# London Prototype House: A Flexible Design Alternative for Accommodating Change

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ABSTRACT: This study serves as an evaluation of London's housing needs and how they can be achieved through environmentally responsive design. This is addressed in relation to (1) the context of the city and (2) the context of household life cycles and patterns. The result is a case study design for a flexible prototype house located on a small back garden site reflective of many sites existing within London. Studies utilising Thermal Analysis Software and the Energy Index provide guidelines with which to inform the design. The design serves as a conceptual low energy housing prototype which provides a viable means of increasing the housing stock through small scale interventions.

Keywords: housing, flexible, low energy, London

## 1. INTRODUCTION

There is a projected increase of 3.8 million households in London between the years 1996 and 2021. To accommodate this growth innovative land usage and designs are necessary. London's housing shortage can be reduced if individuals and government bodies take innovative steps to find complementary alternatives to large scale housing developments. One such alternative is small scale housing interventions in pockets of space existing within London.

The growth of cities and demand for new housing creates a need to understand the factors that influence the transformation of towns and populations. The development of a London Prototype in this study has three primary goals- (1) to supplement housing development within London, (2) to provide flexibility of space so as to extend the life of a building and (3) to minimise energy requirements, allowing for self sufficiency as technologies become available. The result is the design of an adaptable low energy prototype housing unit which serves as an example for use in small sites in London and similar climate regions.

## 2. MAPPING OF LONDON

The projected increase of 3.8 million households, from 1996 through 2021, incites questions about design strategies as well as current patterns of land and building usage in and around London. In theory, if the projected 3.8 million new dwellings are built at average new build density levels they would cover an area larger than that of Greater London. As such, new governmental goals have been developed to consider high density, compact developments in pre-existing urban areas utilising recycled land and buildings. New government goals have been set to provide 60% of new homes on previously developed land or in existing buildings. Part of these goals is to help encourage people to move back to towns and cities by rejuvenating urban neighbourhoods with the reuse of inner-urban land. This initiative could result in 2.3 million households on previously developed sites relative to the target of 3.8 million. [10]

The opportunity to utilise back garden sites presents ample space for the development of small detached housing units. Small houses provide a resource for first time home owners, a means of extending an existing house to provide space for growth and can serve as a source of future income for landowners through private development. Simultaneously these sites provide an opportunity to increase the housing stock in London without negatively impacting the larger development strategies. [10]

Houses with back gardens are scattered throughout the urban fabric of London. A full census of suitable land is a difficult process given the private nature of the sites; however it is possible to form a base understanding of the potential. Case in point 'snapshots' of areas in and around London illustrate pockets of opportunity for development. The centre of London is considerably denser than the outskirts of the city. As one moves out of the centre of the city residential streets become wider and private space becomes larger. The following photographs illustrate the change in density levels around the city in relation to the amount of private green space. (Fig. 1) The opportunity to develop these sites is promising so long as consideration is given to issues including community development and access.

**Figure 1:** Aerial photos of dense Central London (top) as compared to South London (bottom) and other areas in the outskirts of the city.
(Source: earth.google.com)

## 3. HOUSING REQUIREMENTS

Life patterns and choices in addition to life expectancy place new demands on urban environments for the general population as well as individual families. Census data taken between 1979 and 2002 illustrate patterns towards smaller families with fewer children. (Fig. 2)

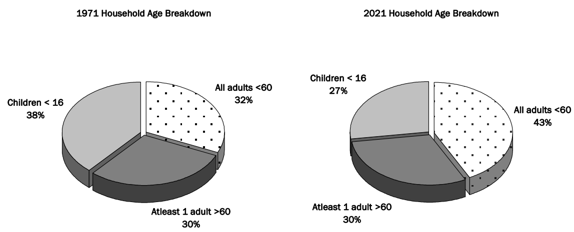


**Figure 2:** Household breakdown 1971 vs. 2021.
(Source: statistics.gov.uk, 2002)

Trends also show that the number of single person households is growing. Nearly 80% of the new dwellings needed are expected to be for individual occupants. These houses will need to accommodate the needs of young people living alone, divorced or unmarried adults as well as the growing elderly population. Projections estimate that half of these dwellings will be occupied by residents over 65 years of age. Therefore, the new housing stock will need to be flexible. [8]

As a factor of the increase in single-person households, the average household size is estimated to reduce from 2.43 in 1996 to approximately 2.1 by 2050. Household size has a large affect on per capita energy consumption. Larger households use a markedly less amount of energy per person then a single person household. A particularly substantial difference exists between one and two person households. In theory, a 60% energy savings would be possible if all one person households moved into five-person households. This is an unlikely reality given that household size is a personal choice and not amenable to policy changes and requirements. As such, the trend of decreasing household size should be considered and accounted for in future design in order to minimise the impact on energy consumption. [3]

The ever-changing occupancy patterns require a housing stock which will be adaptable to the diverse needs of occupants over the lifetime of a building. Future housing needs combined with changing household patterns is beginning to define factors that must influence housing design. These factors set the groundwork for the future of housing in London.

## 4. BUILDING METHODOLOGIES

The design for a London Prototype House is a direct investigation into one particular typology of site. The back garden of a privately owned house located in the borough of Wandsworth in London serves as a backdrop for this case study. (Fig. 3)

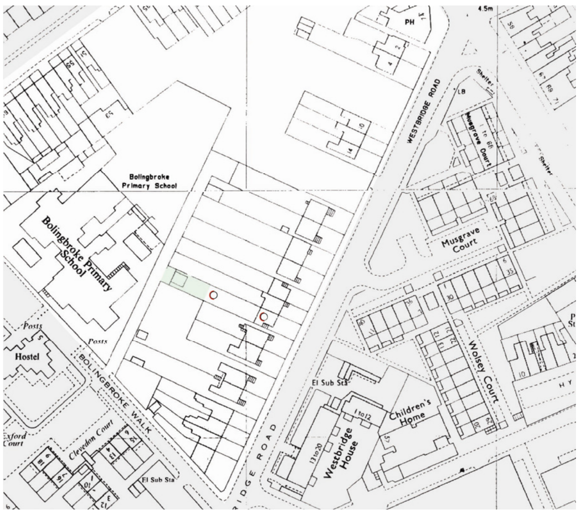


**Figure 3:** Survey map of case study site, Wandsworth London.
(after Source: Ordnance Survey Plans)

A family currently occupies a Victorian home on Westbridge Road with a large back garden. The house has changed hands many times. Before the house was purchased by its current occupants it was divided into multiple apartments with a medical surgery on the ground floor of the house. The present owners converted the house back into a single family home. These changes only represent a fraction of the occupation experienced by the original construction characteristic of much of the housing stock in and around London.

The back half of the garden is currently the home to a derelict garage. The back garden is 40 metres deep and approximately 7 metres wide. The site is representative of many of the residential neighbourhoods sprinkled around London although not as common in the centre of the city. The area of the site that will be used for the design study is 20 metres by 7 metres wide. The depth of the case study site is based on adjacent site developments and enables the landowners to preserve a sizable back garden. (Fig. 4)

**Figure 4:** Panoramic views of case study backyard.

The nature of these types of sites results in a series of constraints relative to the design and construction of a new house. A successful design will react to the constraints and build upon them. Small scale interventions while not a solution to the housing shortage in London can serve as a useful supplement so long as appropriate methodologies and strategies of design are implemented.

Precedents such as traditional Japanese shoji screen architecture in which a house is designed as a single room in addition to Gerritt Rietveld's Schroeder House illustrate different means of accommodating change through design. [2] [7] (Fig. 5)

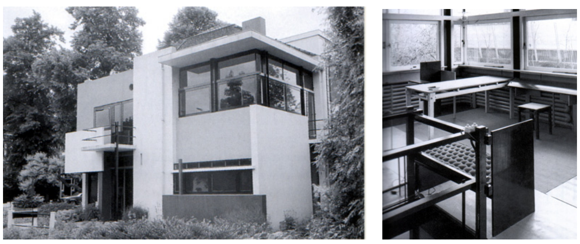

**Figure 5:** Schroeder House at one time considered modern icon of transformable living. The design results in a series rigorously controlled scenarios rather then a fluid flexibility. (Source: Bell, 2000)

Frank Duffy, former president of the Royal Institute of British Architects 1993-1995, said "Our basic argument is there isn't such a thing as a building. A building properly conceived is several layers of longevity of built components." (Fig. 6) [4]

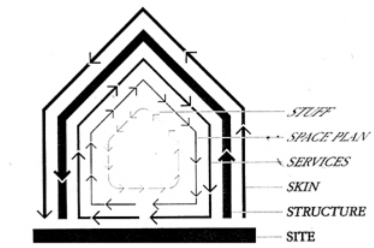


**Figure 6:** Shearing layers of a building.
(Source: Brand, 1994)

A house can be designed for longevity and change if appropriate measures are taken. Providing generous space standards allows greater flexibility for layout. Construction quality is also very important. A house designed with a high standard of construction will physically last longer than a poor construction. Flexibility can be designed into a house through the use of an open plan allowing occupants to develop spatial configurations based on their own needs. Designing with the ability to expand or adapt increases the life of a building. It is possible for requirements to grow beyond the limits of a house, but the occupancy cycle can continue with a new family if the house is designed for longevity. The ability to adjust the shell of a building can dramatically alter the conditions within. Different treatments of openings in the building skin can change the internal environment directly affecting the uses inside. Similarly, designing a building skin in a series of layers allows the occupants to define the architectural expression of their house while also giving the freedom to use spaces in different ways. Furthermore, a home that has a built in framework to take advantage of future technologies and innovations can convert to the use of more efficient energy sources. In turn, this allows for a building to become self sufficient at a point in the future.

The longevity of the new and existing housing stock will be greatly affected by its ability to perform successfully in a warmer climate. Examples from architectural responses to climates in Southern Europe may prove as useful precedents for future homes designed in the United Kingdom. Southern European vernacular architecture minimises unnecessary heat gain and maximises passive cooling through minimising window areas, providing shade, courtyards, shutters and high thermal mass to maximise heat exchange between internal air and building fabric. Designing with the consideration of predicted climate changes will further extend the lifecycle of a building. [1]

## 5. CASE STUDY

5.1 Sustainable Design Strategies.

Guidelines have been drawn, through research and precedent studies, which define how to design a house that will function relative to changing lifestyles and be easily maintained over a long period of time. In this situation, the inclusion of additional housing on a back garden requires a unit which does not overextend the existing network of services. Furthermore, it may prove to be difficult to bring services from the main street to the back gardens. A successful design should minimise energy consumption; an ideal situation would also be self sufficient from the traditional services that are available.

Many variables have an affect on the environmental performance of a house. A design that is climate sensitive and environmentally responsive provides high standards of comfort and environmental quality whilst minimising energy demand.

London experiences a temperate climate with warm summers and cool winters. Weather in London is rarely extreme and there is typically a light precipitation throughout the year. The primary use of energy in housing is in space heating. Overheating as a result of solar gains can be prevented through appropriate design strategies and occupant participation as needed. [12]

The prototype development described in this research results in a single detached house in London. Opposed to a semi-detached or terraced housing scheme a detached house is one of the most exposed building typologies. [12] Detached units are not always the optimal design solution but in some situations, such as private gardens alternatives may not exist. The exposure of this type of construction creates another reason to investigate means of reducing heat loss and increasing energy performance.

A series of simulations have been performed as a means of distilling guidelines for the design of a prototype house for London that experiences minimal space heating requirements. The first series of simulations were conducted with the Energy Index in order to study the rough affects of orientation and ventilation on building heat loss and energy usage. The Energy Index is a simple spreadsheet tool that provides general energy performance values based on schematic design parameters. [11] A base model with a rectangular volume of 150m$^3$ and a glazing to floor ratio of 20% was devised to conduct this analysis. Insulation levels studied were defined according to the Energy Savings Trust's "Best Practice Guidelines for Energy Efficiency in New Housing". (Table 1) [5]

**Table 1:** Energy Savings Trust Best Practice Guidelines for Energy Efficiency in New Housing.
(Source: Energy Savings Trust, 2003)

| | Maximum Permissible U-values (W/m2K) | | |
|---|---|---|---|
| | "1" | "2" | "3" |
| | Good Practice | Best Practice | Advanced Design |
| Roof | **0.25** | **0.13** | **0.08** |
| Wall | **0.35** | **0.25** | **0.15** |
| Floor | **0.25** | **0.2** | **0.1** |
| Windows/ Doors | **2** | **1.8** | **1.5** |

The north facing model consistently experiences the highest heating requirements whilst the south experiences the lowest. The difference in performance diminished significantly as the insulation was increased and the air changes were reduced. The results illustrated that there is a level at which optimising the building physics beyond a certain point no longer results in noticeable savings as per the law of diminishing returns. (Fig. 7)

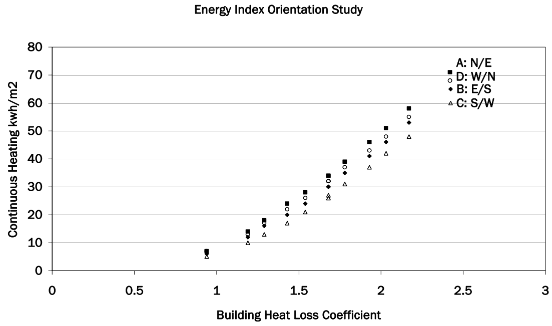


**Figure 7:** Energy Index orientation, insulation and air changes per hour comparison.

The results of the Energy Index simulations were used to define a starting point for Thermal Analysis Simulations using TAS. [6] The preliminary TAS simulations use the Advanced Practice-South facing model from the Energy Index simulations as a base building construction. This model is used to conduct a series of investigations relative to different parameters such as shutters, thermal mass and window conditions. TAS provides a more technical understanding of building heat gains and losses as related to energy usage. (Fig. 8)

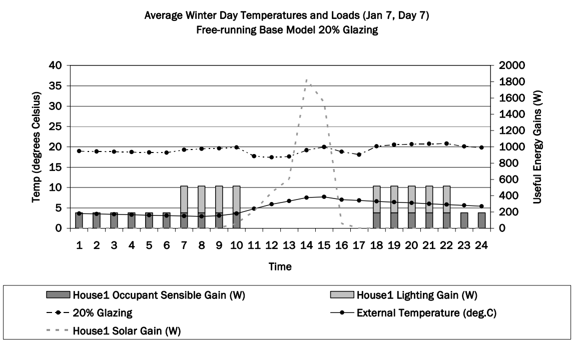


**Figure 8:** Average winter day load comparison.

The thermal analysis simulations of the base building illustrate reduced energy consumption in the winter months with the inclusion of night shutters. The glazing ratios studied between 12-20% did not have a large impact on the performance and therefore serve as a successful range for the final design solution. The average indoor summer temperatures remained within the recommended comfort range and can therefore be mediated with operable windows and appropriately designed shading devices. (Fig. 9)

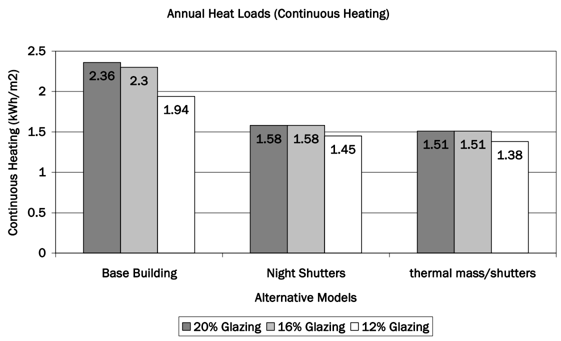


**Figure 9:** Annual heat loads comparison relative to additions of glazing, night shutters and thermal mass.

5.2 Architectural Design Strategies

Environmental analysis conducted in the early stages of this design process identified guidelines and boundaries for the architectural design of the prototype unit. The parameters established through earlier analysis set forth a basis upon which the highest environmental standards were the goal. As a result the building is a very robust construction.

The architectural design aims to achieve a configuration which encourages rather than defines future possibilities for space use. There is a need to minimise unusable or single function spaces such as circulation and fixed elements. The only fixed elements that exist in the plan are the core service functions including the bathroom space and the kitchen. These core elements are consolidated along a horizontal and vertical spine 'plug-in' wall.

The plans, sections, and elevations have been derived from a modular grid developed based on the standard sizes of board available. The grid allows the design to be easily reduced or enlarged based on site restrictions. Simultaneously, the use of a standard plywood module reduces the amount of waste by maximising use of each piece of material. The base prototype has three primary design derivations: house 'A', 'B' and 'C'. All houses have the core and plug-in wall in the same location; the designs are a series of modular extensions which change the dynamics of the unit.

Apertures are designed in a series of layers to provide additional insulation, shading and privacy. Layers allow occupants to personally define the internal conditions. Simultaneously allowing elements to be added and removed as a response to changing climate conditions. The location of fenestration has been defined for the purpose of this study but is ultimately flexible based on occupant needs. These design strategies thereby reinforce the design goal for flexibility to occur through physical building changes as well as internal use changes. (Fig. 10)

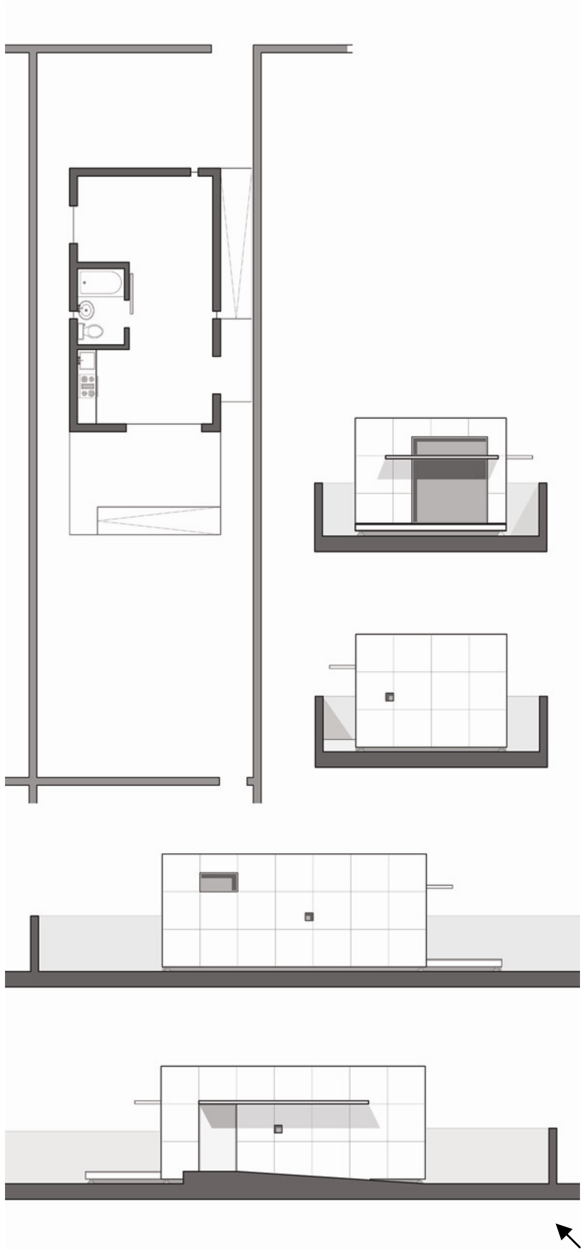

**Figure 10:** Case study house B. Design concept plans and elevations.

5.3 Post Design Analysis

A final series of simulations were run to assess the success of the final design as well as the affects of reducing insulation and ventilation levels.

Minimising the insulation U-values has resulted in the largest impact on the energy performance throughout this study. The levels specified in this design are extremely robust and even with careful material selection may result in massive wall constructions. In some cases this is impractical based on associated costs or site limitations. As such the final design provides a level of comparison for design variations utilising reduced energy specifications.

The resultant simulations illustrated the affect of reducing requirements from Energy Savings Trust Advanced Design Standards '3' to the Best Practice Standards '2' as compared to the air changes per hour. The affects of Air Changes per Hour show that a home of this size can benefit significantly from air changes between 0.25 and 0.35 per hour. Energy requirements for the final design with Advanced standards and 0.25 ACH were below 2kWh/m$^2$. These levels are approaching zero heating requirements. (Fig. 11) Furthermore it can be seen that all of the various building configurations studied result in successful energy usage under the precipice that 35 kWh/m2 represents a very good performance for a home in London. [12]

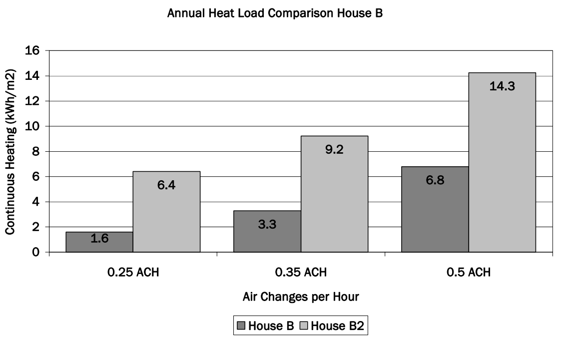


**Figure 11:** Final design annual heat load comparison relative to air changes per hour on House B. House B represents base insulation values from 'Advanced Design' Specifications as compared to B2 with 'Best Practice' insulation levels.

## 6. CONCLUSIONS

The design iterations define a successful prototype for small scale housing interventions in London. The final series of thermal analysis illustrated the ramifications of varying levels of insulation and ventilation. The simulations and results provide the owner/builder with the means to make a decision on the various alternatives relative to the modelled parameters.

New housing should be 'long-life', 'loose-fit' and 'low energy'. Design should consider that the life of a building is much more stable than the changes in use of a building. Reducing energy requirements through passive design measures and construction techniques will provide a house that is suitable to the current and future needs of occupants and the community. This can be achieved through the use of durable materials and systems of fabrication and by designing flexible cost-effective layouts to accommodate the changing demands of occupants and their lifestyles.

Comfort levels vary relative to age, culture and sex, in addition to other variables that can not be fully defined or identified through simulations. Introducing occupant control into a house that has been efficiently designed will allow the occupants to define their personal requirements. It is not possible to predict all of the variables and occupancy scenarios that will occur over the life of the building. As such, the most basic design decisions result in the largest impact. These include attention to orientation, glazing, insulation, construction, building envelope and adaptability. Poor design of these features will result in a house that is not successful in multiple situations. Similarly occupants should be educated as to the use of their home not only at the beginning but throughout their occupancy. A feature that regularly monitors energy consumption would be beneficial to the end user. Visible feedback relative to usage would allow a household to become increasingly efficient.

The design of this London Prototype House has achieved high standards of performance whilst also providing a space that functions as a home for occupants with diverse requirements. Applicable in multiple situations throughout London, this design serves as one possible solution to designing future housing as well as increasing the housing stock within London and other parts of the UK.

## ACKNOWLEDGEMENT

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