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The SALFORD low-energy house:
Learning from our past

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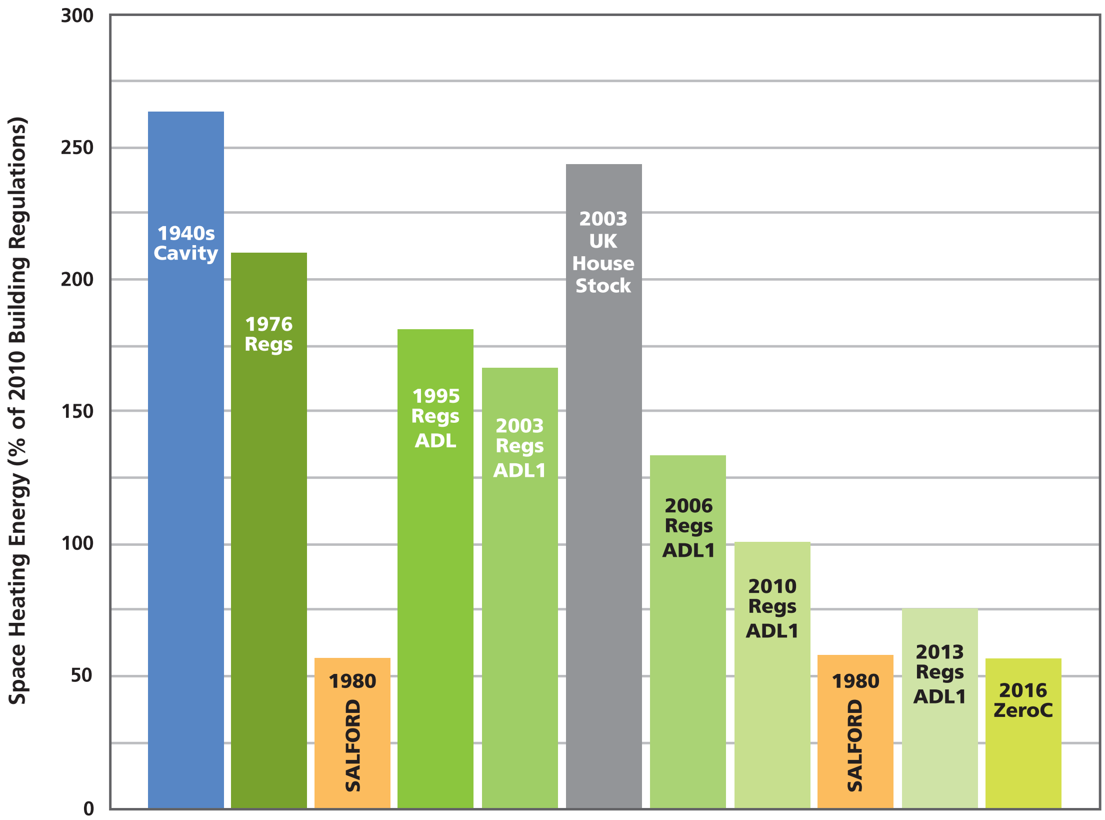
> The potential national energy savings that would result from an adoption of the SALFORD, or an equivalent efficient design, are immense. Conversely, failure to build to the SALFORD standard will impose a massive unnecessary burden on national energy resources that will be carried forward well into the next century

'The SALFORD low-energy house'
Energy Efficiency Office, Report No. ED 179/59,1987



Space heating energy required for UK housing 1976-2016 relative to 2010 Regulations

In the UK the Domestic sector uses nearly 20% of national energy for Space Heating. The SALFORD houses, designed in 1976 for Salford City Council, and extensively monitored in 1980, consume about 25% of that of the general UK housing stock, and less than 60% of current, 2010, Building Regulations.

Thirty years on this survey shows that the SALFORD design is still leading and is one of very few that will be able economically to meet, in both urban and rural locations, the near-zero Carbon 'Code for Sustainable Homes' that is to become mandatory in 2016.

Overview

The SALFORD low-energy house was designed in the late 1970s for Salford City Council in a joint project with the University. A semi-detached experimental pair and a prototype terrace of six mixed dwellings were built and extensively monitored. The results showed substantial energy savings and occupant satisfaction. The passive design, which incorporates a high thermal capacity internal structure protected by a highly insulated, well-sealed envelope, provides a high level of continuous thermal comfort at low cost whilst being fire, rot, damp, mould and vandal resistant.

In the early 1980s, about 200 other SALFORD houses were built for the Council, within government 'yardstick' cost limits, for socially rented housing and a further 50 or so were built by a local developer for the private sector. In the mid-1980s councils had to stop building due to cuts to the funding of housing in the public sector. The SALFORD design and experience did not become widely known and was not implemented to any great extent by the private sector that had taken over the principal house building role.

To mark the University's focus upon the cross-cutting themes of Energy and Social Justice a new study was launched in 2010 to explore the long-term performance of the SALFORD dwellings. This 2010 study shows the houses continue to perform well. Average space heating energy use for the 30-year old SALFORD houses is less than 25% of the UK average, and less than 60% of that required by the current 2010 UK Building Regulations. The house design determines the basic capital cost and the average level of energy consumption.

However, individual occupant choice of equipment and comfort temperature determines actual overall costs and the energy consumption which varies widely from less than 5% to more than 50% of the average. This study has demonstrated that the SALFORD design continues to be ahead of its time. It also suggests that legislation and publicly funded housing developments are the principal drivers in achieving energy-saving improvements in the housebuilding industry and at an individual household level.

Dwellings designed to the SALFORD house principles are expected to be able to meet the proposed 2016 near-zero Carbon Regulations at competitively low capital cost.

Background

In the mid 1970s Salford City Council owned, and managed, approximately 40,000 rented dwellings. They were of different designs and styles but many of them suffered from a range of problems including: condensation, mould-growth and poor thermal comfort. The energy crisis of the 1970s only added to the conclusion that the housing stock was too expensive to heat. This was compounded by the fact that many of the tenants were on low incomes and would today be classed as 'fuel-poor'.

In 1975 the City Council approached the University of Salford for help in jointly designing a new low-energy dwelling that would address these issues. Dr J E Randell, Senior Lecturer in Building Services Engineering, in the Department of Civil Engineering at the University, and J M A Hoyle, architect in the City Technical Services Department, were the project team. Together they established the basic physical principles and then incorporated them into the final architectural design and saw them through to construction.

The City Council laid down the following specifications:

- The cost of the dwellings should, if possible, be within social housing cost 'yardstick' limits.
- Established construction methods, materials and techniques should be used.
- The dwellings must place no limitations on the normal living patterns of the tenants.
- Heating costs and energy consumption should be substantially lower than those of existing housing.
- General maintenance costs should not exceed those of existing housing.
- The dwellings should be adaptable to different types of fuel and heating appliances.

Randell and Hoyle arrived at a basic 'SALFORD house' design philosophy of a high thermal capacity internal structure protected by a highly insulated, well-sealed envelope. In combination these three factors, with attention to associated details, result in a 'passive' structure that can maintain constant equable temperatures with controllable ventilation, low in winter to conserve heat and high in summer for cooling [1].

The Council first built an experimental pair of 2-bedroomed semidetached houses, followed by a prototype terrace of four houses and two flats. After successful detailed monitoring they went on to build a further 200 or so dwellings in Salford.

Unfortunately the radical changes to housing policy in the 1980s brought the number of homes built by local authorities to an effective stop so Salford City Council built no more. However, elsewhere in Salford, a private builder adopted the design for a small estate of about 50 flats and houses and a local Housing Association incorporated the principles into the design of a sheltered housing development.

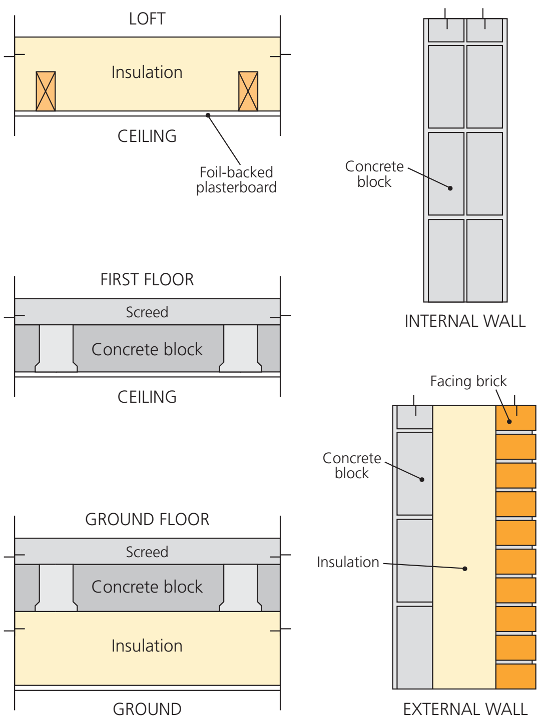
Design detail

Structure and thermal capacity

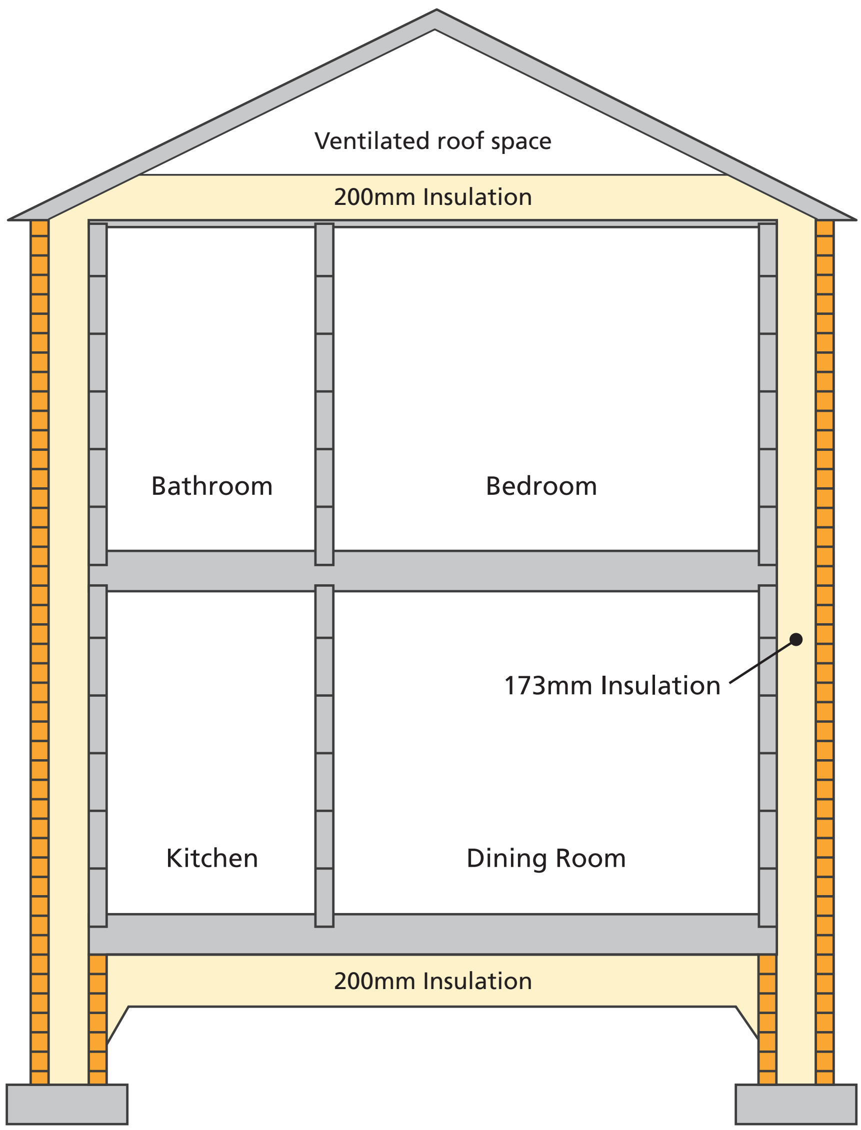
The thermal storage capacity of a building is largely determined by its internal mass. In the SALFORD design high mass is provided by constructing the internal walls of dense concrete blocks and the floors of suspended concrete beams with block infill topped off with sand and cement screed. The result is an internal mass, and thermal capacity, about four times traditional values. The inner walls were wet plastered to ensure good air-tightness and good thermal admittance. The large thermal capacity that results enables maximum use to be made of incidental gains, reduces temperature fluctuations and permits flexibility of heating strategies. This is in marked contrast to lightweight houses, such as most timber-framed constructions, that can have a thermal capacity of around a quarter of traditional values and consequently can suffer large temperature excursions.

Insulation and ventilation

In the SALFORD design the thermal insulation thickness is nominally 200 mm all round. In the experimental and prototype houses this comprised 200 mm glass fibre loft insulation with 200 mm polyurethane granules under the ground floor and in the 173 mm wide external wall cavities. The windows used were proprietary, sliding, dual-glazed units made of treated timber finished with a microporous stain, with trickle ventilators in the heads. 'Cold-bridging' was avoided by design details, and external doors were draught-stripped and separated from main living areas by a lobby or hall. Mechanical extract ventilation facilities were provided in the kitchen, bathroom and toilet to remove water vapour and odours at source.



Cross-sections of the insulation and dense structural and high thermal storage components of the SALFORD house [3]



Cross-sections of the SALFORD house [3]

Cost

Historically Salford City Council built traditional social housing within government 'yardstick' costs. The new SALFORD dwellings were designed, giving priority to factors that involved long-term gains and saving on the non-essential, to the same financial constraints and Council Quantity Surveyor's estimates for the design were close to those for their traditional houses. Tenders were invited from seven builders in 1982 to build a small estate of houses to both traditional and the new SALFORD designs. The tenders for the traditional design averaged out at 'yardstick' with a spread of ±10%. The SALFORD design average was 107% of 'yardstick' ±8%. Consequently the Council were able to build within their 'yardstick' specification. It is to be expected that prudent builders would factor into their estimates an additional amount for unknowns when tendering to build to a new unfamiliar design, and that costs could be reduced as they gained experience with the design. With or without this factor there was very little difference in cost between the traditional and SALFORD designs.

External appearance and orientation

The external house appearance of brick walls with tiled pitched roofs is normal for the UK but is not critical to the design. Overall window area is also normal but, as the road on which the dwellings were built runs NE-SW, the most southerly facing elevation, that to the SE had the most glazing, about 25%, and the NW about 10%. This enabled maximum solar gains to be received via the SE windows and for transmission losses through the NW facade to be minimum. The external doors on the NW face were also sheltered with a porch and outhouse. The NE and SW walls are unglazed brick-faced end walls to the exterior, or are internal concrete block party walls.

Heating systems

During the experimental stages several heating systems were tested. These included experimental heat-pumps combined with heat recovery from extracted air, a gas boiler and both underfloor and warmed-air heating. These technologies all involve relatively high capital cost items with accompanying significant maintenance potential that is difficult to justify when the maximum heating demand, around 2 KW, is so low.

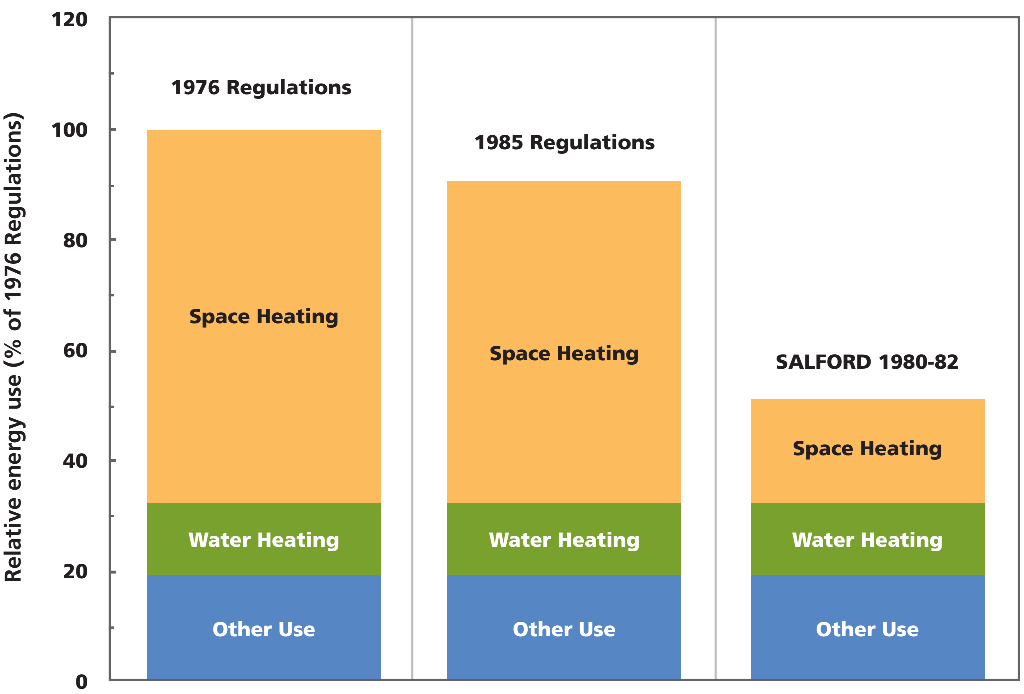
The production houses were heated with just one, or sometimes two, balanced-flue gas convector heaters, delivering in total between 1.5 and 2.5 KW, one in the living room to provide optimum comfort and the other in the hall to ensure equable whole-house temperatures. Conventional central heating, using water-filled radiators distributed under windows in each room, was not installed in the production houses because it could not be economically justified and is not necessary to maintain comfort conditions [2].

SE elevation of the experimental semidetatched pair and prototype mixed terrace [3]

The NW facade of the prototype terrace in 1980 [3]

Monitoring results 1980-82

The prototype terrace was extensively monitored through 1980-82, by Salford University Industrial Centre Ltd., as part of the Government's Energy Efficiency Demonstration Scheme. The results were published as a full Report [3] and as an outline Expanded Project Profile [4] in 1987. The annual average energy used for space heating, water heating and for all other activities as measured for the SALFORD terrace in 1980-82 were compared with values calculated for an equivalent group of dwellings built to the 1976 Building Regulations then in force, and to 1985 Regulations introduced later. It was assumed that energy for water heating and other activities would be the same for all equivalent dwellings. In the dwellings built to 1976 Regulations about two-thirds of the total energy is used for space heating. In the SALFORD dwellings space heating energy consumption is reduced to about a quarter of that of dwellings built to the 1976 Regulations, so that space heating, water heating and other uses are each of comparable magnitude. Overall energy savings in the SALFORD dwellings are about 50%. Typically the length of the heating season, the period of a year in which heating is required to maintain comfortable internal temperatures, is also reduced from the UK average of about 7 months to around 3-4 months in the SALFORD dwellings.



Auunal energy use in 1980-82 for SALFORD houses (% of 1976 Regulations)

A large majority of the tenants indicated satisfaction with the SALFORD dwellings. As well as being very economic to heat, about £1 per week at 1980 prices, the houses are inherently resistant to fire, rot and vandalism, and were reportedly quiet with reduced internal and external noise transmission. As internal surfaces are maintained at equable temperatures day and night comfort is increased and condensation problems are minor. Even without heating, in UK winters the risks of house freezing are virtually eliminated.

30 years on…

Apart from the monitoring activity performed in the early 1980s little attention has been paid to the houses in the intervening period. Indeed, residents from the original monitored terrace had been assured of no further inconvenience and disruption from any more monitoring by researchers.

The houses and their occupants though pose a unique opportunity to better understand – over the long-term – whether the houses continue to be energy efficient, how the residents use them, what they think about them, and whether lessons could be taken from this experience nationally.

Quite a lot has changed in the 30 years. In the mid-1970s the housing concerns of Salford City Council were the plight of their low-income tenants and the inadequacy of their housing stock to meet their needs. Now, the Council has little direct involvement with new-build houses which have become the responsibility of Housing Associations and private developers.

For the first 20 years there was little change in the UK Building Regulations related to the conservation of energy. It is only in the last decade that there has been any significant improvement and it will be only in the next decade that new Regulations will become effective and require expert design to meet. There is now significant concern for the environment, climate change, CO_2 emissions, and an emphasis on ensuring sustainability in development. There is also a national commitment to meet impending requirements of EU legislation and international agreements related to sustainability and near-zero Carbon buildings.

The specific objectives of the new study were to:

- Assess how the SALFORD house has performed, and how it conforms to current and proposed building standards.
- Analyse the current energy consumption of the SALFORD house.
- Determine what maintenance and refurbishment has been required.
- Determine the various views, experiences and everyday behaviours of residents living in dwellings built to SALFORD house principles.

The SALFORD houses today - Survey results 2009-10

It remains unclear exactly how many properties were developed in Salford to the SALFORD house design. One of the main problems in tracking them down was the lack of awareness about their existence by current officers within Salford City Council. Officers and Councillors who were contacted tended to know of the existence of the houses but were unsure how many were developed and where these might be. Indeed, one Council development of SALFORD houses, in Lower Broughton, had been demolished, along with a number of surrounding dilapidated properties, to make way for a large-scale urban renewal project.

Also, as their external appearance is intentionally conventional, and no limitations were placed on normal living patterns, many of the current occupants - as well as external agencies such as the local authority, regeneration partners and estate agents - are unaware of the exceptional nature of their properties. However, through a combination of conversations with City Council staff and the publication of a press release about the study, a number of people came forward who had direct knowledge of the houses of interest to the study. Three sites were located and studied; the original experimental semi-detached house and prototype terrace adjacent to the University; a Council built estate of houses in Pendleton; and a mixed private development in Ordsall. Some of the former Council properties are now privately owned or let.

Interviews were organised with as many people as possible who had experience of the properties. In total 18 people were interviewed, 15 of whom still lived in the houses, one had recently moved to another property and two had been forced to leave their properties as a result of the urban renewal initiative that required the demolition of the houses.

Most of the interviews lasted for around 30 minutes and covered:

— Their awareness as to the background of the development of the house design.
— Length of habitation and reasons for moving there.
— Views on how the house compares to other properties they have experience of.
— Views on comfort.
— Installation of any energy efficiency related modifications.
— The heating season of the house.
— Duration of daily heating usage.
— How they used the property.
— Overall satisfaction with the house.
— Their actual or approximate energy use.

The occupants

Four of the people interviewed were the original tenants of the houses when they were built in the early 1980s. The others had lived there for various periods of time from just a few months to many years. Interviewees ranged in age from 18 to 85. Dwelling occupancies ranged from individuals to a household of four with young children. Seven interviewees were owner occupiers, three were privately renting and eight were existing or former Council tenants.

The heating systems

The original heating systems, of one or two gas convector room heaters, had been replaced by conventional central heating in all the properties, either by the Council or by the private owners.

There was a distinct divide amongst occupants who had experienced the houses both pre- and post-central heating. Two expressed the view that those who complained about the lack of central heating did not understand how to use the house. Another long-term resident reported that people who moved into the houses 'moaned' as they expected central heating and saw the houses as being in that respect inferior to other properties. It was reported by a number of people that the original heating system was more than adequate as they found the properties warm in winter and cool in the summer. There was some suggestion that the people who were satisfied with the original system tended to be the people who had lived in the properties from the beginning and who had been taught to use the heating system correctly. Those who did not like the original system were often later occupiers. However, there were people who had moved into the houses when built in the early 1980s but who did not share the enthusiasm for the properties. One person described the houses as 'difficult to heat' and 'draughty' until they had installed central heating and fitted a secondary external door to the porch.

There is anecdotal evidence from private developers, at the time the houses were built, that it was difficult to sell the houses without central heating installed as potential buyers considered that they lacked an essential amenity. The idea that central heating is not essential for comfort, but is generally only necessary to compensate for inadequate thermal design, was not, and is still not, generally understood or accepted.

Windows

Originally the Council fitted proprietary, sliding, dual-glazing, with a treated timber frame finished with a microporous stain as it was thermally efficient with an estimated 60-year lifetime. Its cost was about the same as that of a single-glazed, hinged, painted wood window with an estimated lifetime of 10 years, that was commonly fitted at the time. The uPVC-framed double-glazed units that are now ubiquitous, were then much more expensive and sealant failure within 10 years was common.

Without exception all the people interviewed reported that the original windows that were installed were unsatisfactory. There were two principal problems, ease of opening and cleaning. Although they were not as easy for occupants to open as hinged windows they were not as secure and could be opened without too much difficulty by intruders from the outside. This failing was not acceptable to occupiers and some had difficulty obtaining house insurance. Some occupants used to remove panes for cleaning between the overlap. This was hazardous as some panes were large and difficult to handle and breakages occurred.

Years later, the Council replaced all the windows in their properties with uPVC double-glazed units. Private owners have done the same, except in one upstairs flat where the original unit is still in use and is serviceable 30 years on.

Condensation, damp and mould

Some problems with condensation and mould were reported but they were not endemic or severe as had been common to houses in the 1970s. All the Council-built production properties were fitted with extractor fans in the kitchen, and in them no damp or mould problems were reported. No fans were fitted in their bathrooms originally, one tenant has since installed one. Another, without a fan, complained of mould growth in the bathroom. In the mixed private development the bathrooms in the flats are situated in the middle of the property and have no windows. Some of the bathrooms have a fan and others not and condensation and mould growth is a problem. One person just opens doors and another uses a dehumidifier. Problems of mould were not reported from the private houses that have bathrooms with windows.

Condensation forms on surfaces in rooms in which there is an excess of water vapour and inadequate ventilation to remove it. Most commonly, in traditional dwellings, condensation forms on the cold inner surfaces of poorly insulated external walls even when the water vapour concentration is not high in absolute terms, because the surface temperature is below the dew-point and the relative humidity is then 100%. If condensation persists mould will inevitably form and may grow rapidly, especially if it is warm, as it is likely to be in an internal bathroom. Insulating the outer walls substantially reduces the traditional problem but has no effect when the cause is not cold but is lack of adequate ventilation. The solution is to provide appropriate ventilation facilities and for them to be used.

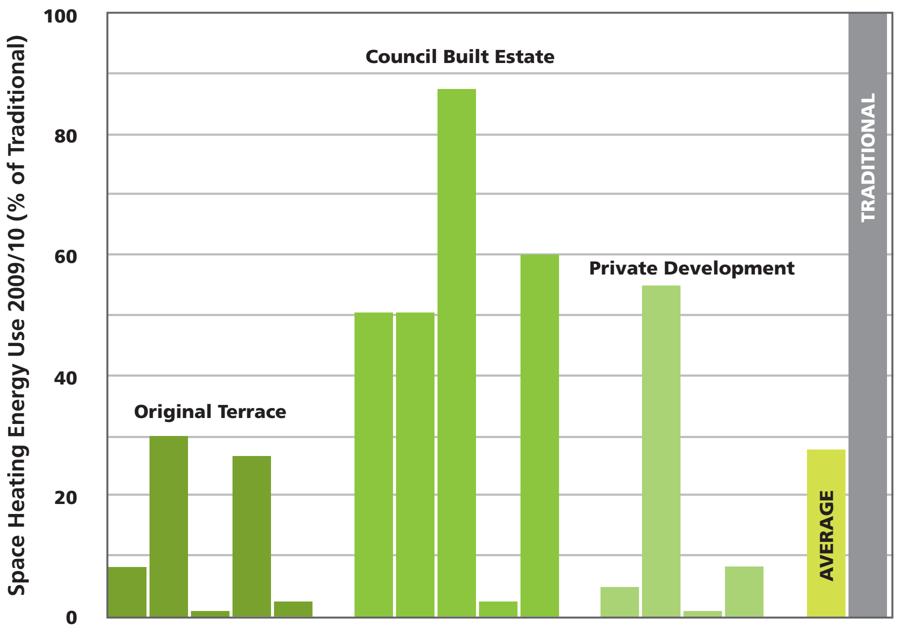
The heating season and annual space heating energy consumptions

The traditional heating season in the UK is about seven months, from early October through to May. For the SALFORD houses it is less, typically about half, from around mid-November through to March on average, as incidental gains are sufficient to heat the houses through much of autumn and spring. Also, on heating days the space heating demand is on average about half that of traditional housing. Overall the annual space heating requirement is about a quarter of traditional, as it is approximately proportional to the product of the daily demand and the heating season length.

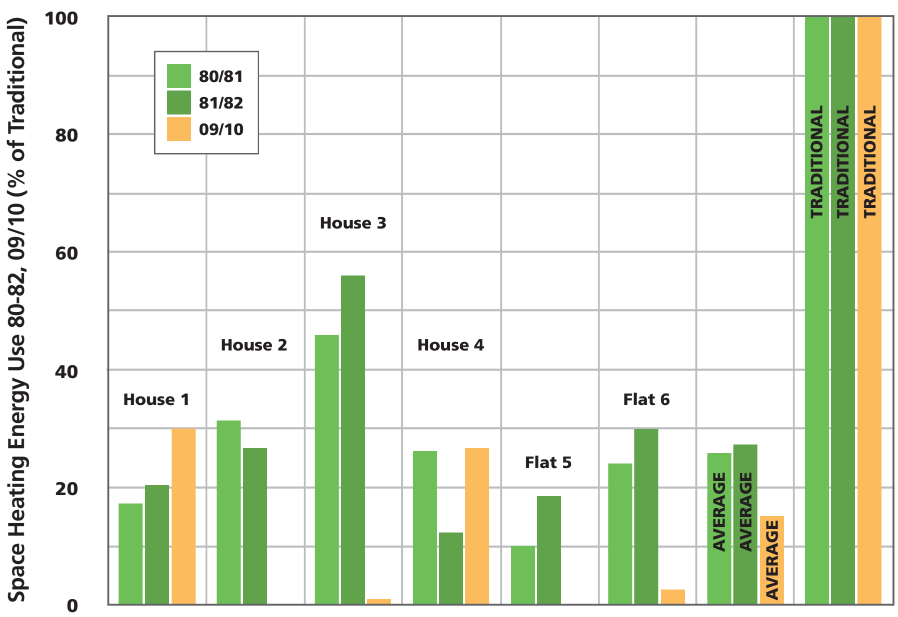
As daily demand and heating season length are approximately proportional to each other the square of either can be used as a measure of annual space heating energy consumption.

The 1980-82 study involved detailed temperature monitoring at half-hour intervals in six dwellings over two years. It produced detailed results which showed that consumptions by different households varied by about a factor of five, from about 10% to 50% of traditional with an average of near 25%. In this 2010 study energy consumption was calculated from the heating season lengths and space heating costs estimated by each interviewee. The results were grouped according to location; the original terrace, the estate of Council production properties and the private development, then averaged and all compared with the equivalent for a Traditionally built dwelling as reference.

The estimated average energy consumption is almost exactly the same as was measured for the 1980-82 seasons; just over 25% of Traditional. However, large fluctuations are observed, from below 5% to near 85%. At least four of the 14, from across the locations, have very small consumptions, each less than 5% of Traditional and less than a fifth of the SALFORD average.



Space Heating Energy Consumtion for SALFORD Dwellings 2009/10



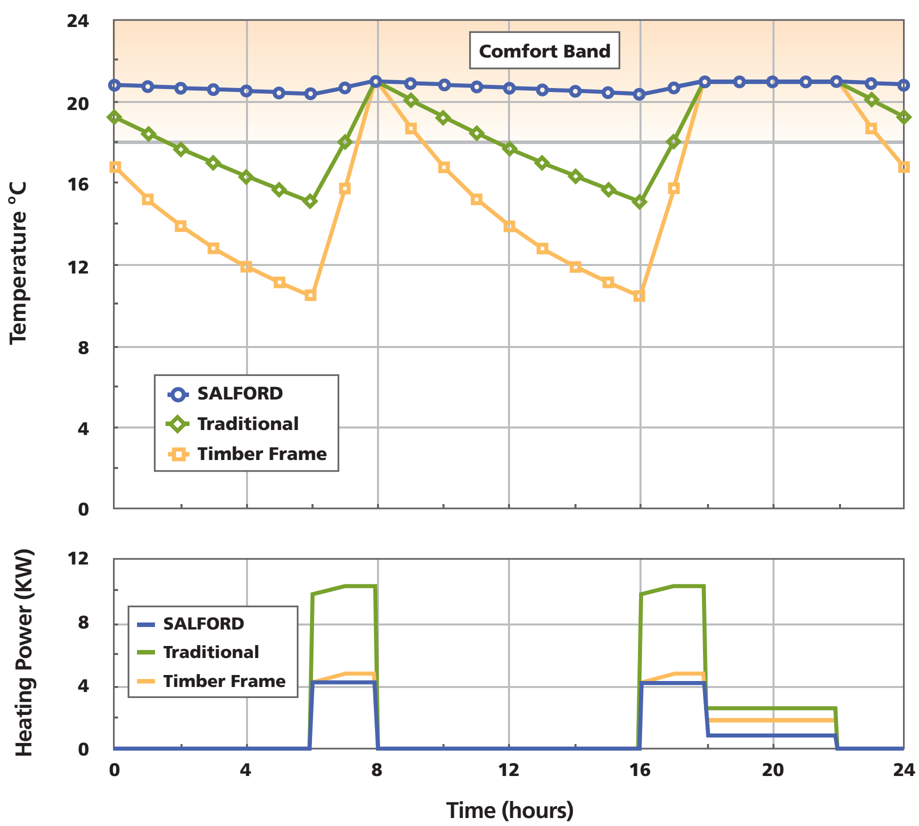
Space Heating Energy Used in the Original SALFORD Terrace 1980/81, 1981/82, 2009/10

In 1980-82 House 3 in the terrace had by far the highest energy consumption, about 50% of Traditional. In 2009/10 the same house had the lowest at well under 5%, less than a tenth of previously. A similar reduction is shown by Flat 6, but the opposite trend is shown by House 4 in which consumption has risen from about 20% to near 30%. All three dwellings had different occupants in 2009/10 from those in the 1980s. In contrast House 1 has the same occupants, but they are 30 years older. In 80-82 House 1 averaged just under 20% and in 09/10 about 30%, a much smaller change but a rise, as would be expected for older retired occupants who generally have higher heating demands than the young and more active.

The differences in space heating energy use in the SALFORD dwellings are largely due to the different internal temperatures chosen by the occupants. A one degree increase in the average internal temperature through the heating season could account for the increase in consumption in House 1. Minimum comfort temperature is often considered to be 18˚C, with 23˚C being very comfortable. At a steady internal temperature of 23˚C through a UK winter a SALFORD house consumes around 25% of the space heating energy of that for a Traditional house run at the same peak temperature, but the latter would have lower nighttime temperatures as a result of using energy-saving intermittent heating. A SALFORD house run at a steady 18˚C would, over a season, consume only about a quarter of one run at 23˚C. Thus it is not surprising that there is such a variation in energy consumption when occupants can choose to live in acceptable comfort at minimal cost, or very comfortably at a quarter of the cost of normal. Furthermore, if one house in a SALFORD terrace is unheated its temperature, during cold spells, could be elevated by up to an additional 5 degrees by heat transfer from neighbouring houses through the uninsulated party walls.

The power requirements and internal temperature responses for SALFORD, Traditional and timber-framed dwellings are very different. Calculations for houses intermittently heated for eight hours to achieve a comfort temperature of 21˚C, for an external temperature 0˚C, after a morning 2-hour boost and for a further six hours through the evening are illustrative.

Traditional and timber-frame dwellings save energy by intermittent heating but at the expense of lower internal temperatures. The Traditional dwelling drops below the comfort band within four hours of switching the heating off and the timber-frame dwelling in less than two hours. The SALFORD dwelling would still be within the comfort zone two days later so there is no need for the heater to be sized for boost power or significant advantage in intermittent heating.



Internal temperature and heating power Chart and Table for SALFORD, Traditional and Timber-Framed Dwellings intermittently heated to 21°C by 2-hour boosts morning and evening for an external temperature 0°C

	SALFORD	Traditional	Timber-Frame
Average Temperature °C	20.7	18.5	16
Minimum Temperature °C	20.4	15	10.5
Average Power (KW)	1	2.5	1.25
Boost Power (KW)	4	10	4.5

Comparison to other properties and UK Building Regulations

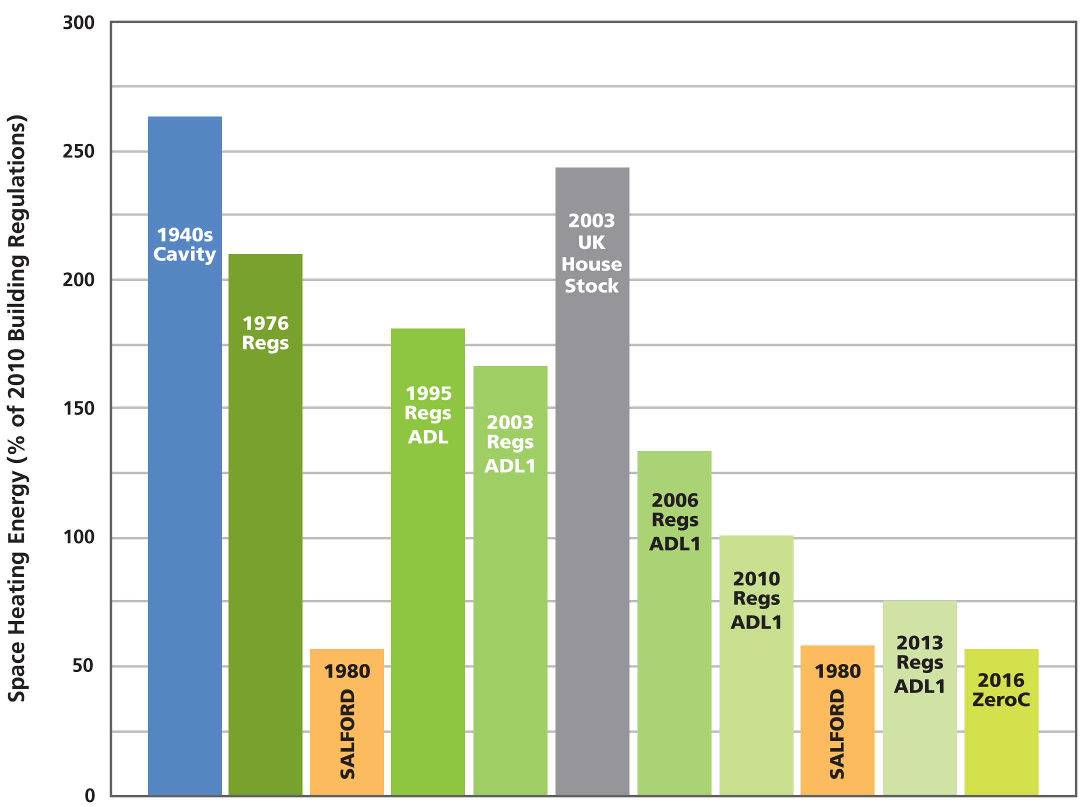
The two former social housing tenants who had recently been moved from the SALFORD houses and had been rehoused in the new large-scale development, were critical of their new homes. They regarded their old houses as being far superior to their new properties which they described as; draughty, noisy, difficult to keep warm, and expensive to run when compared to their old SALFORD houses.

Presumably the recently built new properties in the large-scale redevelopment comply, as a minimum, with the 2006 UK Building Regulations. The 40-year comparison of the space heating energy requirements and usage for UK housing since 1976 shows that the SALFORD house requires less than 45% of 2006 Regulations, which supports the comments of the former tenants that their new houses are relatively difficult to keep warm and expensive to run.

In the twenty years from 1976 the Regulations related to space heating tightened by about 15%. It is only in the last decade that there has been any significant attempt, in response to serious environmental concerns, to use the Regulations to conserve fuel and power. In 2003 the average housing stock was only 8% more efficient than 1940s cavity wall standard constructions and, regardless of new build, it will require substantial refurbishment of the existing stock, and decades, before efficiency improves much further.

The SALFORD design is exceptional in comparison. It is over 40% more efficient than the current 2010 Regulations and 25% better than the proposed 2013 Regulations. With a few practicable improvements, to ensure compliance with the new sustainable energy sourcing requirements, dwellings designed to SALFORD house principles should be able economically to meet the proposed near-zero Carbon 2016 Regulations.

Space heating energy required for UK housing 1976-2016 relative to 2010 Regulations



The social significance of the SALFORD design

Although the SALFORD houses are demonstrably superior in comfort, energy efficiency and lifetime costs to most UK houses that is not enough for them, or for equally efficient innovative designs, to be routinely built. The bulk of new housing stock – around 80% - is built by private developers for sale on the open market. For houses to be built in the private sector they must be profitable for the builder or developer who must compete in the existing market which requires them to take a short-term view of a long-term infrastructure investment – namely a house or dwelling.

These dwellings, and how they are used by occupants, will determine levels of energy consumption which will have an impact for decades or possibly centuries. These are important considerations as domestic space heating accounts for nearly 20% of UK energy consumption. In the past the public council house sector could, and did, take a more socially considered longer-term view, although it was still constrained by stringent capital cost limits. It was only because the public sector was then active that the SALFORD houses were built in the late 1970s. Further building, and exploitation of the innovative technological advancement, ceased when councils were effectively stopped from building in the 1980s; a direct if unintended consequence of national political policy.

Due to the short-term pressures at play in a market economy, private sector developers generally cannot competitively build to much better than current Building Regulations as it usually involves an increase in costs, which it is difficult for them to recover because purchasers rarely appreciate, or are prepared to pay for, the superior long-term or energy efficient features. The prime determinants for private house purchasers have typically been: 'location, location, location', mortgage constraints, perceived property desirability and the view they take of the 'housing ladder'. The average mortgage length is historically only seven years but for younger first-time buyers it will be less as they tend to move more frequently. Older owner occupiers tend to be less active in the housing market as for them social factors tend to supplant financial and career move considerations.

Estate agent marketing tends to reflect potential buyers' interest priorities and, at the same time, serve as a means of maintaining social norms for purchasers and vendors as to what is deemed 'important' or 'desirable' features in a new home. Although the issues of sustainability and energy-efficiency are achieving greater prominence in our economy the references to energy use in the advertisements of estate agents are minimal. Virtually the only references to energy use or comfort are comments such as "the property benefits from having gas central heating and double glazing". In general terms there is little or no interest in energy efficiency from house buyers. At least one of the SALFORD houses was placed on the housing market at the time of the study and no mention was made of the unique characteristics of the property by either the vendor or the estate agent.

Efforts have recently been made by government and most properties, when being built, sold or let, are required to have an Energy Performance Certificate (EPC) or, in the case of new build housing, be rated against the Code for Sustainable Homes. Regardless there remains generally little or no interest in energy efficiency from house buyers and, as yet, there is no evidence that EPCs or the energy rating of a house is having a major impact on how homes are marketed or bought.

It is, however, a positive step and is likely that they will start to have some impact, as has gradually happened for similarly energy-rated consumer durables and cars. Only when the cost of fuel is prohibitively expensive will consumer demand lead to any increase in the attention placed on initiatives like the EPC. Until then it appears that only by legislation to enforce minimum standards will the private sector be able to meet the sustainable and social need. Developers and providers of social housing however tend to driven by different objectives – such as tenant and community welfare – with more attention placed on the long-term investment in their stock. As this study, and other findings, show social housing providers tend to be inclined to invest in improving housing standards as well as being keen to explore new ways to tackle issues such as energy-efficiency and fuel poverty.

UK governments have historically not legislated to any real extent to decrease the use of fuel and power in dwellings until the last few years, and the building industry has not sought to push them in this regard. We are now in the midst of a decade of rapid change driven by the concerns over the consequences of climate change and the requirements placed upon the UK by EU legislation. In the 1970s Salford City Council responded locally in a socially just and innovative manner to the urgent needs of their tenants. This led to the development of housing which was decades ahead of its time. Thirty years on it is, once again, urgent necessity that is the driver for EU, national and local action.

Conclusions

This survey has shown that dwellings built to the SALFORD design over 30 years ago continue to perform to specification, using about 75% less energy than the UK average for space heating and over 40% less than for houses built to the latest 2010 Building Regulations. Houses built to the SALFORD design principles, of a high thermal capacity internal structure protected by a highly insulated, well-sealed envelope, should be able to meet the near-zero Carbon Regulations to be introduced in 2016.

— In the main the occupants are well satisfied with their properties and enjoy a high standard of thermal comfort at much reduced cost.

— There are a few instances of mould growth but they could be eliminated by using an extract fan.

— The properties are inherently resistant to rot, fire, vandalism and noise transmission and maintenance costs are relatively low.

— There has been some refurbishment in response to occupant demand. The original dual-glazed windows, and room heaters, both adopted by the Council on the grounds of their satisfactory thermal performance at minimal cost have been replaced respectively by uPVC double-glazed units and conventional central heating. The original decision was cost optimal but clearly the users prefer the more expensive but more convenient alternatives for these items.

— A marked feature of the results is the variation in energy consumption by different households. This can be explained by householders operating their homes at different temperatures. A SALFORD house could be habitable throughout the year without any space heating at all, comfortable at 10%, and very comfortable at 25% of normal consumption.

Although good thermal design is necessary to enable substantial energy savings it is not sufficient to ensure it. Individual resident behaviour and a lack of understanding about how to use dwellings can make an enormous difference to how efficient a low-energy home is. In order to obtain optimal benefits the design must also be intuitive for occupants to use and match their habitual behaviours.

— Strategically the much shortened heating season required by houses built to the SALFORD design could, in the long-term, if they are built in large numbers, affect the seasonal demand patterns for fuel and power. In the short-term their tolerance to zero heating provides security for occupants in case of extended power, or fuel delivery, failure.

— There is little difference in capital cost between traditional thermally inefficient build and the relatively simple SALFORD low-energy design. They employ traditional building methods and materials, and maintenance costs are correspondingly low.

— Legislation, or renewed public sector involvement, is necessary to further energy-saving improvements in the housebuilding sector.

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