/Resource/0043/00437438.pdf. Note - Building Regulations state: 7.1.3 Bronze Active level - "This is the baseline level where the dwelling meets the functional standards set out in sections 1 – 6 of this Handbook, but in addition the dwelling includes the use of a low and zero carbon generating technology (LZCGT) in respect of meeting standard 6.1 within section 6 Energy. This level is primarily to assist local authorities to meet their obligations under Section 72 of the Climate Change (Scotland) Act 2009 by identifying the use of LZCGT. In this respect, LZCGTs include: wind turbines, water turbines, heat pumps (all varieties), solar thermal panels, photovoltaic panels, combined heat and power units (fired by low emission sources), fuel cells, biomass boilers/stoves and biogas

All Section 3F policies are generic. They tend not to be adapted to the specific regional energy context. This misses a potentially useful approach in integrating the often complex and conflicting macro regional energy constraints with local building scale strategies and solutions. The majority of technologies that are adopted focus on micro-scale and individual buildings. There is little evidence of scaled LZCGT systems in the data or of integration of strategies in a more cohesive way. For example, in the regions where wind farms are already available, the planning system could promote the utilisation of district heating and seasonal heat storage (via large scale housing projects) which would help to alleviate intermittency issues and potential losses in generation. Section 3F policies could therefore incentivise the delivery of large-scale developments for greater impact in GHG reductions.

3.3 What are the benefits of embedding Section 3F Policy in Local Development Plans?

Current Section 3F policies, in addition to specifying LZCGT, could also prioritise the promotion of design-led responses to CO_2 emissions reduction (e.g. energy demand reduction and passive design principles). However, the potential of Section 3F policies to promote awareness, support uptake of more sustainable buildings, and encourage the adoption of more innovative and efficient energy infrastructures, is significant and should not be underestimated. Although most of the LAs studied have a fairly direct interpretation of 3F policy, a few LAs take a broader view of this and include demand reduction as well: e.g. one LA exempts Passivhaus from compliance with Section 3F.

By taking this approach, local authorities could broaden the scope/definition of Section 3F policies at the planning stage to encourage early discussions related to passive design, energy efficiency, CO_2 emissions and LZCGT technology provision. This would mean that an energy strategy becomes a core component of the conceptual design process, encouraging architects and clients to consider and optimise LZCGT options earlier rather than later in the process. Otherwise, the point where a building warrant is required, may have already foreclosed more strategic options for integrating LZCGT in a cohesive and efficient way in the design process.

The evidence suggests that from a local planning authority (LPA) perspective, Section 3F policies can be used to facilitate a more integrated approach to specific regional and local energy contexts, delivering larger CO_2 emissions reduction. This could identify upfront the suitability of particular sites or building energy concepts on a macro scale, and pinpoint opportunities for scaled energy solutions such as district heat networks, combined heat and power and energy storage solutions that could have a greater impact on CO_2 emission reduction.

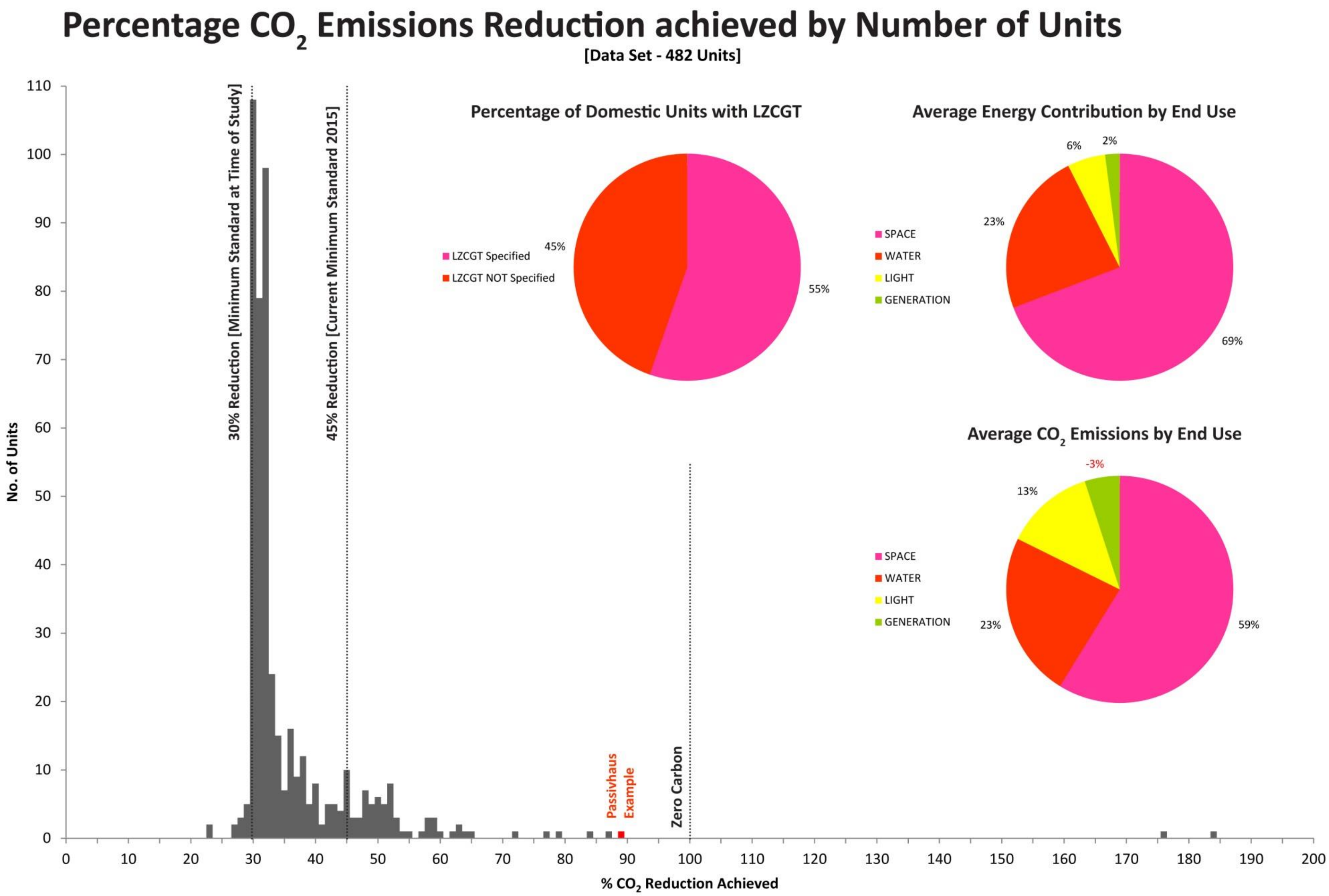

Figure 1: The level of CO_2 Emission Reductions achieved in Domestic Sample. Pie charts show: 1) Percentage of Units specifying LZCGT, 2) Average Total Energy Contribution by End Use (all energy sources) and 3) the Average Total CO_2 emissions by End Use (total of all energy sources) (SAP Data – 403 Units)

Total CO_2 Emissions vs. Percentage CO_2 Emissions Reduction

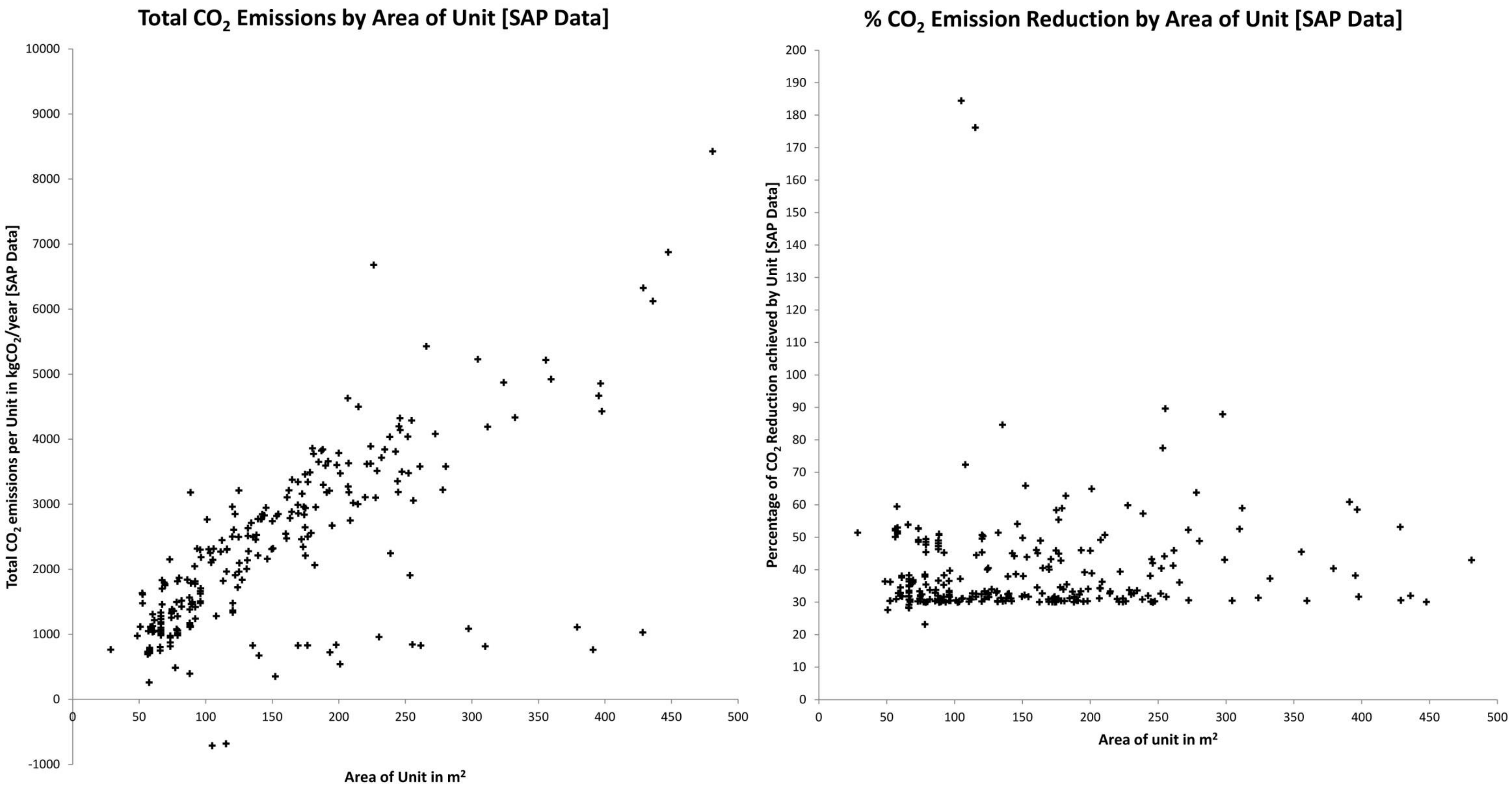

Figure 2: Total CO_2 Emissions and CO_2 Emission Reductions (Domestic Sample: SAP Data – 403 Units). Small Buildings with Low CO_2 emissions are predominantly heated by Efficient Gas Boilers. Large Buildings with Low CO_2 emissions are predominantly heated by Biomass Boilers (see Low and Zero Carbon Technologies for further discussion).

4 Section 3F Policies

4.1 Applications Subject to or Exempt from Section 3F Policy

Key Messages

- Section 3F policies only apply to new builds.
- Regional context (remote rural, near rural, suburban or urban) influences the type of planning applications submitted and by extension the proportion of applications subject or exempt from providing LZCGT.
- The snap shot of each local authority area studied reveals that on average 34% of planning applications are subject to Section 3F policies.
- An additional 11% of applications in the snap shot sample were related purely to the provision of LZCGT, e.g. planning consents for micro-hydro, wind, air source heat pumps etc. as standalone or refurbishment. These are not required by Section 3F policies which relate only to new builds
- A large proportion of LZCGT uptake is not a direct result of Section 3F policies as they were associated with retrofits and other new builds that were exempt from Section 3F.

Overview

Section 72 of the Climate Change (Scotland) Act 2009 requires that local development plans include policies to ensure 'that all new buildings avoid a specified and rising proportion of the projected greenhouse gas emissions from their use, calculated on the basis of the approved design and plans for the specific development, through the installation and operation of low and zero-carbon generating technologies.'

Each of the five LDPs studied clearly state that this policy relates only to new buildings. Authorities A, B & D reinforce this by further defining application types exempt from this policy, as specified in the building regulations (Section 6: Energy: 6.1 Carbon Dioxide Emissions). The LDP for Authority D also exempts Passivhaus from compliance with Section 3F Policy due to its inherently low energy consumption although in reality Passivhaus includes LZCGT in the form of mechanical ventilation heat recovery (MVHR). It is worth noting that heat recovery equipment e.g. MVHR is not currently classified as a renewable technology in respect to building regulations, and yet it can contribute to significant reductions in energy demand. Its contribution is therefore not currently fully accounted for in the SAP.

Snap Shots

To determine the typical proportion of applications subject to or exempt from LZCGT policy, a separate application 'Snap Shot' of each Local Authority area was taken. This was done by selecting the first 100 building or LZCGT related planning applications working backwards from 31/12/14.

These 'Snap Shots' reveal that the inherently different characteristics of each regional context (remote rural, near rural, suburban or urban) influences the type of planning applications submitted and, by extension, the proportion of applications subject to or exempt from providing LZCGT (Table 1). In Authority B, the urban environment places natural limits on expansion and new build developments, resulting in a greater proportion of the planning applications (74%) falling into exempt building categories (alterations, extensions, conversions and change of use). However, the relatively small proportion of new build developments here (21%) represents development on a larger scale than experienced in some of the more rural areas in the study.

As a further point of interest, standalone applications for LZCGTs (e.g. a micro-hydro scheme or the erection of a wind turbine) and retrofitting LZCGTs to existing buildings (e.g. replacing existing heating systems with air source heat pumps (ASHPs) were also extracted from the planning data.

Surprisingly these formed a substantial number of applications in some local authority areas considering that retrofitting most LZCGT (photovoltaics, solar thermal etc.) would not typically require a planning application. This would suggest that the Section 3F policies studied do not provide a complete picture of total LZCGT uptake in a local authority area. The relatively large proportion of this type of application in the Authority D relate in the main to replacing existing heating systems with ASHPs. Fuel availability is also likely to influence the type of heating system.

Averaged across the five local authority areas studied only one third (33.6%) of applications were new builds and subject to LZCGT policy. Two thirds (66.4%) of planning applications fell into either exempt categories (alterations, extensions, conversions and change of use) or related to individual LZCGT applications (standalone and retrofit).

SNAP SHOTS		Domestic	Multi Domestic	Commercial	Industrial	Public	Mixed	Other	TOTAL %
Authority A	Alterations / Extensions	47	2	2	3	1	0	0	55
Near Rural	Change of Use / Conversions	3	1	1	0	0	1	0	6
	LZCGT	0	0	0	0	0	0	5	5
	New Build	31	1	1	1	0	0	0	34
	TOTAL %	81	4	4	4	1	1	5	
Authority B	Alterations / Extensions	46	0	7	0	2	1	0	56
Urban/	Change of Use / Conversions	2	3	9	1	2	0	1	18
Sub-Urban	LZCGT	4	0	0	0	0	0	1	5
	New Build	6	9	1	2	1	2	0	21
	TOTAL %	58	12	17	3	5	3	2	
Authority C	Alterations / Extensions	35	0	2	0	5	0	0	42
Near Rural/	Change of Use / Conversions	3	0	4	0	0	0	0	7
Remote Rural	LZCGT	7	1	1	1	0	0	7	17
	New Build	26	3	1	2	1	1	0	34
	TOTAL %	71	4	8	3	6	1	7	
Authority D	Alterations / Extensions	20.9	0.7	0.7	0.0	2.6	0.0	0.0	24.8
Remote Rural	Change of Use / Conversions	1.3	0.7	5.2	0.0	2.0	0.0	0.0	9.2
	LZCGT	5.9	7.8	1.3	0.0	0.7	0.0	4.6	20.3
	New Build	37.9	2.0	2.6	0.7	2.0	0.7	0.0	45.8
	TOTAL %	66.0	11.1	9.8	0.7	7.2	0.7	4.6	
Authority E	Alterations / Extensions	44	0	5	0	1	1	0	51
Urban/	Change of Use / Conversions	2	0	5	0	0	2	0	9
Near Rural	LZCGT	0	0	1	0	0	0	6	7
	New Build	19	10	1	1	0	2	0	33
	TOTAL %	65	10	12	1	1	5	6	
AVERAGE	Alterations / Extensions	38.6	0.5	3.3	0.6	2.3	0.4	0.0	45.8
	Change of Use / Conversions	2.3	0.9	4.8	0.2	0.8	0.6	0.2	9.8
	LZCGT	3.4	1.8	0.7	0.2	0.1	0.0	4.7	10.9
	New Build	24.0	5.0	1.3	1.3	0.8	1.1	0.0	33.6
	TOTAL %	68.2	8.2	10.2	2.3	4.0	2.1	4.9	
TOTAL % OF EXEMPT APPLICATIONS		44.2	3.2	8.8	1.0	3.2	1.0	4.9	66.4
TOTAL % OF APPLICABLE APPLICATIONS		24.0	5.0	1.3	1.3	0.8	1.1	0.0	33.6

Table 1: Snap shot of the percentage of planning applications exempt or subject to LZCGT policy by Local Authority and Development Type.

4.2 Implementation of Section 3F Policy

Key Messages

- All local authority planning departments studied are seeking a minimum of a Bronze Active Sustainability Level as defined by building regulations: Section 7: Sustainability labelling.
- None of these local authorities' policies require CO_2 emissions reduction beyond those defined in the 2010 building regulations technical handbooks: Section 6: Energy.
- A range of different approaches to Section 3F policy design was identified within the local development plans and supplementary guidance studied.
- Three of the five local authorities recognise the importance of an integrated approach to reducing GHG emissions and give equal weight to reducing energy consumption through passive design strategies and energy efficiency measures as they do to the specification of LZCGT.
- A greater consistency in policy structures and compliance methodologies between different local authority areas might assist design professionals work across regional boundaries.
- A policy that is clear, concise and has all the pertinent information consolidated in one place is easier to use.
- Careful consideration needs to be given to the type and complexity of information requested at planning stages as a detailed level of compliance information appears difficult to interpret at planning application stages.

Overview

Building regulations in Scotland are an entirely separate legislative and consenting process from the planning application process. They are set using performance based standards which allow the architect/designer flexibility to determine how targets are best met within the specific design context. This approach is advantageous as it does not favour one form of construction or product over another and encourages innovation in design and building technologies. The type of LZCGT specified in order to meet the requirements of the planning Section 3F policies is therefore at the discretion of the architect/designer/applicant.

Policy Aspirations

In practice all planning Section 3F policies stipulate that new builds must specify LZCGTs as a means of meeting GHG emissions reduction targets as set out in the building regulation Technical Handbooks: Section 6: Energy. This is equivalent to a Bronze Active Level as defined by Section 7: Sustainability regulations.

None of the local authorities studied are currently implementing policies requiring CO_2 emissions reduction beyond those defined in Section 6: Energy of building regulations. The LDP for Authority A does contain target statements requiring an additional 60% reduction in CO_2 emissions above those set by the 2010 energy standards. However, following a public consultation, the emission reduction was set as a 45% increase on the 2007 standards and deferred to the 2015 regulations in light of the prolonged economic downturn in the construction industry. The LDP was adopted in June 2012, but in practice these targets are not being implemented, as evidenced by the large number of suspensive conditions specifying a minimum Bronze Active Level.

Authorities A, B and E include target statements in their LDPs specifying the percentage of the CO_2 emissions reduction that should be specifically met by LZCGT. This measure seeks to ensure that the LZCGT provided will be capable of reducing CO_2 emissions and is not just a token offering. This is not a straightforward calculation and none of these local authorities stipulates any methodology for verifying this provision so it is difficult to ascertain whether the requirement is actually being met. As an aside, one of the Local Authorities not included in the final data sets does define an evidencing methodology in their LDP, which requires additional SAP Calculations to be undertaken without the LZCGT and the results compared.

Policy Design

A range of different approaches to Section 3F policy design was identified within the LDPs and supplementary guidance. Authorities B & D include the LZCGT requirement as a clearly defined standalone Section 3F policy detailed in their LDPs. Authorities A, C & E promote a more integrated approach to reducing CO_2 emissions that includes improvements in fabric performance, energy efficiency measures and passive design strategies as well as the specification of LZCGT. This is achieved by embedding the LZCGT requirement within an umbrella sustainability policy in their LDPs.

This latter approach runs the risk of losing the specific Section 3F policy requirements within a raft of other sustainability measures. To avoid this, Authority E has clearly articulated the policy requirements within the LDP policy statement. Authority A takes a different tack and uses the LDP to reference a clearly defined standalone policy contained within the supplementary guidance. Authority C, however, despite quoting the requirements of Section 3F, does not articulate a clear Section 3F policy either in the LDP or the Supplementary Guidance.

Accessibility

To be effective, LDPs and supplementary guidance must be suitably structured so that pertinent policy information can easily be extracted from the background text. This allows the design professional to quickly assess the intentions of the policy and the implications it will have on design decisions. The simple expedient of highlighting the policy statements is used in all the LDPs to achieve this objective. For ease of use, a policy needs to be clear, concise and structured so that all the pertinent information relating to Section 3F policy is consolidated, easily accessible and in one place. Umbrella sustainability policies contained in LDPs can be problematic if the structure of the document does not permit full explanation of the 3F Policy in one place. Authority A has overcome this problem by using the LDP almost as a short policy overview, which points practitioners to clearly defined stand-alone policies detailed within the supplementary guidance.

Clarity

To be effective any policy must be clear about its objectives, the targets to be met and the means by which compliance will be shown, as this engenders confidence in the architect/designer that the design strategy taken will meet requirements. The research identified issues in several of the policies that may have a direct bearing on the effectiveness of their implementation. These include:

- *Failure to define explicit policy objectives*
  Despite directly quoting the requirements of Section 3F, the LDP for Authority C is vague in the description of its objectives, simply stating that buildings should '. . . maximise energy efficiency in terms of location, layout and design, including the utilisation of renewable sources of energy and heat . . .' As a result LZCGT policy objectives and targets are not clearly defined.

- *Failure to emphasise obligation to provide LZCGT*
  Several policies reiterate the importance of using passive design principles and energy efficiency measures as well as providing LZCGT as means of reducing CO_2 emissions. Authority C goes further and states that '. . . *simply bolting on renewable energy technologies without first reducing the energy demand of the building through sustainable design must be avoided* . . .' and subsequently only requests the LZCGT portion of the compliance documentation to be completed on developments over 500 m^2. Whilst these sentiments are logical, they imply that the local authority would prefer to see a Fabric First or Passive Design approach and that LZCGT provision is an optional extra.

- *The use of confusing or ambiguous terminology*
  The LDP for Authority B is generally clear in its objectives and targets. However, the definition of the percentage contribution to be made by the LZCGT has caused confusion in practice. The statement that 'Proposals for all new buildings will be required to demonstrate that at least 10% of the carbon emissions reduction standard set by Scottish Building Standards (2007) will be met through the installation and operation of zero-carbon generating technologies.' has been varyingly interpreted as a 10% contribution to CO_2 emissions reduction, a 3% contribution (i.e. 10% of 30%) and an additional 3% contribution to CO_2 emissions reduction (i.e. 10% of 30%) above the current 30% reduction. Further, the means by which compliance with this requirement should be evidenced is not defined.

- *Lack of consistency across all policy documents*
  Authority E states very clearly in the local development plan that the baseline for compliance is Bronze Active. The supplementary guidance however contradicts this and in one particular table suggests the baseline for compliance is Bronze and also requests a sustainability statement be submitted demonstrating how a Zero Net Annual CO_2 from energy use will be achieved. Such discrepancies have potential to confuse both design professional and planning officers.

- *Inclusion of non-LZCGT in list of acceptable technologies*
  Some openness in the definition of LZCGT has the benefit of encouraging innovative or design specific responses. However the inclusion of non-LZCGT within this definition weakens the LZCGT policy objectives. Authority E includes '. . . *Efficient Gas Boilers and Efficient Appliances. . .'* in their definition of acceptable LZCGTs, in contravention of the definition contained in the Scottish building standards. As a result 54 of the 92 units in their warrant data set chose to use efficient gas boilers as the primary heating source and 35 of these units had no other LZCGT specified.

Compliance Procedures

There are significant variations in the compliance methodology and the type and complexity of evidence requested, which appears to have a direct consequence on the level of compliance observed at the planning stage (see 4.4 Extent of Compliance with Section 3F Policy). Simple and clearly defined evidencing procedures seem to encourage higher levels of compliance. Authority D, for example, requires a simple tick box form to be completed and receives almost universal compliance, whilst at the other end of the spectrum Authority A requests full SAP calculations and initially receives a very low level of compliance. However, while Authority D provides procedural compliance, it does not require quantification of GHG reduction.

Part of the underlying problem is the variability in the quality of information contained within individual planning applications. Although some planning drawings do contain information on building services, many do not, as this type of detail will not usually be finalised until the building warrant stage. Planning officers must therefore rely in a large part on written statements submitted with the drawings for confirmation of the LZCGT specified. If the evidencing procedure is made too onerous, or the information requested is not readily available, the policy is often simply not complied with at the time of the planning application. It is also important that local authorities ensure that the different types of information submitted are reviewed and cross-checked. While not quantitatively assessed here, drawings and specifications submitted with planning applications were reviewed and it was not uncommon to find that despite a sustainability approach being defined in sustainability statements, it was either not evidenced in the design drawings, or compatible with the drawing evidence as submitted.

Obtaining basic information on the type of LZCGT proposed early in the planning process is useful, as it offers the opportunity for the local authority to open a dialogue and make strategic energy suggestions. For example in relation to the use of district heating networks with large scale developments, or other appropriate technologies suited to regional influences etc. It also permits conditions pertaining to the proposed LZCGT to be attached to the planning consent. The need to correlate the standard of compliance documentation requested with the appropriateness to the design stage is therefore vital. A simple tick box exercise or a short form requesting some very basic information is perhaps the easiest way to ensure LZCGT information is submitted. SAP calculations tend not to be completed until after the design has been finalised and are simply not available at this early stage in the process. Requesting SAP calculations as evidence at planning appears to be counter-productive, as it results in no information being submitted at all.

4.3 Enforcement of Section 3F Policy

Key Messages

- Evidence suggests that the systematic application of the LZCGT policy is lacking in some local authority areas.
- No evidence was found of any attempt, either in policy documents or in practice, to monitor developments under construction to ensure that the specified LZCGT is delivered in practice.
- No conditions were imposed on any planning application stipulating what type of LZCGT was to be used.
- Only two of the five local authorities impose suspensive planning conditions at planning stage, if the application fails to comply with Section 3F policy.

Overview

All the units in the study, whether they complied with Section 3F policy, or not, achieved the minimum standards required by the 2007 building regulations: Section 6: Energy. During the period relating to the applications studied this was an aggregate 30% reduction in CO_2 emissions relative to 2007 (Figure 1, Figure 2).

Application and Enforcement

The lack of obvious enforcement of Section 3F policies in our sample was not explainable. However, based on a limited questionnaire survey, the anecdotal evidence suggests this might simply be due to planning officers being increasingly pressurised into fast tracking planning applications. It was also suggested that there is a range of attitudes, both individual and institutional, towards the relative importance of climate change issues, which reflects on the rigour with which the Section 3F policy is applied and enforced in practice. Some local authorities systematically check for LZCGT provision and routinely discuss the policy in handling documentation. In others evidence suggests it is rarely discussed. This tends to be the case where the LZCGT policy is just part of a more comprehensive umbrella sustainability policy rather than a stand-alone policy.

Whilst most policies clearly define targets and compliance evidencing procedures, only two of the five local authorities appear to have developed any procedures for non-compliance. The way Section 3F policy is applied and enforced is unique to each local authority area and plays such a substantial role in the results achieved, it is difficult to draw conclusive arguments about the effectiveness of the policy design itself in promoting compliance. It is therefore worth noting these different approaches:

- **Authority A** has a very low initial compliance rate and routinely attaches a suspensive compliance condition to the planning consent to ensure that compliance documentation (an Energy Statement and SAP Calculations) are submitted and agreed prior to commencement on site. The policy document acknowledges the difficulties involved in submitting SAP information at the planning stage and is willing to accept the compliance documentation being submitted at the same time as the building warrant application to enable applications to be processed quicker. Warrant data suggests that the Section 3F policy is usually only complied with at this stage. This is the only local planning authority to set CO_2 emission reduction targets higher than the current Scottish Standards but the evidence indicates that these are currently not being enforced, most likely due to the deferral in the emissions reduction standards to 2015 (refer to explanation in Section 4.2 Policy Aspirations)

- **Authority B** also routinely reinforces the LZCGT policy by attaching a suspensive condition to the planning consent, requesting compliance documents before works commence on site where this information has not been previously submitted. Whether these are pursued in practice is uncertain as the study did not have access to completion certificates to verify this. However, if there is no evidence of LZCGT provision and a completion certificate is given it would infer the suspensive condition isn't being enforced. This is the only local authority to record a slight reduction in the LZCGT provision in the building warrant data (see 5.3.3 Technology Trends). This data set is dominated by Multi Domestic developments.

- **Authority C** initially appears to enforce its Section 3F policy. It is routinely discussed in the handling documents and the majority of applications have been deemed to comply. However, this is an umbrella sustainability policy, and on closer inspection, there is little evidence that the specific LZCGT portion of the policy is fully considered. Suspensive conditions are not imposed to enforce compliance where LZCGT is not indicated on the drawings and documents. Despite this, they do have an almost universal compliance with the LZCGT provision at the warrant stage, in the sense that LZCGT in some form has been delivered.

- **Authority D** achieved almost universal compliance at every stage of the process. The stand-alone Section 3F policy is prominently positioned in the local development plan and is always considered in the handling documents.

- **Authority E** does not appear to prioritise enforcement of its Section 3F policy. The policy is not discussed in the handling documents. It has a relatively low rate of compliance at planning and no suspensive conditions are imposed to enforce compliance prior to works starting on site. The addition of efficient gas boilers and efficient appliances to the definition of LZCGT also obscures the actual level of compliance with the Section 3F requirements. It is worth noting that while this may reduce emissions compared to old boiler technology, it does not encourage a move away from fossil fuel energy sources. However, it does achieve an average level of compliance at the warrant stage.

No evidence was found of any attempt, either in policy documents or in practice, referring to the monitoring of developments under construction to ensure compliance with the Section 3F policy.

Conditions of Consent

Two distinct types of planning conditions were recorded in consent documents: suspensive compliance conditions and LZCGT specific conditions (Table 2).

Authorities A and B both applied suspensive compliance conditions to consent documents when planning applications either did not specify LZCGT or did not provide the required standard of compliance documentation. These conditions typically require that the requested information be provided and agreed with the local authority prior to any works commencing on site. The remaining local authority areas did not actively pursue new build planning applications where LZCGT had not been specified. Although it is fair to note that 97% of new build planning applications in Authority D complied with the Section 3F policy without recourse to such action.

LZCGT specific consent conditions were imposed by all five local authorities. Only certain technologies attracted this type of conditions: micro wind, biomass, ASHP, MVHR and CHP. Specific conditions were coded as aesthetic, performance and end of use related and recorded. LZCGT specific conditions can only be attached to an application if an LZCGT is clearly identified in the planning submission. As the type of LZCGT specified is at the discretion of the architect/designer, no conditions were imposed on any planning application stipulating that certain LZCGT had to be used. However, in our opinion, LZCGT specific conditions can be applied whether or not technology is identified in the planning application.

LDP	COMPLIANCE					MICRO WIND					BIOMASS								ASHP										MVHR	CHP
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	9	10	1	1
Authority A	218																													
Compliance	191	2				0					25								19										7	0
Aesthetics																														
Performance												1	1									1			2					
End of Life																														
Authority B	261																													
Compliance			3	163	1	0					0								2										34	1
Aesthetics																														
Performance																											1			
End of Life																														
Authority C	150																													
Compliance						0					15								7										3	1
Aesthetics												1																		
Performance																		1			1		1						1	1
End of Life																														
Authority D	150																													
Compliance						2					49								84										9	1
Aesthetics						2	2	2	2	2	1								37											
Performance						1	2	1	1										78	2						82		82		
End of Life						2	2												76											
Authority E	132																													
Compliance						0					19								3										1	0
Aesthetics																														
Performance											4			4	4	2	4							1		1				
End of Life																														
All LDP Areas	911																													
Compliance	191	2	3	163	1	2					68								89										44	2
Aesthetics						2	2	2	2	2	1	1							37											
Performance						1	2	1	1		4	1	1	4	4	2	4	1	78	2	1	1	1	1	2	83	1	82	1	1
End of Life						2	2												76											

Table 2: Number of Units with LZCGT and Number attracting LZCGT Specific Planning Conditions (Categories numbered 1-10 =conditions identified) (Planning Data Set - 911 Units)

4.4 Extent of Compliance with Section 3F Policy

Key Messages

- The pattern of compliance with Section 3F policy was unique to each local authority area and is the result of a combination of factors.
- Only 55% (Range 34 - 100%) of the Domestic sample returning full SAP data for analysis (403 Units) specified LZCGT.
- The vast majority of non-compliant applications were Multi Domestic developments.
- 100% of the Non-Domestic sample returning full SBEM Data for analysis (24 Units) specified LZCGT.
- A simple, clearly defined, compliance procedure requesting stage appropriate evidence appears to engender a higher degree of compliance with policy at the planning stage.
- A staged compliance procedure could provide the means of increasing early evidencing and confirming the LZCGT is delivered in practice.

Overview

The pattern of compliance with Section 3F policy at planning and building warrant stages was distinct to each local authority area and is the result of a combination of factors: the building type, overall policy design, appropriateness of the compliance methodology, desire for a cost effective autonomous energy source, need to utilise LZCGT to meet SAP/SBEM constraints and to what extent the policy is systematically applied in practice. Ultimately any policy is only as effective as it is implemented and enforced in practice.

Extent of Compliance

55% of the Domestic sample that returned full SAP data for analysis specified LZCGT (Table 3). Compliance ranged from a low of 34% in Authority A to 100% in Authorities C & D. The overall high level of compliance achieved by the Authority D at every stage of the process is suspected to be a result of a simple, straight forward and clearly defined compliance evidencing procedure. 100% of the Non-Domestic sample returning SBEM Data (24 Units) complied with LZCGT policy. The units refer to the number of dwellings in an application.

	Planning Data		Warrant Data		SAP Data		SBEM Data	
	No of Units	% with LZCGT	No of Units	% with LZCGT	No of Units	% with LZCGT	No of Units	% with LZCGT
Authority A	218	28%	108	60%	39	46%	11	100%
Authority B	261	46%	196	35%	187	34%	1	100%
Authority C	150	23%	63	95%	40	100%	11	100%
Authority D	150	97%	62	98%	57	100%	0	N/A
Authority E	132	23%	92	61%	80	55%	1	100%
TOTAL	911	43%	521	60%	403	55%	24	100%

Table 3: Specification of LZCGT by Local Authority and Total at planning and warrant stages

Notes:

1. In sample for Authority A the percentage of units with LZCGT specified at planning includes those that had subsequently complied with suspensive planning conditions.
2. Although efficient gas boilers are deemed an LZCGT in the LDP for Authority E, they are not included as such in this study.
3. As each of the subsequent data sets in Table 3 is a smaller subset of the planning data set, it is important to trace just those applications back to planning to obtain an accurate reflection of the changes in LZCGT specification and the proportion of units complying with policy as applications progress from planning to warrant stage (see 5.3.3 Technology Trends).

All local authority areas recorded either a similar or higher level of LZCGT provision at building warrant compared to planning application stage (see 5.3.3 Technology Trends). In Authority C the increase in the number of units specifying LZCGT was dramatic. The low initial compliance here could be a result of this LDP not requesting evidence of LZCGT at planning on developments below 500m^2, which in effect excludes all single domestic dwellings. It also suggests that other factors may be in play in the delivery of LZCGT such as the desire for an autonomous readily available energy source to counteract problems relating to energy supply, availability and price in remote regions, or simply the necessity of meeting SAP requirements. However, LZCGT is not a requirement in order to meet SAP.

A deeper interrogation of the Domestic sample (SAP data set) reveals that the single domestic and mixed developments were much more likely to comply with the Section 3F policies than multi domestic developments (Table 4). A mixed development includes domestic and other uses e.g. retail, and a multi-domestic development comprises solely of domestic units, typically volume house building. This would suggest that in some local authorities, volume house builders are not required to comply with Section 3F policy. As the multi domestic sample represents 70% of all Domestic units this appears to be a significant compliance issue.

LDP	Single Domestic			Multi Domestic			Mixed		
	No. of Units	No. with LZCGT	% with LZCGT	No. of Units	No. with LZCGT	% with LZCGT	No. of Units	No. with LZCGT	% with LZCGT
Authority A	14	14	100%	25	4	16%	-	-	-
Authority B	2	2	100%	185	62	34%	-	-	-
Authority C	22	22	100%	14	14	100%	4	4	100%
Authority D	44	44	100%	13	13	100%	-	-	-
Authority E	30	26	87%	49	18	37%	1	1	100%
TOTAL	112	108	96%	286	111	39%	5	5	100%

Table 4: Percentage of Domestic Buildings specifying LZCGT by Domestic Sub-Type (SAP Data - 403 Units)

Encouraging Compliance

In terms of encouraging compliance[6], the level of information requested and the complexity of the compliance procedure appears to have a significant impact on the number of applications evidencing LZCGT at the planning stage. For example the tick box form simply requiring the architect/designer to identify what LZCGT will be used, resulted in 97% of units in Authority D specifying LZCGT at the planning stage. This translated to 100% inclusion of LZCGT in the SAP data set. In comparison requesting SAP/SBEM Data at the planning stage appears to be counterproductive and results in no evidence being submitted purely because these calculations are typically not available at this stage in the design process. There obviously needs to be a correlation between the standard of compliance documentation requested and its appropriateness to the design stage, which speaks to a need for legislators to better understand the design process in practice.

Although the evidence is inconclusive, it would be logical to presume that encouraging a commitment to utilising LZCGT early in the design process would improve the chances of a well thought out energy strategy being incorporated into the building when constructed – even if the type and extent of the LZCGT provision is altered somewhat in the final design.

With the exception of the two local authority areas that impose suspensive compliance conditions on planning consents, where the application has failed to specify LZCGT or not included the level of data requested, there appears to be little evidence of actual enforcement of the policy in practice. Only Authority A, in requesting SAP/SBEM calculations as evidence of LZCGT prior to commencement on site, has in place any mechanism for checking that the specified LZCGT is delivered.

[6] In this section, compliance refers to uptake of LZCGT and not the actual quantities of emission reductions met.

We would suggest that a staged procedure might be the most suitable approach to promote policy compliance. This might be a simple tick box form to encourage a commitment to using LZCGT early in the design process, followed by a suspensive compliance condition applied to the planning consent, requiring proof at the building warrant stages.

Ideally such a checklist would be no more than a single page in length to encourage universal compliance and would be used purely to ascertain basic pertinent information regarding the energy efficiency of the design proposals, the proposed energy systems, the role of LZCGT in this mix and any proposed electrical or thermal storage. Establishing a simple standard format for the submission of LZCGT data is important both for the design professional and planning officers, as it permits a familiarisation with the type of data required and eases the document handling process. The tick box form used by Authority D, or the relevant sections extracted from the complex sustainability checklists deployed by Authorities C & E, could be utilised as a framework for the design of this checklist.

To ensure that the proposed LZCGT is actually implemented, a suspensive condition could then be applied to the planning consent, requesting that the full SAP calculation be submitted to the local planning authority for consideration and approval prior to works commencing on site. This could follow a similar format to the standard suspensive condition employed by Authority A, with any changes to the proposed LZCGT to be agreed in writing with local planning authority prior to works commencing on site. Adopting such a process would also enable the local authority to evidence their commitment to reducing CO_2 emissions by meeting their obligations under the Climate Change (Scotland) Act 2009.

To ensure that the policy has been implemented, evidence could also be requested at the point where the building is completed, and completion certificate issued.

5 Results & Interpretations

5.1 Applications

5.1.1 Scale of Development (SAP & SBEM Data)

Key Messages

- Domestic applications dominated in all local authority areas.
- A large proportion of the non-domestic applications were not subject to LZCGT policy as they were not heated e.g. agricultural buildings and shell industrial units.
- The Domestic sample (403 Units) had an overall net energy consumption of 3221.9 MWh/year, which represented a total CO_2 emission of 812.8 tonnes CO_2/year.
- The Non-Domestic sample (24 Units) had an overall net energy consumption of 1793.8 MWh/year, which represented a total CO_2 emission of 425.9 tonnes CO_2/year.
- The average net energy consumption was 63.9kWh/m^2/year in the Domestic sample and 120.5kWh/m^2/year in the Non-Domestic.
- The average CO_2 emissions were 16.1kgCO_2/m^2/year in the Domestic sample and 28.6kgCO_2/m^2/year in the Non-Domestic.
- In the authorities studied it wasn't possible to calculate percentage CO_2 emission saving as a result of implementing LZCGT's from the SAP data supplied at building warrant stage (refer to note on p22 Overview)

Overview

A high degree of variability in the standard of drawings submitted at the planning stage was evident in the data collected. In most cases information regarding the size of developments in terms of floor areas was not stipulated in drawings and documents at this stage. This level of information was only obtainable through the SAP and SBEM calculations submitted with the warrant application. The analysis in this section is therefore based on the units returning complete SAP and SBEM Data, representing 403 Domestic units with an aggregate floor area of 50 416 m^2 and 24 Non-Domestic units with an aggregate floor area of 14 887 m^2 (Table 5). An application refers to the referenced document submitted by the developer whilst units refer to the number of dwellings in an application.

Domestic and Multi-Domestic applications dominated in terms of numbers of applications and individual units in all local authority areas. There were far fewer Non-Domestic applications and a large proportion of these were not subject to Section 3F policy as they were not heated e.g. agricultural buildings and shell industrial units. The majority of the Non-Domestic sample returning complete SBEM data was concentrated in Authorities A and C.

The Domestic sample had an overall Net Energy Consumption of 3221.9 MWh/year, which translated to Total CO_2 Emissions of 812.8 tonnes CO_2/year. Over the sample this results in an Average Net Energy Consumption of 63.9 kWh/m^2/year (equivalent to 7995 kWh/unit/year) and Average CO_2 Emissions of 16.1kgCO_2/m^2/year (equivalent to 2017 kgCO_2/unit/year).

The Non-Domestic sample is smaller and more diverse in its makeup, so extrapolating statistically significant results is more problematic. The sample had an overall Net Energy Consumption of 1793.8 MWh/year which translated to Total CO_2 Emissions of 425.9 tonnes CO_2/year. Over the sample this results in an Average Net Energy Consumption of 120.5 kWh/m^2/year (equivalent to 74 743 kWh/unit/year) and Average CO_2 Emissions of 28.6 kg CO_2/m^2/year (equivalent to 17 746kgCO_2/unit/year).

Overall Scale of Development

LDP	Domestic (SAP Data) No. of Applications	No. of Units	Total Area m^2	Gross Energy Consumption MWh/year	Net Energy Consumption MWh/year	Total CO_2 Emissions tonnes CO_2/year	Non-Domestic (SBEM Data) No. of Applications	No. of Units	Total Area m^2	Gross Energy Consumption MWh/year	Net Energy Consumption MWh/year	Total CO_2 Emissions tonnes CO_2/year
Authority A	15	39	8260	489.2	488.4	139.9	11	11	8900	826.2	827.7	237.7
Authority B	8	187	16419	1203.7	1181.5	262.5	1	1	1204	207.9	207.9	68.1
Authority C	26	40	4916	366.9	342.3	85.0	10	11	4423	661.3	652.1	110.6
Authority D	48	57	8389	486.8	484.9	141.8	-	-	-	-	-	-
Authority E	40	80	12432	748.4	724.8	183.6	1	1	360	106.1	106.1	9.5
TOTAL	137	403	50416	3294.9	3221.9	812.8	23	24	14887	1801.6	1793.8	425.9

Table 5: Scale of Development by Local Authority and Total (SAP Data – 403 Units & SBEM Data - 24 Units).

5.1.2 Status of Development (Planning & Warrant Data)

Key Messages

- All applications were selected on the basis that they were new builds subject to LZCGT policy.
- 48% of applications in the planning data set (158/330 applications) have been granted planning consent but building work is still to commence.
- Only 15% of applications in the planning data set (50/330 applications) have been completed.

Overview

All applications were selected for inclusion in this study on the basis that they were new builds subject to LZCGT policy and had advanced to a stage where one would expect SAP and SBEM Calculations to have been completed. Practically, this meant that all the applications had building warrant approval (see Annex 1: Methodology & Sample Data Sets). 52% of these planning applications (453 Units) are currently under construction or have been completed (Table 6). The remaining 48% of applications (458 Units) have building warrant consent but work has yet to start on site. This is not unusual particularly in the current economic climate and considering that the sampling method was designed to favour recent applications.

LDP		Applications: Total Applications	Warrant Approved	Works Commenced	Works Complete	Units: Total Units	Warrant Approved	Works Commenced	Works Complete
Authority A	No.	101	48	34	19	218	92	104	22
	%		47.5%	33.7%	18.8%		42.2%	47.7%	10.1%
Authority B	No.	15	3	6	5	261	130	122	9
	%		21.4%	42.9%	35.7%		49.8%	46.7%	3.4%
Authority C	No.	65	33	23	9	150	113	26	11
	%		50.8%	35.4%	13.8%		75.3%	17.3%	7.3%
Authority D	No.	93	35	41	17	150	42	82	26
	%		37.6%	44.1%	18.3%		28.0%	54.7%	17.3%
Authority E	No.	56	39	17	-	132	81	51	-
	%		69.6%	30.4%			61.4%	38.6%	
TOTAL	No.	330	158	121	50	911	458	385	68
	%		48.0%	36.8%	15.2%		50.3%	42.3%	7.5%

Table 6: Status of Development by Local Authority and Total (Planning Data – 911 Units).

5.2 Energy Demands

5.2.1 Heat Demand (SAP Data)

Key Messages

- Data captured by local authority area clearly indicates that social context and its effect on domestic building design is a major factor in the determining Heat Demand.
- On average 92% of the total energy demand of the domestic sample (SAP Data – 403 Units) was attributed to heating (63% space heating and 23% water heating).
- Space Heat Demand (SHD) is by far the most significant factor in determining Total Heat Demand (THD) in all but the smallest and most energy efficient dwellings.
- Large dwellings require substantially more energy for Space Heating than small dwellings, and therefore have substantially higher Total Heat Demands.
- Occupants of larger dwellings consume substantially more energy per head than those accommodated in more modest dwellings.

Overview

The analysis is based on the sample of domestic units returning complete SAP Data for analysis. This sample represented 403 individual dwellings with an aggregate floor area of 50 416 m^2 and an assumed occupancy of 1054. The average dwelling size was 125m^2 representing 47m^2/person. While this seems comparatively large it is representative of the proportionally high numbers of large dwellings of low occupancy ratio across the sample, with the largest dwelling in the sample having occupancy of 3 people derived from the SAP data. On average 92% of the total energy demand of this sample was attributed to heating - 63% space heating and 23% water heating (Figure 1, Figures 6a-6f). The 403 dwellings in the sample had a combined Total Heat Demand (Space & Water) of 3161 MWh/year; equivalent to an average of 62.7 kWh/m^2/year or 3000 kWh/occupant/year (Table 7). Every dwelling in the sample had a Heat Demand.

Data captured by local authority area indicates that social context and its effect on domestic design is a major factor in determining Heat Demand. For example Authority A returned a significantly higher Total Heat Demand/Unit than Authority B. This can be primarily attributed to the small dwelling sizes in Authority B due to the urban area reflected in the requirements for larger numbers of affordable housing. (Table 7).

				Average Heat Demands							
				Space			Water		Total		
LDP	No. of Units	Average Area m^2	Average Occupancy	SHD/Unit kWh/year	SHD/m^2 kWh/m^2/year	SHD/occupant kWh/occupant/year	WHD/Unit kWh/year	WHD/occupant kWh/occupant/year	THD/Unit kWh/year	THD/m^2 kWh/m^2/year	THD/occupant kWh/occupant/year
Authority A	39	212	3.02	9911	46.8	3286	2350	779	12261	57.9	4065
Authority B	187	88	2.46	3495	39.8	1422	1806	735	5301	60.4	2157
Authority C	40	123	2.66	6524	53.1	2451	2238	841	8762	71.3	3292
Authority D	57	147	2.73	7488	50.9	2746	2280	836	9768	66.4	3582
Authority E	80	155	2.68	7629	49.1	2843	2179	812	9809	63.1	3655
SAP Data Set	403	125	2.61	5802	46.4	2219	2043	781	7845	62.7	3000

Table 7: Average Heat Demands by Local Authority and Total.

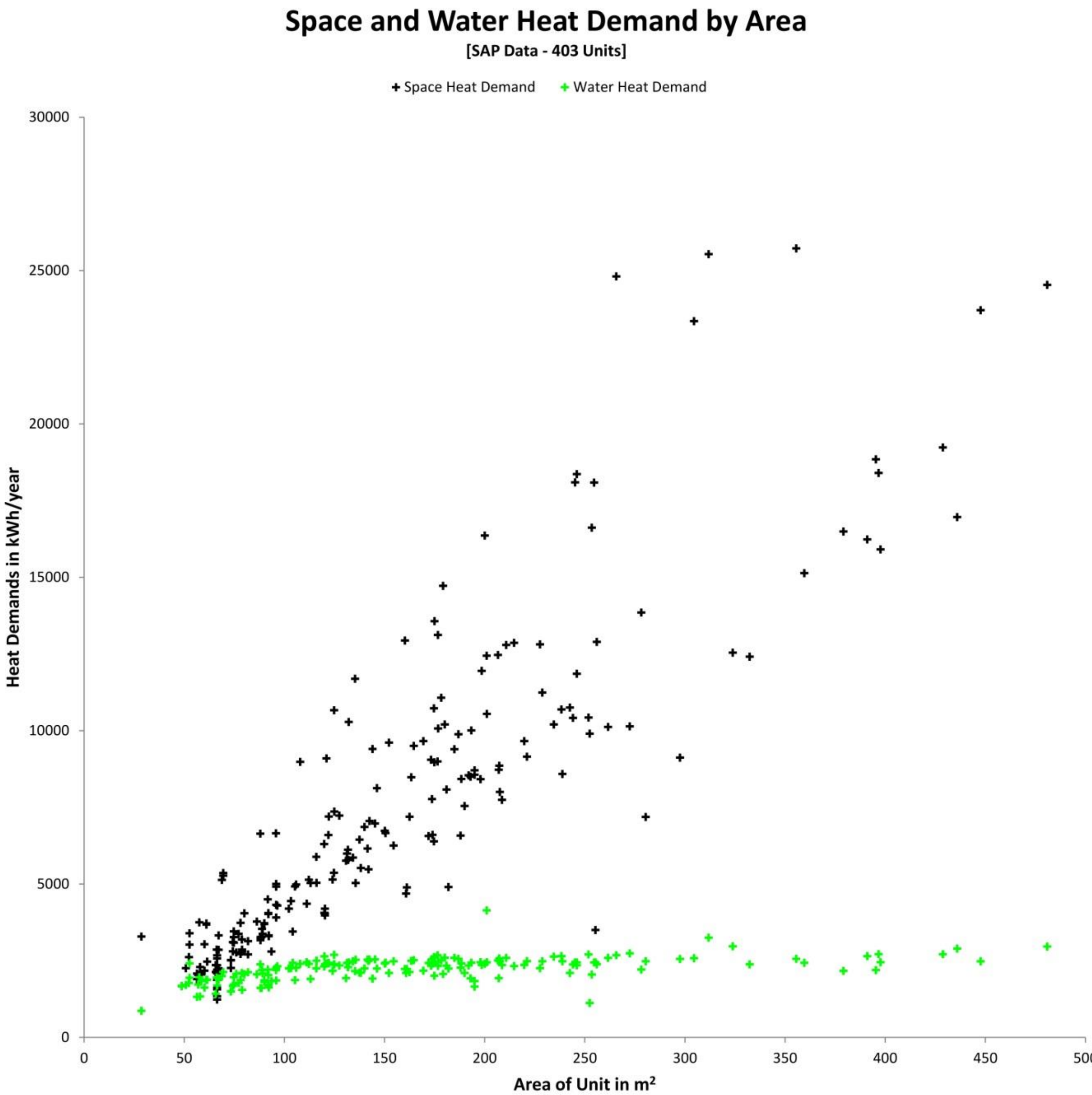

Figure 3: Space and Water Heat Demands plotted by Area of Unit (SAP Data - 403 Units).

Space Heat Demand

While all dwellings in the sample complied with the minimum levels of the Scottish building standards, it is clear that large dwellings require *substantially* more energy for space heating than small dwellings, purely because of their size (Figure 3). Whilst this point is apparently self-evident, the importance of dwelling size as the single largest contributing factor to space heat demand, total heat demand and carbon dioxide emissions, cannot be overstated. The impact of building scale is masked in the calculation methodology in SAP. This is a direct consequence of defining factors such as Space Heat Demand and CO_2 emissions targets in terms of *per* m^2; because these units of measure statistically conceal the size of the dwelling and the true magnitude of its space heat demand and resultant CO_2 emissions (Figure 2). This is illustrated when considering the Total Heat Demands calculated from the study (Table 7). Despite having the highest THD/Unit and the highest THD/occupant, Authority A has the lowest THD/m^2. Conversely Authority C has the second lowest THD/Unit and THD/occupant, but the highest THD/m^2. Variance in the upper and lower limits of space heat demand in the smaller units may be due to typology with small detached houses having poorer form factors and correspondingly higher heat loss than similarly sized terraced and apartment typologies. Across the sample differences in space heat demand for dwellings of similar area could be due to differences in fabric efficiency specifications e.g. the Passivhaus returned in the sample in Figure 4 has similar space heat requirements to the smaller dwellings in the sample despite having a floor area equivalent to some of the highest space heat demands sampled.

Water Heat Demand

Water Heat Demand is calculated relative to the assumed occupancy of the dwelling as defined in SAP. As dwelling size increases the corresponding increase in Water Heat Demand is therefore relatively slight. As a result, Water Heat Demand is statistically more significant in smaller and/or more energy efficient dwellings (Table 7, Figure 3). Although still rare, several cases were evident in the sample for Authority B where the Water Heat Demand approached or even surpassed the Space Heat Demand. These were typically one or two bedroom flats or mid-terrace houses in Multi-Domestic developments with an inherently low space heat demand due to their typology and compact size resulting in good form factors (surface to volume ratio) This would suggest that in more modest affordable housing of suitable typology (e.g. terrace or apartments), targeting the Water Heat Demand with Zero Carbon Technologies (Solar Thermal, Photovoltaics/Immersion Unit, PFGHR, WWHR) could be significant in reducing both CO_2 emissions and fuel poverty because it is a proportionally higher component of total energy demand than in the larger dwellings.

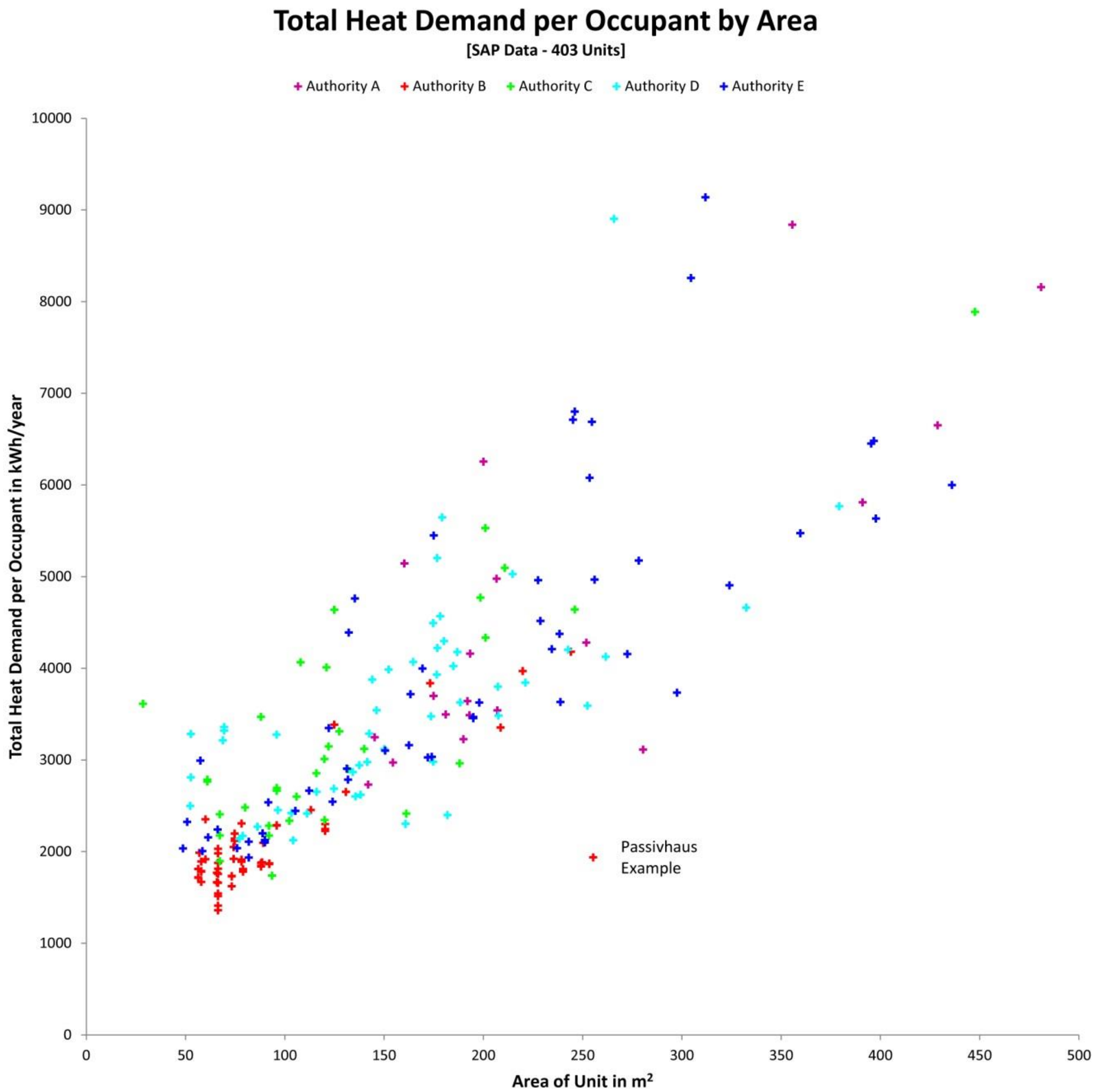

Figure 4: Total Heat Demand/Occupant plotted by Area of Unit (SAP Data - 403 Units).

Total Heat Demand per Occupant

In large dwellings the Total Heat Demand per Occupant is substantially higher than in small dwellings (Table 7, Figure 4). This is a direct result of an increase in Space Heat Demand without a proportional increase in assumed occupancy. Put simply, occupants of larger dwellings consume substantially more energy per head, than those accommodated in more modest dwellings.

5.2.2 Electricity Demand

Key Messages

- The regional context and resulting choice of heating system is a major factor in determining the Gross Total Electricity Demand.
- Electricity used for space & water heating accounted for 65% of the Gross Total Electricity Demand.
- Electricity used for lighting and ventilation accounted for 35% of the Gross Total Electricity Demand.
- On average 6% of the total energy demand of the domestic sample (SAP Data – 403 Units) was attributed to lighting; which translates to 13% of the total CO_2 emissions.

- Electricity generated from LZCGT (directly related to or fixed to the dwelling) (Photovoltaics) totalled 73 095 kWh/year; equivalent to 12% of the Gross Total Electricity Demand.

Overview

The analysis is based on the sample of domestic units returning complete SAP data for analysis. This sample represented 403 individual dwellings with an aggregate floor area of 50 416 m^2 and an assumed occupancy of 1054 for the total sample (2.6 occupants/dwelling). These dwellings had a combined Gross Total Electricity Demand of 599 MWh/year; equivalent to an average of 11.9 kWh/m^2/year or 568 kWh/occupant/year (Table 8). Factoring in the 73 MWh/year electricity generated by LZCGT incorporated in the dwellings (Photovoltaics) this is reduced to a Net Total Electricity Demand of 526 MWh/year; equivalent to an average of 10.4 kWh/m^2/year or 499 kWh/occupant/year. Every dwelling in the sample had an Electricity Demand.

SAP does not distinguish between the electricity produced, which is used within the building or subsequently exported. It assumes energy produced is used directly to reduce the carbon emissions of the building. It is also not possible to deduce from SAP data submitted for warrant, the percentage CO_2 emissions reduction due specific LZCGT. Consequently, one local authority not included in the survey requests two SAP calculations (with and without LZCGT) in order to calculate energy contribution and percentage CO_2 emission reduction due to LZCGT uptake. In Section 5.3 Low and Zero Carbon Generating Technologies the actual energy contribution, energy used and CO_2 emitted by the technologies is detailed.

				Average Electricity Demands								
				Space & Water			Light & Ventilation			Gross Total		
LDP	No. of Units	Average Area m^2	Average Occupancy	S+W/Unit kWh/year	S+W/m^2 kWh/m^2/year	S+W/occupant kWh/occupant/year	L+V/Unit kWh/year	L+V/m^2 kWh/m^2/year	L+V/occupant kWh/occupant/year	TED/Unit kWh/year	TED/m^2 kWh/m^2/year	TED/occupant kWh/occupant/year
Authority A	39	212	3.02	1431	6.8	474	720	3.4	239	2151	10.2	713
Authority B	187	88	2.46	166	1.9	68	433	4.9	176	600	6.8	244
Authority C	40	123	2.66	1666	13.6	626	560	4.6	211	2226	18.1	836
Authority D	57	147	2.73	2381	16.2	873	547	3.7	201	2928	19.9	1074
Authority E	80	155	2.68	1245	8.0	464	589	3.8	220	1834	11.8	684
SAP Data Set	403	125	2.61	965	7.7	369	521	4.2	199	1486	11.9	568

Table 8: Average Electricity Demands by Local Authority and Total.

Electricity Demand (Space & Water)

65% (388 804 kWh/year) of the Gross Total Electricity Demand is utilised for Space and Water Heating. The vast range of individual values recorded in the sample is attributed to the differences between dwellings using electricity as a primary fuel source (ASHPs, GSHPs and electric heating systems) and the majority for which electricity is purely used to operate pumps and fans associated with the heating system. This leads to two distinct groupings in the graphed results (Figure 5).

Data captured by local authority area also clearly indicates that regional context and the resultant choice of heating system is a major factor in determining Electricity Demand (Space & Water). Remote areas with the potential for generating renewable wind and tidal power and inherent problems accessing traditional fuel supplies appear to be specifying more electrical heating systems (ASHPs and GSHPs) than urban areas. As a result Authority D has a significantly higher average

Electric Demand (Space & Water) than Authority B where efficient gas boilers are almost universally used for heating as they are the energy system of choice due to existing infrastructure and comparatively inexpensive fuel costs (Table 8).

Electricity Demand (Lighting & Ventilation)

The remaining 35% (209 857 kWh/year) of the Gross Total Electricity Demand is utilised for Lighting and Ventilation. There tends to be a gradual increase in Electricity Demand (Lighting & Ventilation) as dwelling size increases most likely due to increased numbers of bathrooms and larger floor areas requiring increased lighting. Specification of Mechanical Ventilation and Heat Recovery (MVHR) typically doubled the Electricity Demand (Lighting & Ventilation) recorded and appear as slight outliers in the graphed results (Figure 5). SAP Data does not clearly indicate the contribution made by MVHR, but it is widely accepted that heat recovery can significantly reduce space heating demand. While the specification of MVHR is aligned with buildings constructed to very good levels of airtightness where infiltration is less than 3m3/h.m2 measured at 50Pa efficiency gains are as a result of a combination of improved airtightness and heat recovery. These cannot be separated as air tightness cannot be improved beyond 3m3/h/m2 without using mechanical ventilation due to air quality issues but without coupling mechanical ventilation to heat recovery it tends to be inefficient. While MVHR is considered in the ventilation calculation in SAP, a weighting factor is used but it is unclear from the calculation methodology how this is taken into account in the contribution of the heat recovery element to reducing space heat demand. In this study, as a conservative estimate, it is presumed that the presence of MVHR will have reduced Space Heat Demand by a third i.e. the contribution made by MVHR is calculated as 0.5 x Space Heat Demand. In the sample for Authority B Electricity Demand (Lighting & Ventilation) is greater than Electricity Demand (Space & Water) because of the large number of MVHR units in the sample

Figure 5: Electricity Demand plotted by Area of Unit (SAP Data - 403 Units).

5.2.3 Impact of the Building Scale

Key Messages

- Building scale is the most significant factor in determining the Total Energy Demand of a Domestic building
- Large dwellings constructed using the same specification have substantially higher Total Energy Demands than small dwellings.
- Occupants of large dwellings tend to consume substantially more energy per head, than those accommodated in more modest dwellings.
- Performance indicators defined in terms of *per m^2* effectively mask the realities of building scale.

Overview

All the dwellings in this study have building warrant approval and have therefore achieved the minimum standards set by the 2010 building regulations: Section 6: Energy,

In the Domestic sample it is obvious that Space Heating dominates in terms of energy demand, energy consumption and CO_2 emissions in all but the smallest and most energy efficient dwellings (Figure 1; Figure 3; Figures 6a-6f). The data also clearly records a vast range of individual Heat and Electrical Demands (kWh/year) across the sample and demonstrates that these differences relate primarily to variations in dwelling size (Figure 3; Figure 5). In large dwellings, the total heat demand per occupant can be over six times greater than that in homes of a more modest scale (Figure 4). It is recommended that consideration of building scale and by extension energy use per occupant are important issues that could be addressed by Section 3F legislation for controlling development and emissions e.g. larger dwellings with small occupancy could be incentivised to comply with higher fabric specifications or increased uptake of LZCGT's to align emissions with those of smaller dwellings of similar occupancy.

This situation stems in part from the current method of evaluating Space Heat Demand, energy consumption and CO_2 emissions in terms of *per* m^2. These types of measurement effectively mask the realities of building scale and are based on the assumption that as dwelling size increases the assumed occupancy will increase proportionately, which is generally not the case evidenced by the SAP data.

The Passivhaus outlier highlighted in the sample for Authority B (Total Heat Demand of 5949 kWh/year, area of 255 m^2 and assumed occupancy of 3.07) illustrates clearly that the Total Energy Demand/Occupant is in line with the more affordable dwellings in the sample (Figure 4).

This finding would suggest that it could be beneficial to assess Space Heat Demand and Energy Consumption in terms of kWh/year *per occupant* and CO_2 emissions in terms of $kgCO_2$/year *per occupant*, and set targets accordingly. Setting targets relative to these measures could necessitate substantially higher fabric energy efficiencies and/or utilization of increased LZCGT in larger dwellings to compensate for their increased CO_2 emissions.

We would recommend that local authorities require that individual dwellings above a certain scale to be built to more exacting standards to compensate for their inherently greater Space Heat Demand. Taking this approach could naturally limit excessive individual consumption of energy and materials without actually restricting free choice, and favour the development of more modest dwellings and more energy efficient building forms e.g. terraces or clustered typologies. In the long term however, as building standards improve in all dwellings the underlying issue of scale would resurface and need to be addressed.

Examples exist of other assessment systems that adopt approaches to tackle this issue of scale and individual energy consumption and would benefit further investigation. The LEED Green Building Certification System[7] recognises the importance of dwelling size in total energy consumption and has developed a system that awards smaller dwellings and discriminates against excessively large dwellings. Correlations could also be drawn here with the concept of the 2000-Watt Society[8]

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[7] http://www.usgbc.org/leed

[8] http://www.2000watt.ch/fileadmin/user_upload/2000Watt-Gesellschaft/de/Dateien/weitereInformationen/2KW_article_in_Sustainability_Magazine.pdf

proposed by the Swiss Federal Institute of Technology in Zurich in 1998. This concept envisions maintaining current living standards whilst reducing average total energy consumption per citizen, across all sectors of the economy, not just domestic usage, to no more than 2000 watts (equivalent to 17 520 kWh/year) by 2050.

5.3 Low and Zero Carbon Generating Technologies

5.3.1 Technology Types

Key Messages

- Micro-hydro, micro-wind, photovoltaics, solar thermal, biomass boilers & stoves, biogas, heat pumps, CHP fired by low emission fuels and fuel cells are defined as LZCGT in the Scottish building standards.
- Planning departments appear willing to extend this definition to include heat recovery, district heating systems and other innovative LZCGT.
- Inclusion of efficient gas boilers and efficient appliances within the definition of acceptable LZCGTs is evident in one policy.
- Not all LZCGT are equal
- Hydro, wind, photovoltaics and solar thermal are efficient Zero Carbon Technologies. They consume little or no energy in their operation compared to other technologies and consequently produce little or no CO_2 emissions. However their contribution to the energy mix in the sample was comparatively small or not evident. No examples of small scale hydro and wind were evident in the SAP data, although there were some examples of proposed wind and hydro in the planning data.
- Some heat recovery devices (Passive Flue Gas Heat Recovery and Waste Water Heat Recovery) also consume little or no energy in their operation or produce little or no CO_2 emission. Currently these are not classified as LZCGT's, although a number of authorities open to new and emerging technology allow these within their policy.
- MVHR utilises a larger amount of energy in its operation, so does result in some CO_2 emissions; but aligned with high level of building fabric performance simultaneously delivers significant reduction in the Space Heat Demand.
- Biomass, heat pumps and combined heat and power (fired by low emission fuels) (CHP) are low carbon technologies. They all emit significant amounts of CO_2 but either because of the accounting methods employed or their inherent efficiency they offer varying degrees of carbon saving relative to more traditional fuels and technologies.

Overview

The Scottish Technical Handbook: Section 7 Sustainability: Clause 7.1.3: recognises several LZCGT that could be specified to assist Local Authorities to meet their obligations under Section 3F. These include micro hydro, micro wind, photovoltaics, solar thermal, biomass boilers/stoves, biogas, heat pumps and combined heat and power (CHP) fired by low emission sources. Fuel Cells, although actually an energy storage technology, are also included in this list.

Most planning departments appear to be open to expanding the definition of LZCGT. Such openness has the benefit of encouraging innovative or design specific responses, such as the use of energy recovery technologies such as Passive Flue Gas Heat Recovery (PFGHR) to heat a crematorium, heat recovery from refrigeration and freezer units to heat a food store or the use of mechanical ventilation and heat recovery (MVHR) in Passivhaus designs. The inclusion of non-LZCGT generating technologies within this definition however only appears to weaken the LZCGT policy objectives. Authority E for example includes '. . . Efficient Gas Boilers and Efficient Appliances. . .' within the definition of acceptable LZCGT. As a result, 54 of the 92 units in their warrant data set chose to use efficient gas boilers as the primary heating source and 35 of these units had no other LZCGT specified.

All of the policies studied encourage the use of scaled LZCGT (CHP and district heating) but there was little evidence for this being strategically supported in practice. Local authorities could advocate CHP and district heating schemes by suggesting they be considered as an option in all Multi-Domestic and Mixed developments.

Low vs. Zero Carbon Technologies

Not all LZCGT are equal. Whilst the number of occurrences of a LZCGT in the sample may indicate its prevalence in the market, it does little to describe its relative importance within the energy mix or its effectiveness at reducing GHG emissions. To ascertain how relatively important and effective a technology is one must consider the amount of energy it contributes relative to the amount of energy consumed to make that contribution and the amount of CO_2 emitted as a result. This is clearly evidenced in the energy maps (Figures 6a-6f). It should be noted at this juncture that in SAP calculations CO_2 emissions are calculated relative to the theoretical energy consumed or generated, by applying multiplication factors determined in the methodology for each energy type. Energy consumption leads to positive CO_2 emissions being recorded, energy generation to negative CO_2 emissions. It is useful therefore to consider the impact and effectiveness of various LZCGT on CO_2 emissions.

Traditional renewable generating technologies - hydro, wind, photovoltaics, solar thermal and some heat recovery devices (PFGHR, WWHR) are true zero carbon technologies. They consume little or no energy in their operation and consequently produce little or no CO_2 emissions. The energy they generate is used to offset the energy requirements of the building so following the SAP methodology their contribution is converted into a negative CO_2 emission. This is an accounting device, as in reality these technologies neither emit nor remove CO_2 from the atmosphere. However they do displace CO_2 that would have been created had the renewable technology not been used.

Mechanical ventilation heat recovery (MVHR) utilises a moderate amount of energy in its operation and results in some CO_2 emissions, but aligned with good levels of fabric insulation simultaneously delivers significant reduction in the Space Heat Demand due to the heat recovery system. The extent of the energy savings from MVHR, which is fundamental to the Passivhaus concept, is not clearly accounted for in SAP methodology in terms of heat energy savings. While there was no direct evidence to substantiate if this disincentives the uptake of MVHR it may be difficult for a building to comply with SAP using this technology particularly where an auxiliary heating system is not needed. It was evident that there were relatively low numbers of instances of the technology being used in the sample.

Biomass, heat pumps and combined heat and power (CHP) are low carbon technologies. They all emit significant amounts of $CO_{2,}$ but either because of the accounting methods employed or their inherent efficiency they offer varying degrees of carbon saving relative to more traditional fuels and technologies. The SAP methodology uses CO_2 emission factors on figures defined by DEFRA which incentivises specific technology/fuel sources, which it considers sustainable.

Biomass could be construed as being particularly controversial because other sources recognise its combustion releases 0.39kgCO_2/kWh[9]; almost twice as much as natural gas which releases 0.22kgCO_2/kWh. However, the multiplication factors used in SAP to calculate CO_2 emissions are 0.198 for gas and 0.008 for biomass, which implies emissions from biomass are a factor of 100 less

[9] http://www.volker-quaschning.de/datserv/CO2-spez/index_e.php

than gas. In the sample for 198.4MWh/yr, biomass produced 4.5 tons/yr CO_2 emissions or less than 1% of CO_2 emissions for the sample. In contrast, 134.02 MWh/yr delivered energy from gas produced 315 tons/yr CO_2 emissions or 35% of the total CO_2 emissions.

Heat pumps operate on electricity, so their ability to reduce CO_2 emissions is directly related to how green the electricity source is. They are generally considered more efficient than gas boilers, but are responsible for 20% of the Gross CO_2 emissions in the domestic sample due to the amount of energy they consume (SAP Data – 403 Units). Ground source and water source heat pumps are more efficient than air source heat pumps, but cost more and require more space outside the building envelope. In SAP the manufacturers rated efficiency of the heat pump is used to calculate the energy consumption of the unit and this is used to determine CO_2 emissions by applying a multiplication factor of 0.517. In the sample, ground source heat pumps consumed 86.5MWh/yr and produced 246.5MWh/yr of useful energy, resulting in 44.7 tons/yr CO_2 emissions or 5% of total CO_2 emissions. In contrast air source heat pumps consumed 215.7 MWh/yr and produced 483.2MWh/yr useful energy, resulting in 111.6 tons/yr CO_2 emissions or 12% of total CO_2 emissions for the sample. As the conversion factor for GSHP and ASHP is the same, dividing the energy produced by the energy consumed gives the typical efficiency of the technology. Therefore in the total sample ASHP had an efficiency of 224% and GSHP had an efficiency of 285%.

5.3.2 Energy Maps

Key Messages

- The type of LZCGT specified is at the discretion of the architect/designer
- The distribution of LZCGT by local authority area suggests that regional context plays a key role in both the type and extent of LZCGT specification.
- Data captured by local authority area suggests remote areas currently have a greater proportional uptake of renewable technology than urban areas in terms of number of units specifying LZCGT and its overall contribution to the energy mix.

Overview

The procedures for analysing energy use within Domestic (SAP) and Non-Domestic (SBEM) buildings differ substantially. The structure of the SAP calculation defines very clearly energy demands, energy consumptions and CO_2 emissions relative to the technology types used. It is therefore an ideal data mining source for information pertaining to LZCGT provision and the overall energy mix. The SBEM data output reports for the non-domestic sample returned from Building Standards were less transparent, did not contain the same level of data breakdown and were therefore not as easy to interpret in this way. In addition, only 24 units returned complete SBEM data in the entire sample. 22 of these units were concentrated in just two areas: Authorities A and C. Authority D returned no SBEM data. In SAP, all energy generated by the building is accounted for within the context of the building. Excess energy generated through LZCGT is deducted from the total energy consumed by the building. This either lowers or creates negative energy consumption and CO_2 emission figures. The SAP calculation assumes that all energy produced by the building is consumed within the building. Carbon emission reduction for any subsequent energy exported is already accounted for in the SAP calculation and energy exported is not detailed in the calculation.

Energy Maps

The energy maps developed here are therefore based on the sample of domestic units returning complete SAP Data for analysis (Figure 6a-6f). This overall sample represented 403 individual dwellings with an aggregate floor area of 50 416 m^2 and an assumed total occupancy of 1054. Individual energy maps were developed to graphically summarize each local authority area studied and the overall sample. Each energy map includes the number of instances of LZCGT recorded, the energy consumption of the technology, the energy contribution to the building and the associated

CO_2 emissions by technology type. Importantly, it places this in the context of end use and the overall energy mix.

Clarification of Terminology and Figures used in Energy Maps

In the following diagrams the energy consumption is the total energy used in delivering the heat/electrical demand of the building. Due to the inherent inefficiencies in the combustion process it is typically necessary to consume a larger amount of energy than the heat or electrical demand infers. This is normally due to incomplete combustion and unutilised heat losses. There are exceptions to this rule as electricity is 100% efficient as the energy consumed is the same as the energy contributed. Whereas, heat pump technology consumes less electrical energy than the heat energy delivered. Solar thermal and MVHR contributes more energy than they consume but use relatively small amounts of energy in their operation relative to the energy they contribute. The energy contribution is the amount of useful energy delivered to the building. In SAP CO_2 emissions are calculated by applying a multiplication factor to the energy consumption figure which is representative of the fuel type and the efficiency of the technology. These factors are regularly updated therefore the figures used in this report reflect those used at the time of the sample building's construction.

In the Energy Maps [Technology] represents the different technologies used, these primarily supply heating demand. [Number] refers to the number of instances the technology was recorded. It should be noted that some electricity is used in the operation of most of these technologies e.g. to run pumps and fans in solar thermal and other technologies. Some buildings within the sample did not include LZCGT while others use more than one fuel source or LZCGT. Table 11 details the number of LZCGT's recorded per unit.

In the sample there were only a few instances of buildings using electricity directly for heating and this is represented by the [Number.]. All buildings in the sample [403] had an electricity demand for lighting which is represented in the graphs simply as [LIGHTS]. In the Electricity category the energy consumption equals the energy contribution. The inefficiencies of grid supplied electricity production is represented in the SAP calculation for the CO_2 emission from this technology type. Contribution of electricity from LZCGT's is deducted from the grid electricity consumption to reduce this figure. Solar Photovoltaics consume no energy therefore all energy produced is presumed to be consumed within the building and is deducted from the electricity demand.

Dual Fuel refers to Solid Fuel Stoves that utilise a variety of low carbon or fossil fuel sources e.g. biomass and coal. These are given a conversion factor in SAP of 0.028 which is lower than biomass but higher than coal.

The contribution of MVHR is not easily quantifiable from data contained within the SAP calculation. A conservative estimate was made based on the premise that the space heat demand will have been reduced by one third due to the heat recovery component of the technology. When graphing MVHR in the pie charts its contribution to space heating is shown. As the CO_2 emissions offset by the heat saved from heat recovery is not clearly represented in the SAP data; it should be noted that the CO_2 figures illustrated represents emissions from operating the ventilation component of the technology and NOT the emissions saved from the heat recovery component. Therefore, it would be expected that in reality that the use of MVHR would have a greater impact on CO_2 emission reduction than is represented in the figures illustrated here (see also Page 22).

Over the sample ASHP had an efficiency of 224% and GSHP had an efficiency of 285%. (60% average difference). Variances across the sample which would contradict this are due to individual assumed efficiencies of devices used within the SAP calculation (refer to page 27).

The most significant conclusion drawn from the Energy Maps is that if the relative efficiencies of different technologies were calculated i.e. energy contribution to CO_2 emission, then it would be possible to determine which technologies would be more efficient at reducing CO_2 emissions if incentivised. In the sample, the relative contribution of LZCGT and non-LZCGT technologies to overall carbon emission reductions can be calculated by comparing total delivered energy contribution against total CO_2 emissions (Table 9).

	Total Energy Contribution MWh/yr	Total CO_2 Emissions Tonnes CO2/yr	CO_2 Emissions / Delivered Energy Tonnes CO2/ MWh	Percentage of Total Energy Contribution %	Percentage of Total CO_2 Emissions %
Non-LZCGT	2385.5	677.7	0.284	68	86
LZCGT	1144.7	113.4	*0.099	32	14
Total (Non-LZCGT + LZCGT)	3530.2	791.1	0.224		

* This figure would reduce if heat recovery component of MVHR is factored into the calculation (See note above).

Table 9: Contribution of Technology to Energy Demand and CO_2 Emissions

Authority A: Energy Map: New Build Domestic

[SAP Data - 39 Units]

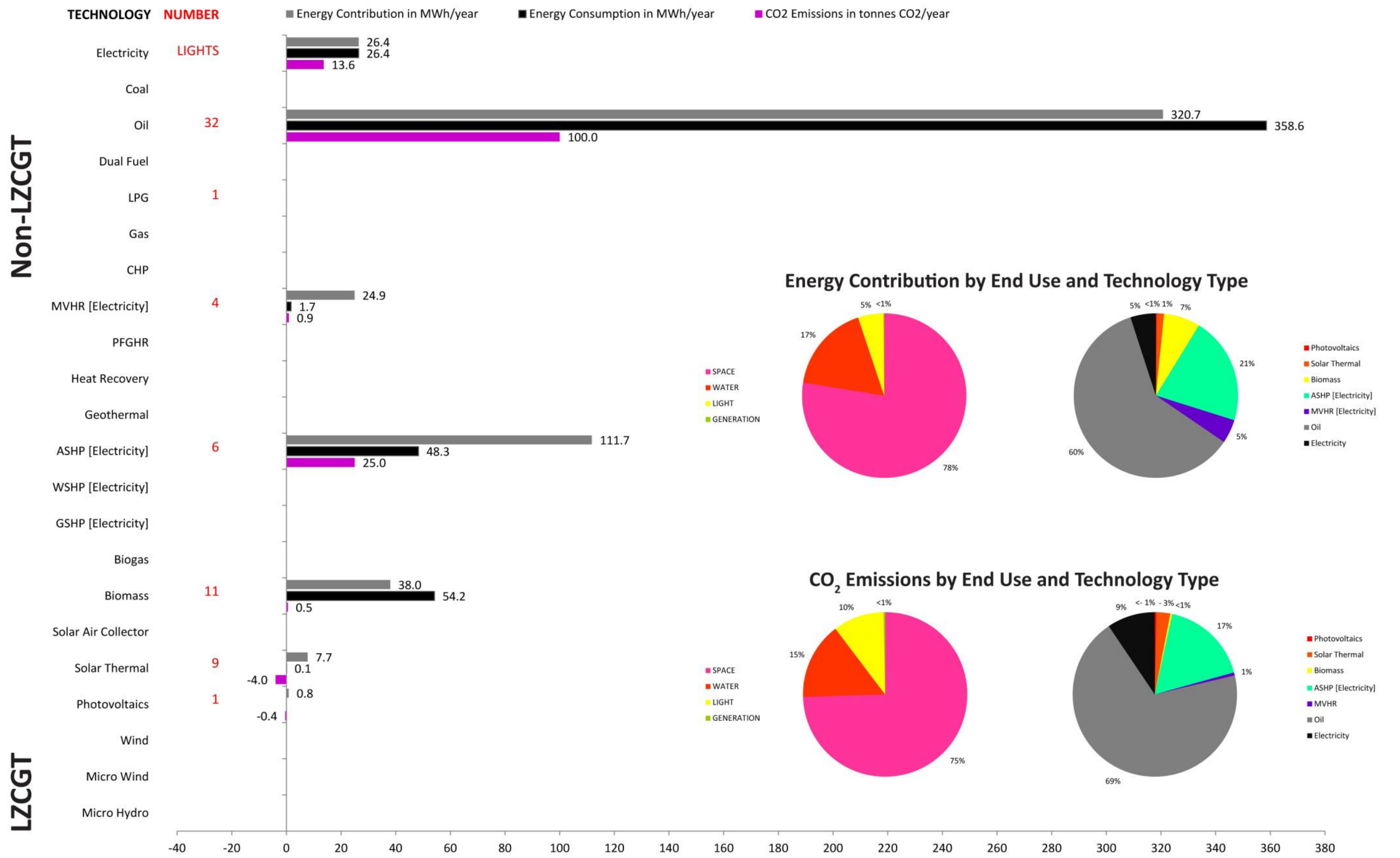


Figure 6a: Energy Map: Authority A

e

Authority B: Energy Map: New Build Domestic

[SAP Data - 187 Units]

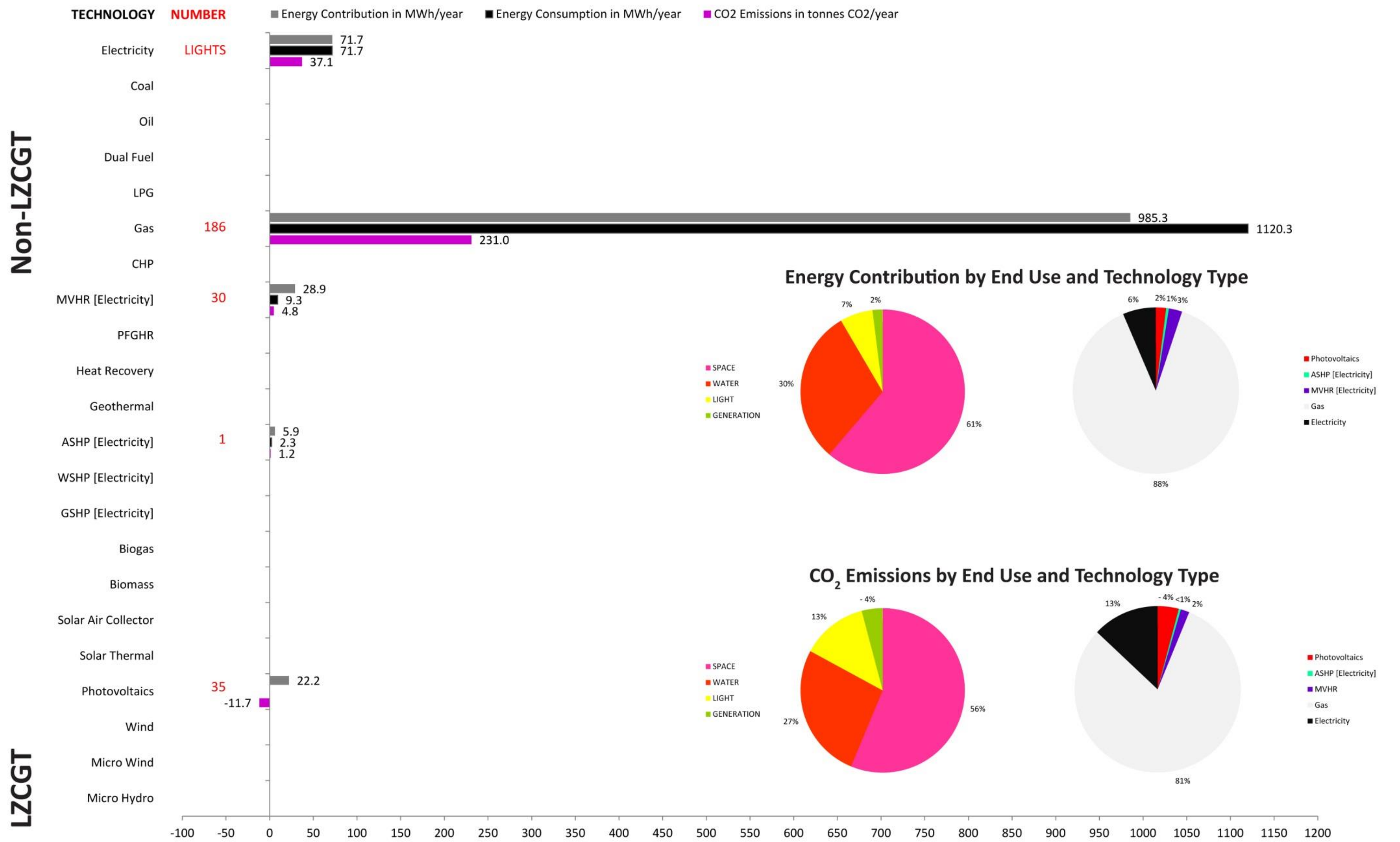


Figure 6b: Energy Map: Authority B

Authority C: Energy Map: New Build Domestic

[SAP Data - 40 Units]

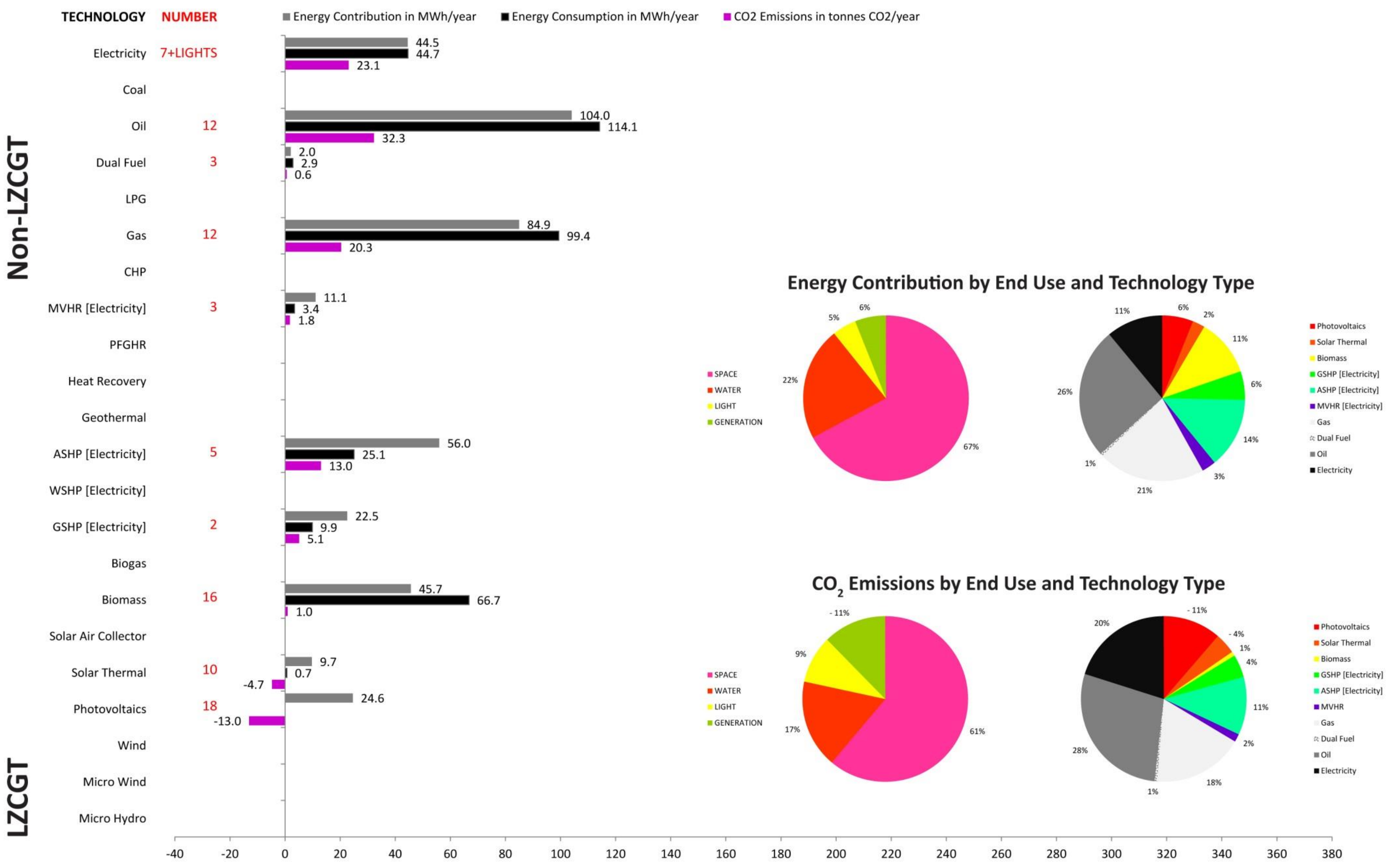


Figure 6c: Energy Map: Authority C

x

Authority D: Energy Map: New Build Domestic

[SAP Data - 57 Units]

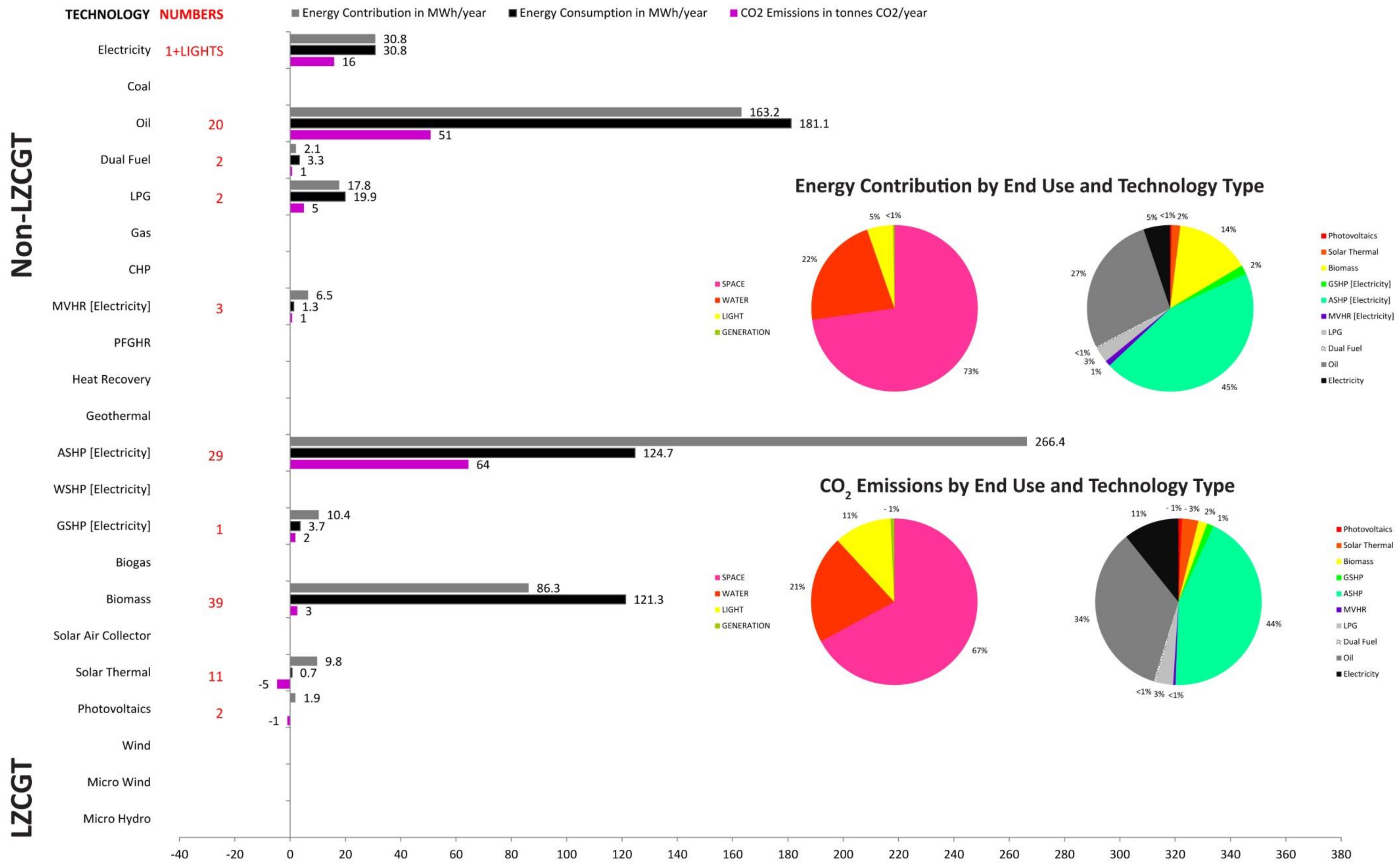


Figure 6d: Energy Map: Authority D

Authority E: Energy Map: New Build Domestic

[SAP Data - 80 Units]

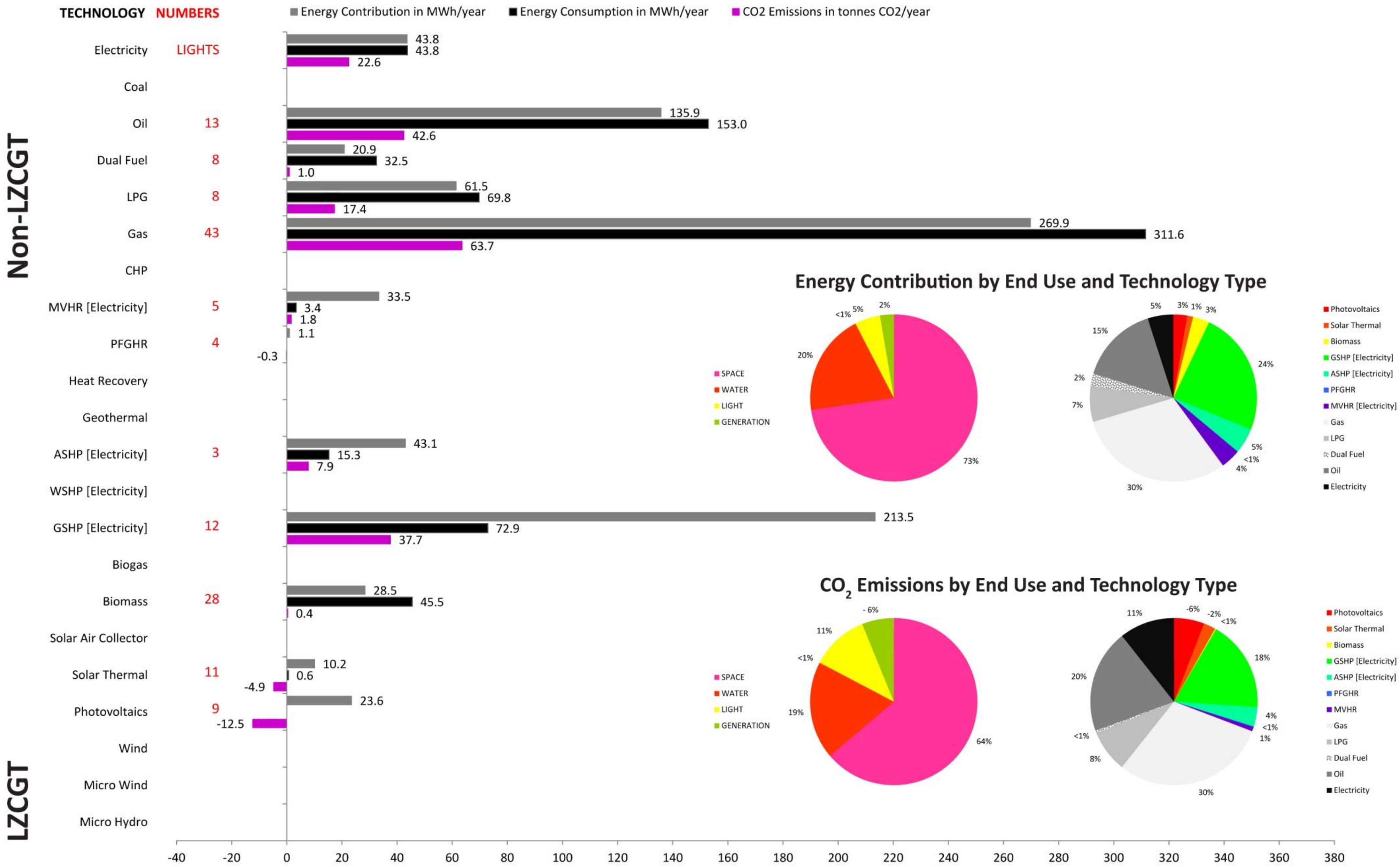


Figure 6e: Energy Map: Authority E

Energy Map: New Build Domestic

[SAP Data - 403 Units: Authority A [39], Authority B [187], Authority C [40], Authority D [57] and Authority E [80]

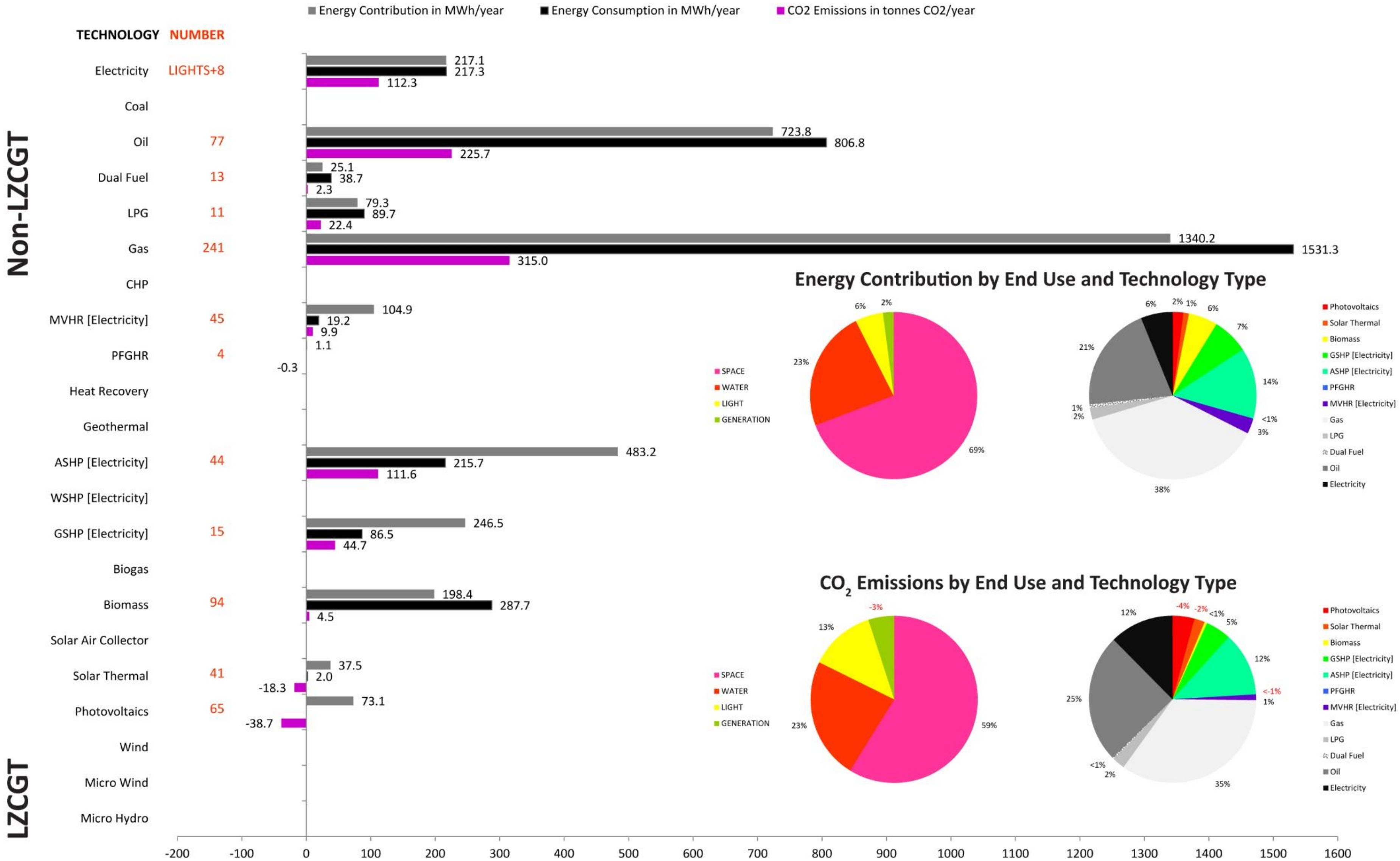


Figure 6f: Energy Map: All Local Authorities Studied

5.3.3 Technology Trends

Key Messages

- Section 3F Policies make no distinction between low and zero carbon generating technologies.
- Biomass stoves or small photovoltaic arrays were observed as compliance LZCGTs in all local authority areas.
- The largest LZCGT energy contributions were made exclusively by low carbon, not zero carbon technologies (e.g. Air Source Heat Pumps, Ground Source Heat Pumps and Biomass).
- The distribution of LZCGT by local authority area suggests that regional context is being taken into consideration by architects/designers when specifying LZCGT.
- Data captured by local authority area suggests remote areas currently have a greater proportional uptake of renewable technology than urban areas in terms of number of units specifying LZCGT and its overall contribution to the energy mix.
- Observed differences in the type of LZCGTs specified in Domestic and Multi Domestic buildings relate primarily to the context and the ease with which specific LZCGTs can be accommodated in urban vs. rural environments.

Overview

None of the policies studied make a distinction between Low and Zero Carbon Technologies. However, Authorities B and E do stipulate that the contribution of the LZCGT should provide a defined percentage of the aggregate 30% CO_2 emissions reduction over the 2007 standards required by building regulations, namely: 10% and 2% respectively. It should be noted that these percentages are not very onerous and no documentary evidence appeared to be submitted in support of these percentage reductions in the sample. This would normally be evidenced in SAP but without undertaking an additional calculation (with and without technology) it is not possible to confirm if this was complied with (see note in Section 5.2.2, page 22). In Authority A the policy adopted in 2012 is aiming to significantly accelerate emissions reduction beyond 2007 regulations, requiring an additional emissions reduction of: 60%/2012, 90%/2014 and 100%/2016. However, the policy does not appear to be currently enforced due to reasons outlined in Section 4.2, page 8 and the lack of evidence found in the data. It is recognised that if these accelerated reductions were enforced compliance would necessitate using LZCGT.

It seems clear however that in a significant number of cases the LZCGT provision is included only to comply with Section 3F policy or reduce CO_2 emissions in SAP calculations. In all of the local authorities studied (with the exception of Authority B, which is a smoke free zone), the compliance LZCGT usually takes the form of a biomass stove (Figure 7). Biomass stoves are reasonably inexpensive, aesthetically desirable and provide an autonomous heat source. As a secondary heat source, SAP typically considers that a biomass stove will provide 10% of the Space Heat Demand and because the fuel source CO_2 emissions defined in SAP are considered to be low, specifying a biomass stove is an effective way to compliance with SAP.

Typically a photovoltaic array for a single dwelling in the sample would be approximately 3 - 4kW capacity. In the sample the majority of PV installations are around 1 – 1.5kW capacity. In Authority B, small photovoltaic arrays, some with less than 1kW capacity have been employed most likely to gain compliance (Figure 7). PV was installed on 65 dwellings in the sample but it was not possible to calculate an average installed capacity due to the variability of the dataset.

Solar thermal makes a relatively small energy contribution and has relatively low operational energy consumption but can typically provide about half of the Water Heat Demand. This is a significant proportion of the energy demand in small and energy efficient dwellings and consideration could be given to incentivising its uptake in the Policy.

The study has shown that the largest LZCGT energy contributors are all Low Carbon Technologies: biomass boilers, ASHPs and GSHPs used to provide space and water heating. Although these are considered Low Carbon Technologies, in reality they all emit CO_2 from their operation (Figures 6a-6f) (Table 10).

	Total Energy Contribution MWh/yr	Total CO_2 Emissions Tonnes CO2/yr	CO_2 Emissions / Delivered Energy Tonnes CO2/ MWh	Percentage of Total Energy Contribution %	Percentage of Total CO_2 Emissions %
ASHP	483.2	111.6	0.230	14	13
GSHP	246.5	44.7	0.181	7	5
Biomass	198.4	4.5	**0.022	6	<1
Non-LZCGT	2385.5	677.7	0.284	68	81
Total LZCGT + Low Carbon*	3530.2	838.5	0.238		

*Low carbon includes ASHP, GSHP & Biomass

Table 10: Contribution of Low Carbon Generating Technologies and CO_2 Emissions

The conservative estimate of the contribution made by MVHR included in this study clearly indicates that this is a technology that could have greater impact in reducing CO_2 emissions, by facilitating further reductions in space heat demand. However, while PFGHR, WWHR and MVHR all contribute to energy reduction by recovering waste heat in different ways, they are not classified as a LZCGT's as they do not generate energy independently. PFGHR relies on an additional heating system being present and captures heat otherwise wasted through flue gases. WWHR is an emerging technology but no incidences of its application were found in the sample. This distinction may be counter-productive and unhelpful in encouraging uptake of passive energy conservation measures.

The issue of energy storage was absent in all Section 3F policies with the exception of the inclusion of fuel cells as a LZCGT. There was little evidencing of energy storage provision in practice, with the exception of hot water storage cylinders for solar thermal, biomass boilers, heat pumps and some heat recovery devices. Grid connections were presumed in all instances of photovoltaics, although none of the applications explicitly stated such.

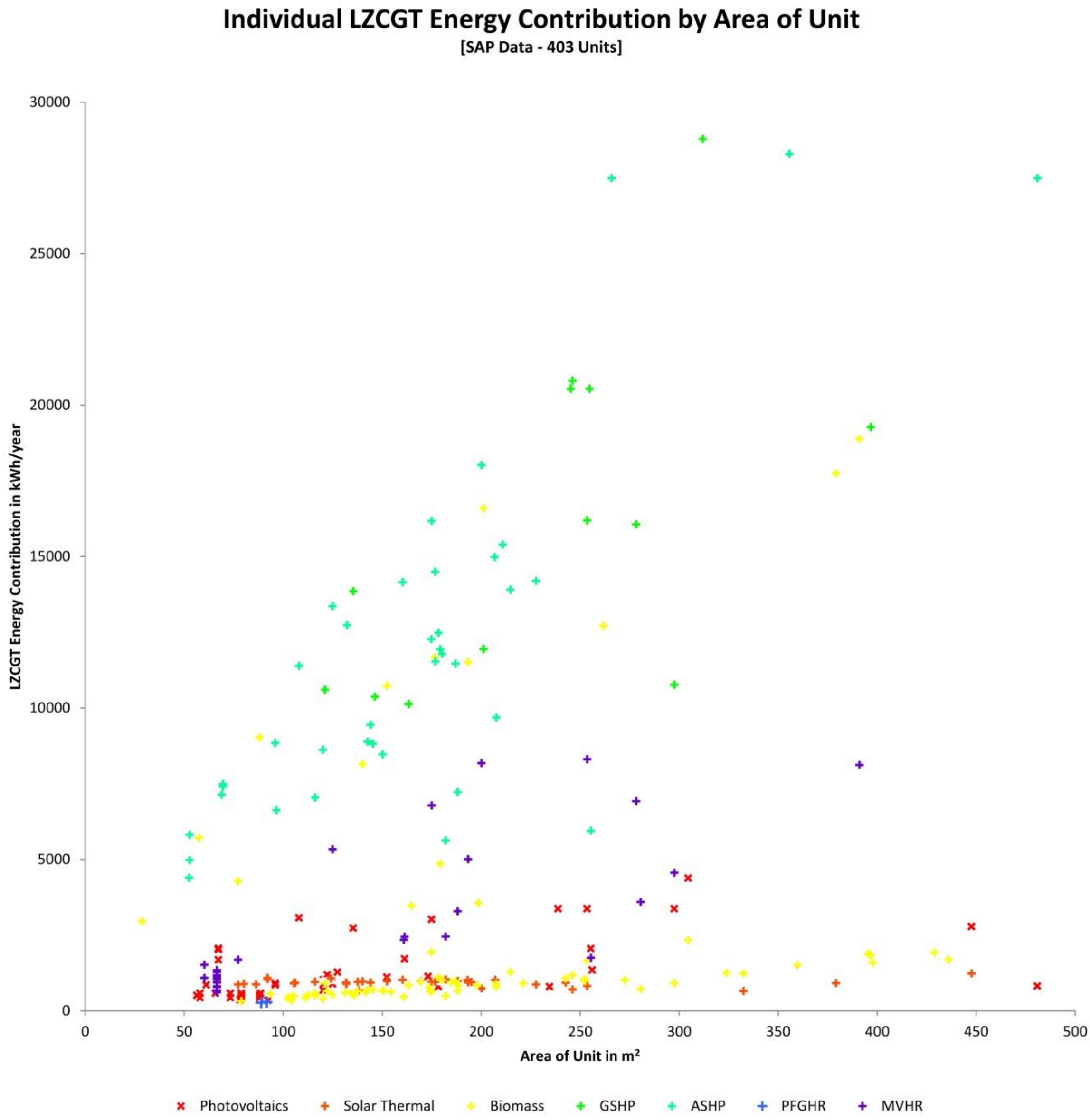


Figure 7: Energy Contribution of LZCGT plotted by Area of Unit (SAP Data - 403 Units)

Regional Influences

In all policies the type of LZCGT specified is solely at the discretion of the architect/designer. The distribution of LZCGT by local authority area however suggests that regional context is being taken into consideration by architects/designers when specifying LZCGT (Figure 8). For example, Authority D includes a large proportion of ASHPs in anticipation of locally produced wind and wave power, whilst Authorities B & A with a sunnier east coast climate specify larger proportions of photovoltaics and solar thermal. Generally across all policies there is a lack of evidence of scaled solutions or significant energy storage technologies (heat or electrical). Biomass boilers and stoves are evidenced in large numbers in all local authority areas that are not smoke free zones. The sample returned very few examples of non-domestic buildings but 9 units in the sample specified biomass as a heating source out of a total of 26 units (35%) a relatively high proportion.

None of the policies studied proactively addressed the most appropriate energy solutions for their specific regional or local context, or made strategic suggestions as to preferred technologies e.g. scaled generation and storage solutions in urban areas and large scale development. In some regions particularly those off the gas grid indicated a higher uptake of LZCGT. The energy maps also clearly indicate that regional influences impact not only on the type of LZCGT specified but also the extent of its contribution to the energy mix (Figure 6a-6f; Table 11). This data suggests remote areas currently have a greater proportional uptake of renewable technology than urban areas in terms of number of units specifying LZCGT and its overall contribution to the energy mix.

				LZCGT Provision											
				No. of Units with LZCGTs						Percentages			Ratios of LZCGT Mix		
LDP	No. of Units	Total Area m^2	Total Occupancy	No LZCGT	1 LZCGT	2 LZCGTs	3 LZCGTs	4 LZCGTs	5 LZCGTs	LZCGT Specified % of Total	Energy Contribution % of Total	Energy Consumption % of Total	Contribution : Consumption kWh/kWh	CO_2 Emissions : Contribution $kgCO_2/kWh$	CO_2 Emissions : Consumption kgCO2/kWh
Authority A	39	8260	118	21	8	8	2	0	0	46	34.5	21.3	1.76	0.120	0.211
Authority B	187	16419	460	123	63	0	1	0	0	34	5.1	1.0	4.90	-0.100	-0.490
Authority C	40	4916	106	0	29	7	3	1	0	100	41.9	28.8	1.60	0.019	0.030
Authority D	57	8389	155	0	36	16	4	1	0	100	64.1	51.7	1.51	0.038	0.057
Authority E	80	12432	215	35	23	15	4	2	1	56	39.9	18.4	2.57	0.085	0.218
SAP Data Set	403	50416	1054	179	159	46	14	4	1	56	32.4	18.5	1.87	0.099	0.186

Table 11: Specification of LZCGT by local authority and Total (SAP Data – 403 Units)

Note: The way CO_2 emissions are recorded relative to photovoltaics, solar thermal (negative values) and biomass (low calculated value) has a significant effect on the final two columns of this table, so these values should be employed with caution.

SAP data returned for Authorities D and C showed that 100% of the dwellings specified LZCGT in compliance with Section 3F policy and that the LZCGT contributions to the energy mix were the highest at 64.1% and 41.9% respectively. In comparison, the data indicates that Authority B had both the lowest percentage of new builds specifying LZCGT at 34% and by far the lowest LZCGT contribution to the energy mix at just 5.1%, but this evidence is weak due to the reliability of this data and should be read with caution (Table 11). It should however be noted that the type of LZCGT specified in this sample (mainly photovoltaics and MVHR) showed a high return in terms of energy delivered for energy expended (Table 11).

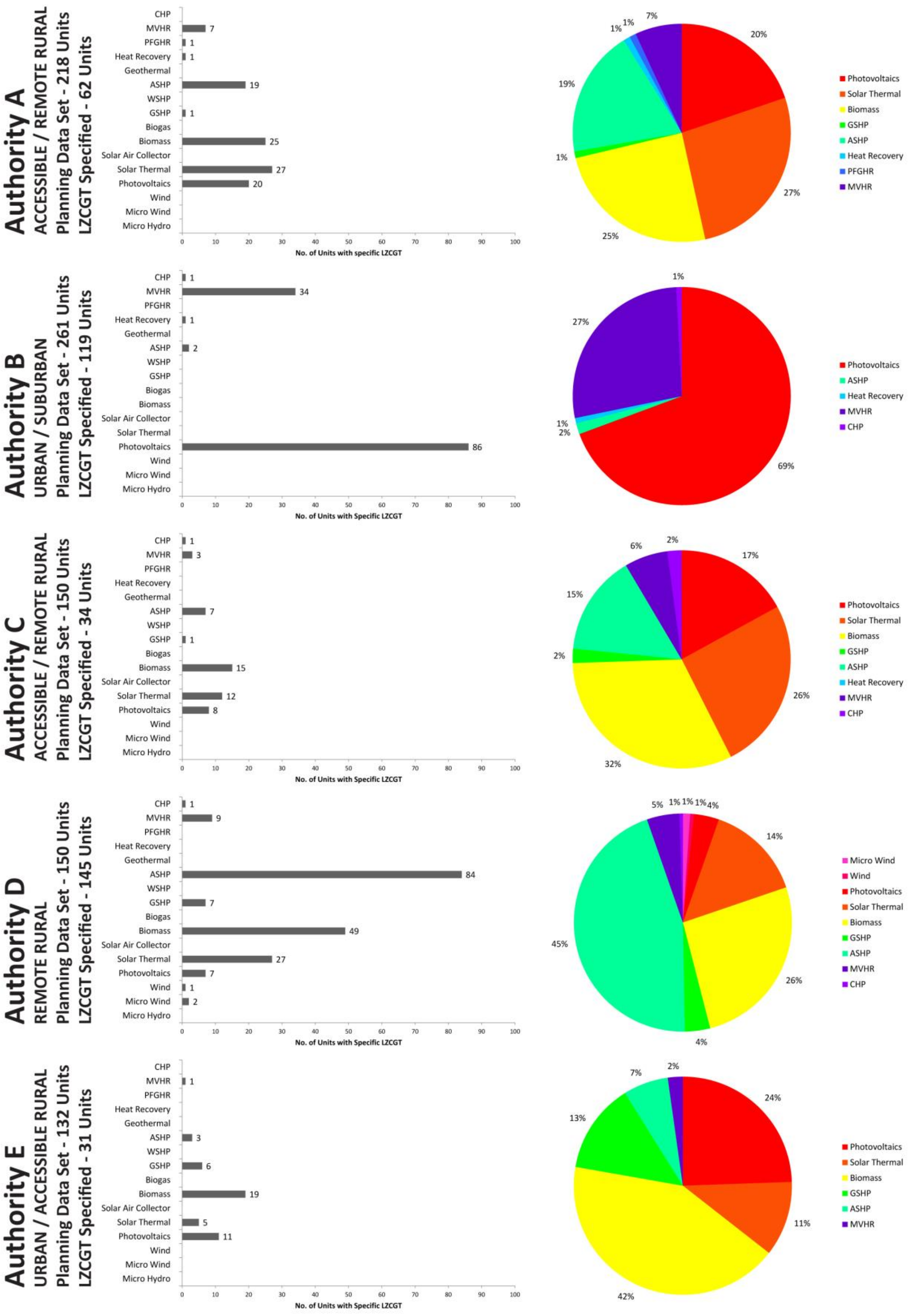


Figure 8: Numbers and Relative Distribution of LZCGT types by Local Authority (Planning Data Set – 911 Units)

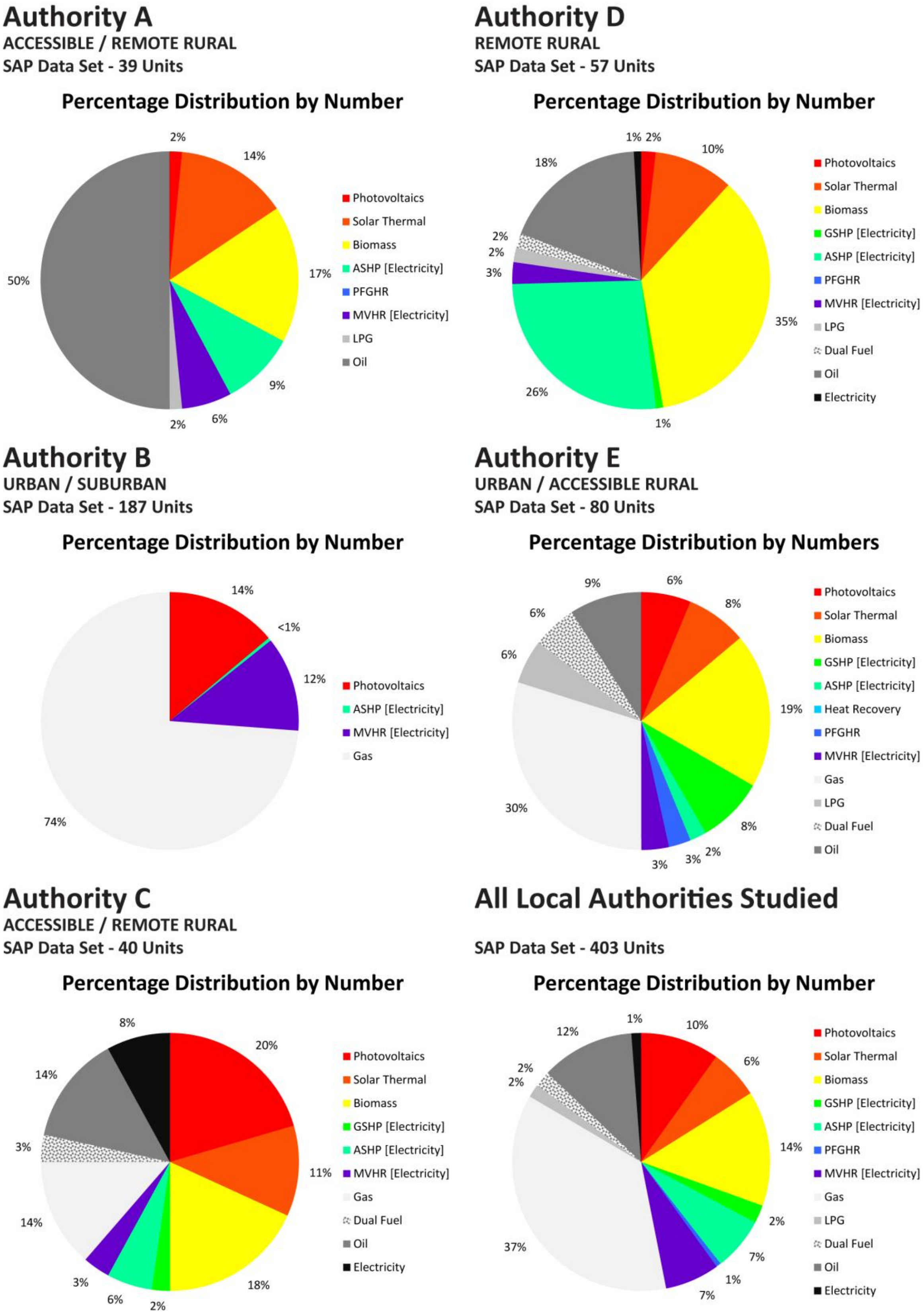


Figure 9: Percentage Distribution of LZCGT and Non-LZCGT types by Local Authority (SAP Data Set – 403 Units)

Impact of Building Type

In terms of the type of LZCGT specified there does appear to be a difference between single? Domestic and Multi Domestic Developments, although this might in part be related to the regions from which the respective developments originate (Figure 10). Larger Multi Domestic developments tend to be in urban areas which could limit certain LZCGT types e.g. biomass in smoke free zones but facilitate others such as district heat networks. It is observed that in Authority A, MVHR and Photovoltaics were the LZCGT of choice for Multi Domestic developments because they are relatively undemanding in terms of space. As urban areas also tend to be smoke free zones, biomass is not an option, which explains the lack of biomass in the Multi Domestic relative to the Single Domestic sample.

It is perhaps surprising that the number of ASHPs was not higher in the Multi Domestic group, as this technology does not require much external space, although this probably relates to the fact that urban areas have an established gas supply infrastructure with which new technologies have to compete. It should be noted that the SAP data included no instances of scaled LZCGT in any of the local authority areas (Figure 10).

The most significant trend, however, in terms of LZCGT provision relative to building type is that many Multi Domestic developments are failing to comply with Section 3F requirements to specify LZCGT (Table 4).

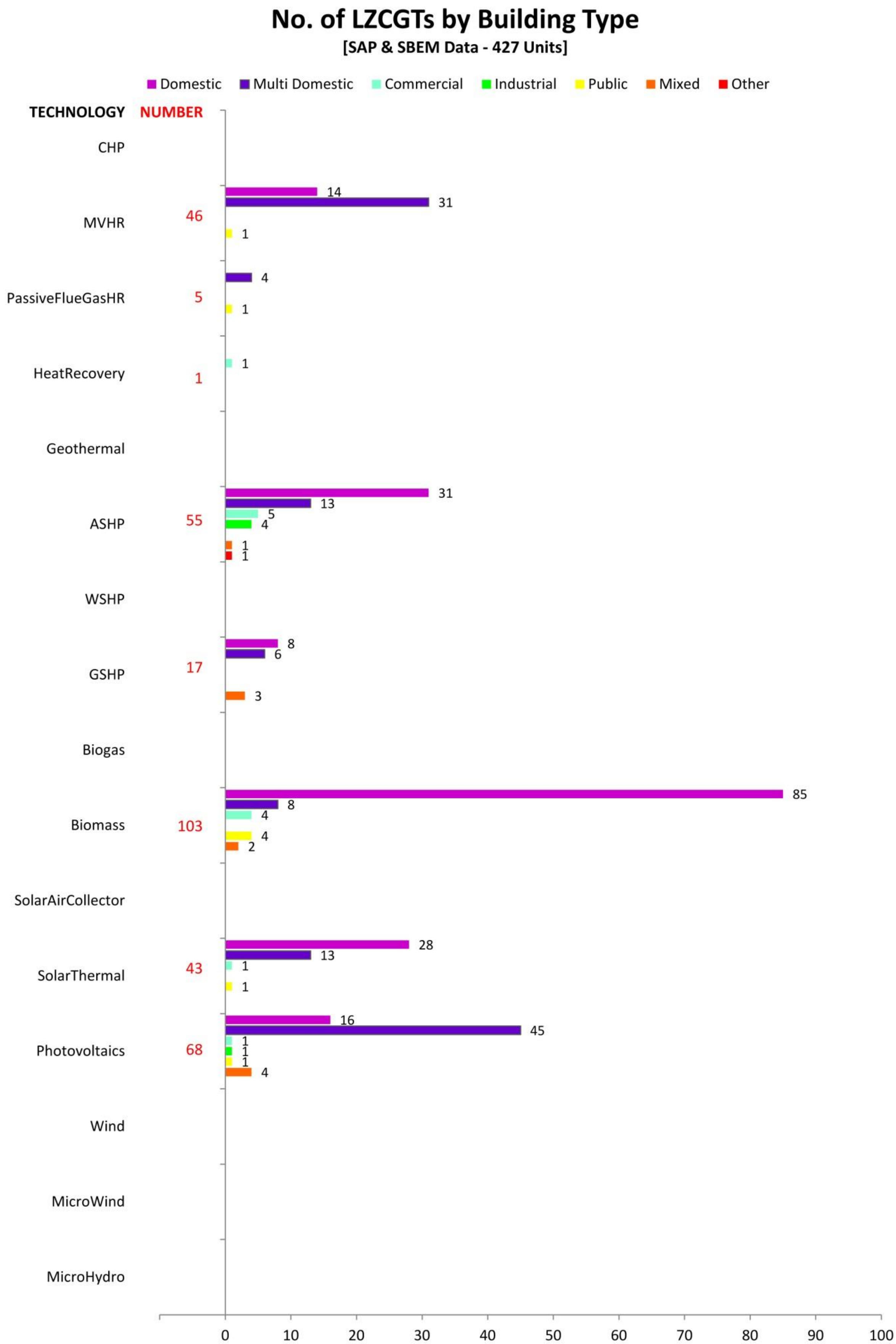


Figure 10: Distribution Trends of LZCGT in the Domestic Sample (SAP & SBEM Data - 427 Units).

5.3.4 LZCGT Delivery (Planning & Warrant Data)

Key Messages

- The trend is towards improved levels of LZCGT provision being evidenced in the warrant data relative to the data submitted at planning.
- The quality of energy data available at the warrant stage is far superior to that submitted at planning.
- 60% of units in the warrant data set specified LZCGT (range 35% - 98% by local authority)
- Whilst some change in the type and extent of LZCGT provision is to be expected during the design process, evidence suggests that when LZCGTs are specified at planning, even with changes LZCGTs are delivered. However, not all applications in the sample specified LZCGT at planning (refer to Section 4.2 p 14).
- The most immediate improvement in LZCGT provision could be made by enforcing the Section 3F policy in Multi Domestic Developments.

Overview

The planning data set consists of 330 planning applications that represent 911 individual units (Domestic and Non-Domestic). All of the applications were subject to Section 3F policy. Therefore, this data provides the most comprehensive picture of the distribution of LZCGT by local authority area at the planning stage. Unfortunately we were unable to obtain warrant data for the entire sample and some of the information acquired was incomplete. Consequently, warrant, SAP and SBEM data are all subsets of the planning data set.

Comparison of LZCGT at Planning and Warrant stages

Direct comparison between the distribution of LZCGT in the planning data (Figure 8) and the warrant data (Figure 10) would initially suggest some major changes in the type of LZCGT specified. These apparent discrepancies are in the main the result of specific building projects present in the planning data being absent from the warrant data. When the projects included in the warrant data set are traced back to planning and the two sets of data compared the changes are less significant and in all local authorities the trend is towards similar or improved levels of LZCGT provision being evidenced in the warrant data relative to the data submitted at planning (Figure 10).

An analysis tracking the extent and type of the changes in LZCGT provision, in terms of actual deliverables, similarly indicates that the trend was for a general improvement evidenced from planning to warrant submissions (Figure 11). It should however be noted that these changes are relative to a general low level of compliance with Section 3F policy at the planning stage in 4 of the 5 local authorities, and includes the specification of energy efficient gas boilers as a minor improvement if this energy efficiency measure was not explicitly stated at the planning stage.

60% of units in the warrant data set (520 Units) specified LZCGT in compliance with policy. This ranged from a low of 35% recorded in Authority B to a high of 95% and 98% respectively in Authorities C and D (Table 3). That Authority D managed to obtain such a high degree of compliance with Section 3F policy in the warrant data set was particularly unexpected, considering only 23% of the units in the planning data set specified LZCGT. This major shift in the uptake of LZCGT is most likely due to compliance with energy standards in the building regulations but other factors may also be influencing this e.g. availability and price of fossil fuel energy in remote regions.

Overall Summary

The overall compliance level with Section 3F Policies was generally good in all sectors except Multi Domestic developments, which made up a large part of the sample in a number of the authorities studied (Table 4). Approximately two thirds of all the individual units included in this study originate from Multi Domestic developments (Appendix 1: Tables 11, 12, 13).

While this study relied on building warrant stage data for quantification of the technologies, compliance under the policy is assessed in reality at the planning stage, where only 55% of the sample were found to comply (see Section 4.4).

One finding that could be drawn from this would be that the most significant immediate improvement in terms of deliverables from this policy could be realised by simply enforcing the policy in Multi Domestic developments. The data also implies that more significant long-term GHG emission reductions could be achieved by adopting a fabric first approach to design. This approach directly targets the Space Heat Demand which is the biggest contributing factor to CO_2 emissions from buildings. A recommendation for improving Section 3F policy would be to ensure that specification of LZCGT's is additional to energy demand reduction as this is likely to have the greatest impact on reducing GHG emissions.

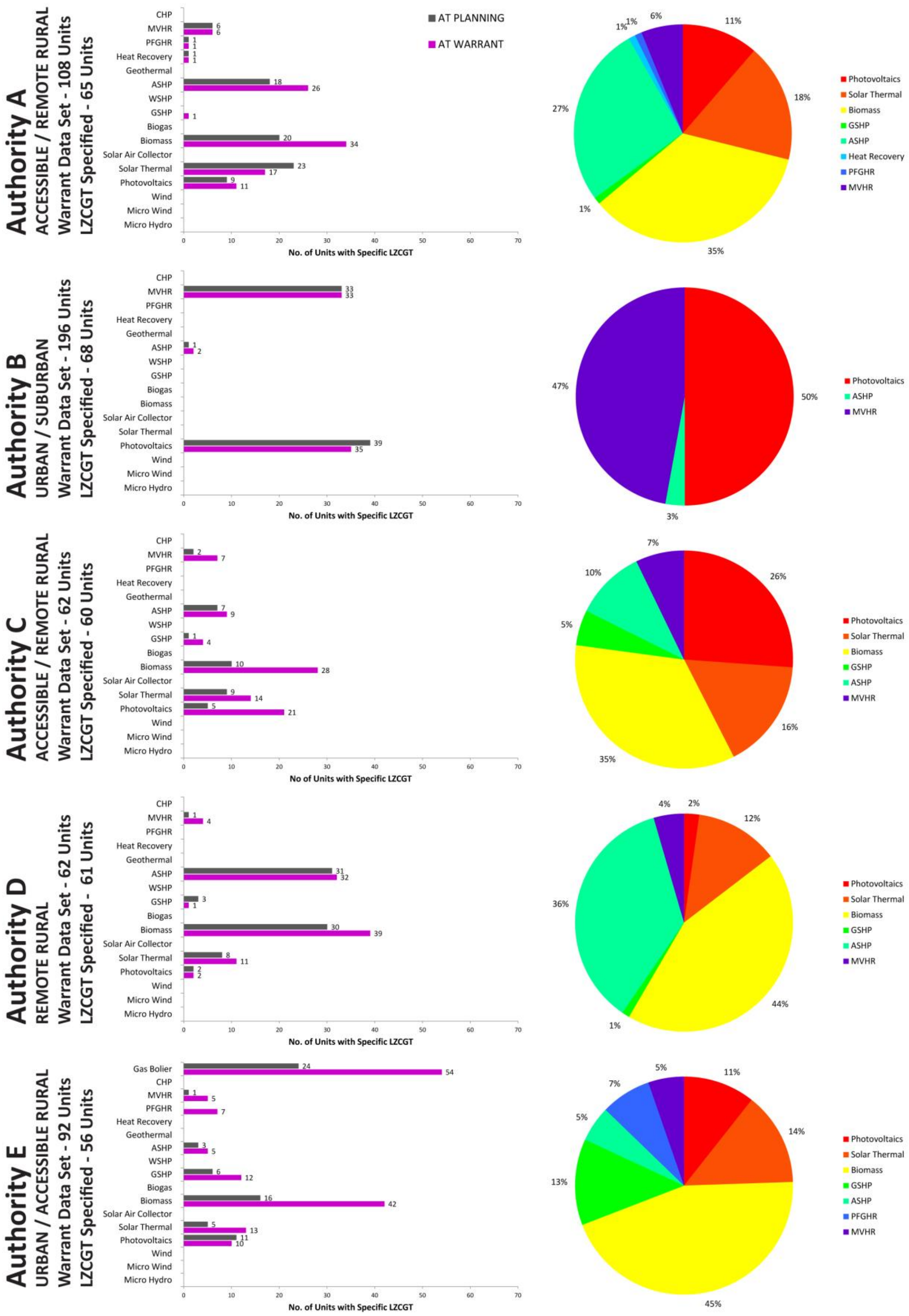
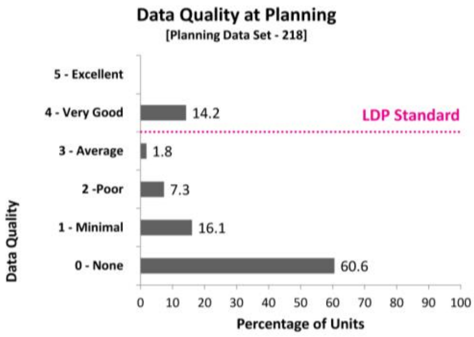
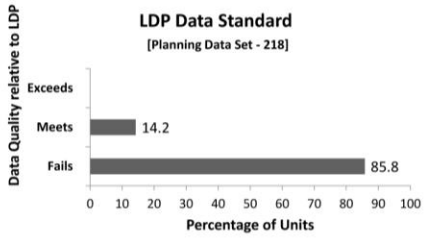


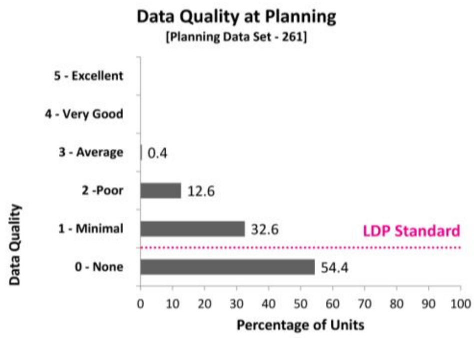
Figure 11: Numbers and Relative Distribution of LZCGT types by Local Authority (Warrant Data Set – 520 Units).

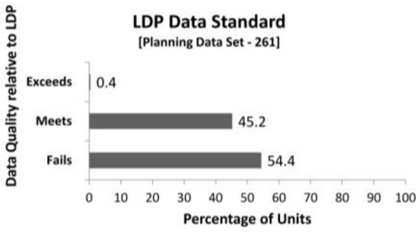
Authority A
ACCESSIBLE / REMOTE RURAL
Planning Data Set - 218 Units
LZCGT Specified - 62 Units



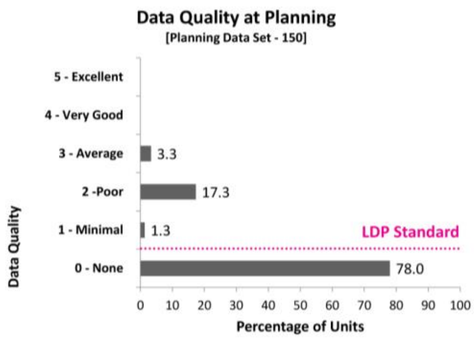


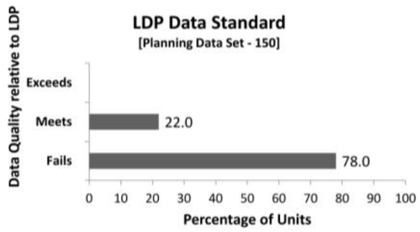
Authority B
URBAN / SUBURBAN
Planning Data Set - 261 Units
LZCGT Specified - 119 Units



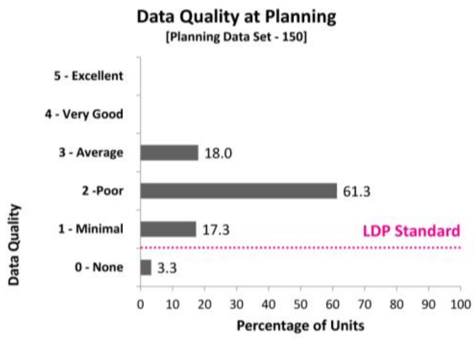


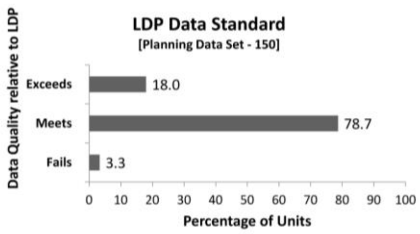
Authority C
ACCESSIBLE / REMOTE RURAL
Planning Data Set - 150 Units
LZCGT Specified - 34 Units



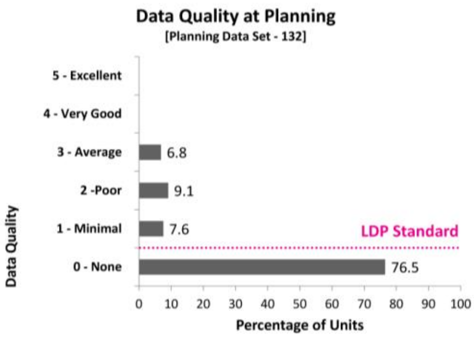


Authority D
REMOTE RURAL
Planning Data Set - 150 Units
LZCGT Specified - 145 Units





Authority E
URBAN / ACCESSIBLE RURAL
Planning Data Set - 132 Units
LZCGT Specified - 31 Units



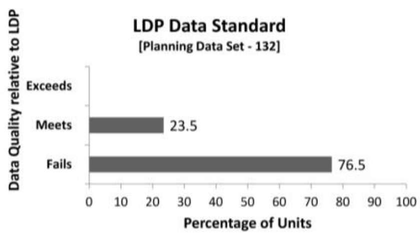


*Figure 12a: Data Quality (Planning Data)***.** (Indicators of the quality of the supplementary and supporting data (sustainability statements, drawings etc.) received with the planning application; LDP Standard refers to the quality threshold of data requested by the LPA)

Data Quality:

A definition in *absolute* terms [0 – 5] of the quality of the data received with the planning application:

0. **None** - No indication that the *Relevant Policy* has been considered by the applicant at this stage [may or may not result in a *Compliance Condition*]

1. **Minimal** - Minimal indication that the *Relevant Policy* has been considered by the applicant:

A Tick Box on a Statement, **OR**

An Outline Indication on Basic Drawings, **OR**

Inconsistent Data [see *Data Correlation* above]

2. **Poor** - LZCGT provision is indicated on Drawings and/or Statements [where available], but the *LZCGT Data Set* describing the Overall System is incomplete and cannot be simply extrapolated.

3. **Average** - Good Quality Annotated Drawings with the proposed LZCGT System clearly indicated with Additional Notes, Statements or Product Literature to describe the Overall System in detail. *Full LZCGT Data Set* should include:

- LZCGT [Type, Location, Model, Size or Capacity]
- Electrical or Heat Storage [Storage Type and Location]
- Role of LZCGT System in the Building [Electricity Generation, Primary/Secondary Heat Source etc.]

4. **Very Good -** Full LZCGT Data Set with either:

- A *Full Sap Calculation* to quantify the specific contribution of the proposed LZCGT and the Overall CO_2 Reduction achieved, **OR**
- A well-considered *Design Response Strategy* stating what Design Measures have been taken to reduce CO_2 emissions. This should be an accurate representation of the Design Drawings submitted and include a clear explanation of how the Design overcomes particular problems inherent to the site and/or the compensatory measures taken to maximise the potential to reduce CO_2 emissions.

5. **Excellent -** All of the Above

Data Quality Note: The quality of data received *relative* to that requested by the LDP

- Fails LDP Minimum
- Meets LDP Minimum
- Exceeds LDP Minimum

Notes: No Data - Where no LZCGT data has been submitted, the application is deemed to have failed the LDP Minimum.

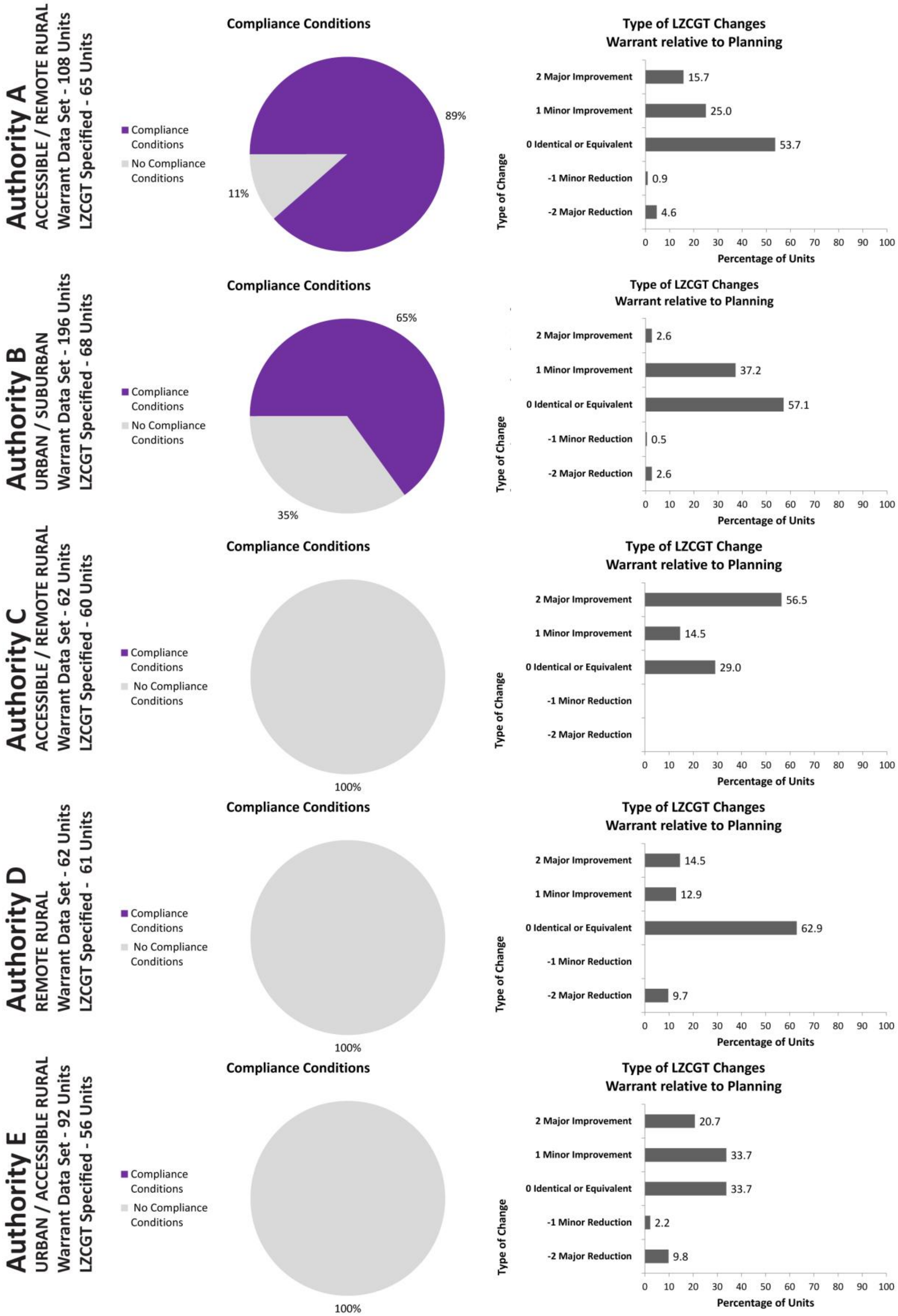


Figure 12b: Suspensive Compliance Conditions & Changes in LZCGT Provision (Planning and Warrant Data).

6 Conclusions

This study shows that the Section 3F Policies contained in Scottish Local Development Plans are associated with a modest increase in the uptake of LZCGT and reduced CO_2 emissions. Whilst a clear trend can be identified in the uptake and implementation of LZCGTs in recent years, the extent and type of the LZCGT provision varied significantly across the regions studied. Whether this trend is a direct result of Section 3F policies or due to a number of external factors such as improvements in Building Standards legislation, the regional context, market influences and consumer preferences was not easy to determine in this study. What was achieved seems to be more attributable to building regulation requirements, with the exact role and measurable contribution of Section 3F policies not easily discernible.

Significant differences have also been noted in the interpretation, inclusions, verification, robustness and application of each Section 3F policy. Currently there does not appear to be an appetite in the building industry to meet aspirational CO_2 emissions reduction targets higher than the minimum legislated for in the Scottish building standards. This implies that there is room for Section 3F policies to be applied more broadly with potentially significant impacts, within planning stages, in ways that can enhance building warrant stages. It was also found that there was significantly less compliance with Section 3F policy requirements in the Multi Domestic compared to Single Domestic Builds.

To improve the effectiveness of Section 3F policies and allow local planning authorities to verify compliance, it is suggested that a staged compliance procedure could be employed. Ideally, this would involve a simple initial compliance procedure comprising a brief checklist/tick box form to be completed and submitted with the planning application. To ensure that the proposed LZCGT is implemented and confirm its actual impact, a suspensive condition could be applied to the planning consent, requesting that the full SAP/SBEM calculation be submitted to the LPA for approval prior to works commencing on site.

The planning policy/condition could specify the design aspects of LZCGT, perhaps indicate minimum amount of emissions to be saved using the technology, to be later ascertained at the building warrant stage.

A further significant improvement to CO_2 emission reduction could be obtained if Section 3F policies were more proactive in defining criteria for the relationship between new build developments and regional energy requirements. This might for example define the specific criteria or requirements for particular sites e.g. the need for energy storage or scaled energy systems such as district heat or CHP. It might also limit development scale in relation to energy availability or apply specific increases to energy conservation and/or low and zero carbon energy generation requirements. Further consideration could be given in Section 3F policy to the appropriateness and effectiveness of particular LZCGT's in their ability to meet regional energy conditions e.g. the use of ASHP in areas where there is already a 'green grid'[10].

Energy and CO_2 abatement issues are complex and it is difficult to precisely quantify the effectiveness of a specific policy in delivering physical results. It is clear, however, that the general consensus among building design professionals is that the most cost effective and long term approach to reducing CO_2 emissions is to reduce overall energy consumption through improved

[10] A grid mainly carrying electricity from renewable sources

fabric efficiency and site specific passive design before considering the specification of LZCGT [11] [12]. It would therefore be more useful to consider CO_2 emissions from buildings within a wider context, which includes:

- Overall building design
- Appropriateness of scale
- Passive design principles (appropriate siting, solar orientation, avoidance of wind chill and frost pockets, natural daylight, natural ventilation, thermal mass and landscaping)
- Fabric energy efficiency (insulation, airtightness, high performance double or triple glazing)
- Efficient building systems and efficient appliances, as required by the building regulations
- The judicious use of appropriate Low and Zero-Carbon Generating Technologies.

Embedded in local development plans, Section 3F policies are ideally placed to address some of these more design orientated approaches to reducing greenhouse gas emissions, and could potentially be broadened to achieve greater impact.

A key lesson from this study is that LZCGTs are recognised as one solution in fulfilling the minimum legislated CO_2 emission reduction as outlined in Section 6 (energy) of the building regulations. The implication of this is that additional energy generation, via LZCGT, is being favoured over energy conservation measures. Although more efficient than traditional fuel sources, many of the commonly specified LZCGTs still emit significant amounts of CO_2 and may consequently have less impact on long-term CO_2 emissions reduction than improvements in fabric energy efficiency and passive design approaches.

Consideration could be given to utilising Section 3F policy to specify application of LZCGT in ways that add-value and go beyond reductions in CO_2 emissions beyond legislated for in Section 6 and improved energy standards. This would ensure that energy conservation is prioritised and the LZCGT is effectively contributing to the smaller energy demand. If this is combined with Section 3F Policies that are more strategic in their response to regional energy context, more significant CO_2 emissions reduction could be achieved as a result.

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[11] David MacKay, Sustainable Energy without the Hot Air, UIT Cambridge Ltd, 2009.

[12] Department of Energy and Climate Change, The Energy Efficiency Strategy: The Energy Efficiency Opportunity in the UK, Crown copyright, London, 2012

Annex 1: Methodology & Data Sample

Methodology

Preliminary Analysis

The study was informed by two distinct lines of analysis. Initially, the five Section 3F policies and associated supplementary guidance were examined and compared in terms of design (accessibility, clarity of objectives, targets set and verification procedures), approach to GHG emission reduction, and specific LZCGT suggested. This was subsequently accompanied by an investigation into the possible sources and availability of quantitative data essential for the statistical analysis and how these disparate data sources might be used to trace an individual planning application from consent to completion stages.

The above preliminary stages were fundamental in shaping overall approach to the research: the methodology employed and the developing structure of the Microsoft Access Database essential for the complex data handling underpinning the subsequent quantitative analysis (Figure 12). In the final analysis data drawn from local authority planning portals, planning documents and drawings, building warrant documents and drawings, SAP/SBEM calculations and sustainability statements, were all incorporated into the database.

Data Sources and Sampling

Each local authority maintains a publically accessible planning portal which is a searchable online database containing documents and drawings pertaining to planning applications. These planning portals were used to identify relevant planning applications for the study. Criteria for inclusion in the sample were:

- The proposal was either a Domestic or Non-Domestic new build.
- The received date of the planning application was after the adoption of the relevant Section 3F policy.
- The proposal was not exempt from Scottish building standards, Section 6: Energy, 6.1: Carbon Dioxide Emissions (Mandatory Standard).
- The application had obtained building warrant approval and could be expected to furnish relevant SAP/SBEM Data.

Utilising the advanced search feature of the planning portal, each local authority was searched for relevant applications. The search was performed using the planning approval decision date, and worked backwards through each year from the 31st December until the target sample size was obtained. The target sample was 50 - 100 planning applications per local authority weighted to favour more recent applications and distributed evenly between Domestic and Non-Domestic developments (Table 11).

	Domestic	Non-Domestic	TOTAL
2014	25	25	50
2013	15	15	30
2012	10	10	20

Table 11: Distribution of Target Sample by Year and Building Type.

In practice the numbers of approved planning applications that had also obtained building warrant approval varied significantly between local authorities and in several areas it was not possible to meet the full 100 target sample. Furthermore, although attempts were made to make the target sample representative of all building types, applications for Domestic buildings dominated in all local authorities. As some of the planning applications such as Multi-Domestic and Mixed developments contain a number of individual units, each of which might differ in design and the type of LZCGT specified the database was organized with respect to individual units rather than applications. This enabled the correct SAP or SBEM data to be assigned to the appropriate number of units within such developments. Such developments are simply sub-divided and the planning and building warrant references numbers appended with #1, #2 . . . etc.

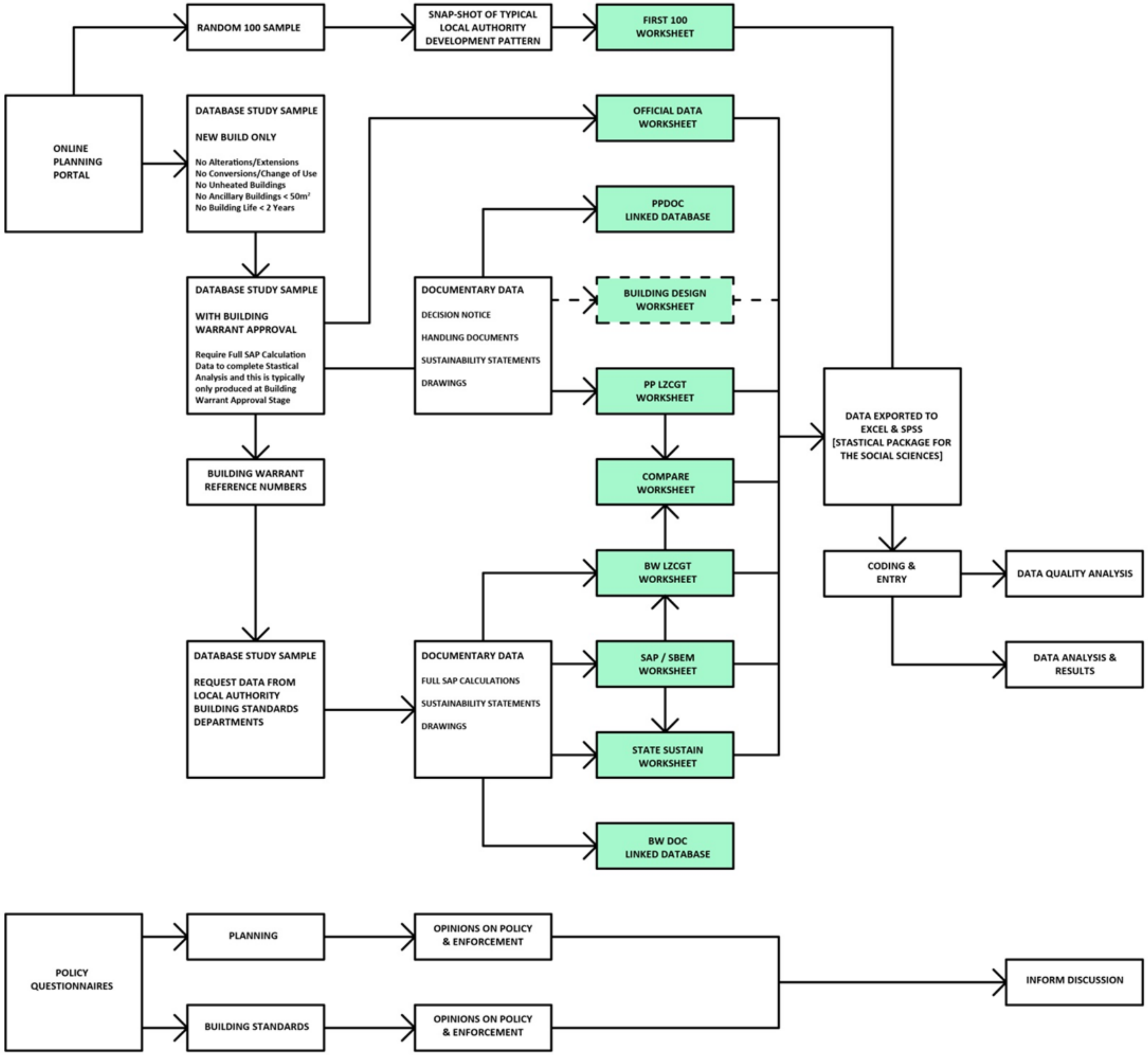

Figure 12: Workflow Diagram

Research Methodology

Once a planning application was identified, relevant planning application data, documents and drawings were downloaded from the planning portal, analysed and the resulting information entered into the database as the planning data set. As the type of quantitative data required for the statistical study is typically not available until the building warrant stage and is not publically accessible online, this data collection process was also used to generate a list of building warrant references for each local authority area. Each of the Building Standards Departments was then approached directly in order to retrieve the relevant building warrant documentation. We were particularly interested in gaining access to full SAP or SBEM calculations as these would give us a very clear understanding of how well the policies were performing in practice, for example what LZCGT were actually being installed, the overall energy contribution in terms of kWh/year and the CO_2 emissions related to each of these technologies.

Sample Data Sets

Most Building Standards Departments were unable to provide warrant data for the entire planning sample. Furthermore the quality of data in terms of the number of Domestic buildings returning complete SAP data or Non-Domestic building returning complete SBEM data varied immensely across the local authority areas. As a consequence the SAP data set is dominated by Authorities B and E and the contribution made by development in Authority A is particularly under-represented. This resulted in 3 subsets of the planning data: the warrant data (all buildings for which warrant data was received), the SAP data (all Domestic buildings for which complete SAP calculations were received) and the SBEM data (all Non-Domestic buildings for which complete SBEM calculations were received). The numbers of applications and units of dwellings generated for each local authority are outlined in Table 11 (planning data), Table 12 (warrant data), Table 13 (SAP data) and Table 14 (SBEM data).

Planning Data Set		Domestic	Multi Domestic	Commercial	Industrial	Public	Mixed	Other	TOTAL
Authority A	Applications	55	12	15	10	9			101
	Units	55	124	20	10	9			218
Authority B	Applications	4	9			1	1		15
	Units	4	225			1	1		261
Authority C	Applications	36	4	13	2	4	3	3	65
	Units	36	76	13	4	4	14	3	150
Authority D	Applications	80	7	2	1	1	1	1	93
	Units	80	57	2	1	2	7	1	150
Authority E	Applications	40	12	3			1		56
	Units	40	87	3			2		132
TOTALS	Applications	215	44	33	13	15	6	4	330
	Units	215	599	38	15	16	24	4	911

Table 11: Planning Data Set by Local Authority and Total.

Warrant Data Set

		Domestic	Multi Domestic	Commercial	Industrial	Public	Mixed	Other	TOTAL
Authority A	Applications	34	5	6	7	5			57
	Units	34	55	7	7	5			108
Authority B	Applications	3	8				1		12
	Units	3	192				1		196
Authority C	Applications	26	3	9		2	3	2	45
	Units	26	16	9		2	7	2	62
Authority D	Applications	47	4	1					52
	Units	47	14	1					62
Authority E	Applications	39	10	1			1		51
	Units	39	51	1			1		92
TOTALS	Applications	149	30	17	7	7	5	2	217
	Units	149	328	18	7	7	9	2	520

Table 12: Warrant Data Set by Local Authority and Total.

SAP Data Set

		Domestic	Multi Domestic	Mixed	TOTAL
Authority A	Applications	14	1		15
	Units	14	25		39
Authority B	Applications	2	8		10
	Units	2	185		187
Authority C	Applications	22	2	2	26
	Units	22	14	4	40
Authority D	Applications	44	4		48
	Units	44	13		57
Authority E	Applications	30	9	1	40
	Units	30	49	1	80
TOTALS	Applications	112	24	3	139
	Units	112	286	5	403

Table 13: SAP Data Set by Local Authority and Total.

SBEM Data Set		Commercial	Industrial	Public	Mixed	Other	TOTAL
Authority C	Applications	4	4	3			11
	Units	4	4	3			11
Authority C	Applications				1		1
	Units				1		1
Authority C	Applications	6		2	1	1	10
	Units	6		2	2	1	11
Authority D	Applications						
	Units						
Authority E	Applications		1				1
	Units		1				1
TOTALS	Applications	10	5	5	2	1	23
	Units	10	5	5	3	1	24

Table 14: SBEM Data Set by Local Authority and Total.

Annex 2: Glossary & Abbreviations

ASHP	Air Source Heat Pump
Form Factor	The compactness of a building i.e. the surface area to volume enclosed ratio has significant impact on the rate of heat loss from the building. Passivhaus determines this as the Form Factor; the relationship between the external surface area (A) and the internal Treated Floor Area (TFA). A form factor ≤ 3 is suggested as a benchmark for small Passivhaus buildings.
GHG	Greenhouse Gas
Gross CO_2 Emissions	The amount of CO_2 emitted as a result of providing the energy demand of a building. This includes all CO_2 emissions from heating, lighting and ventilation. It does not include CO_2 emissions from appliances and household electricals. Typically measured in kg/CO_2/year or tonnes/ CO_2/year.
Gross Energy Demand	The useful energy required to operate a building. This includes all heating, lighting and ventilation. It does not include energy used by appliances and household electricals. Typically measured in kWh/year or MWh/year.
Gross Energy Consumption	The energy consumed in order to provide the Gross Energy Demand. Typically measured in kWh/year or MWh/year.
GSHP	Ground Source Heat Pump
LDP	Local Development Plan
LPA	Local Planning Authority
LZCGT	Low and Zero Carbon Generating Technology Add list?
MVHR	Mechanical Ventilation Heat Recovery. Airtightness is an important factor in reducing uncontrolled ventilation heat losses from buildings, however to maintain internal air quality some form of mechanical ventilation is typically required. MVHR is an energy efficient system that recovers heat from the exhaust air and uses it to heat fresh incoming air. The use of this type of system can reduce the space heat demand of a building by approximately one third, leading to significant savings.
Net CO_2 Emissions	The amount of CO_2 emitted as a result of providing the energy demand of a building balanced against energy generated by the building (Photovoltaics etc.) This includes all CO_2 emissions from heating, lighting, ventilation balanced against generated power. It does not include CO_2 emissions from appliances and household electricals. Typically measured in kg/CO_2/year or tonnes/ CO_2/year.
Net Energy Consumption	The energy consumed in order to provide the Gross Energy Demand

	balanced against energy generated by the building (Photovoltaics etc.) Typically measured in kWh/year or MWh/year.
Occupancy	The Assumed Occupancy as determined by the SAP Calculation. This represents the typical occupancy patterns observed in the UK and is a function of the Floor Area of the proposed Dwelling.
PFGHR	Passive Flue Gas Heat Recovery.
SAP	The Standard Assessment Procedure (SAP) is the methodology determined by the Government to assess and compare the energy and environmental performance of Domestic buildings. Its purpose is to provide the accurate and reliable assessments of energy performance needed to underpin energy and environmental policy initiatives.
SBEM	The Simplified Building Energy Model (SBEM) is the methodology determined by the Government to assess and compare the energy and environmental performance of Non-Domestic buildings. Its purpose is to provide the accurate and reliable assessments of energy performance needed to underpin energy and environmental policy initiatives.
SHD	Space Heat Demand. The useful energy demand for Space Heating.
THD	Total Heat Demand. The total useful energy demand for Space and Domestic Water Heating.
WHD	Water Heat Demand. The useful energy demand for Domestic Water Heating.
WSHP	Water Source Heat Pump
WWHR	Waste Water Heat Recovery.

[i] http://www.legislation.gov.uk/asp/2009/12/contents
[ii] http://www.gov.scot/Resource/Doc/276273/0082934.pdf
[iii] http://www.gov.scot/About/Performance/scotPerforms/indicator/renewable
[iv] David MacKay, Sustainable Energy without the Hot Air, UIT Cambridge Ltd, 2009.