3 Opportunities for Energy Efficiency

Improvements to the Building Regulations have led to current standards relating to energy consumption and CO_2 emissions being significantly higher than for older buildings. In addition to this, despite growth levels proposed in Hertfordshire, the majority of buildings in the County by 2050 will still be buildings constructed prior to this study. Therefore, to make significant reductions in energy use and CO_2 emissions, it is vital that local authorities address the existing stock efficiency levels alongside promoting high standards in new development. For this reason, this study also considers related opportunities to improve energy efficiency in existing buildings.

3.1 Energy Efficiency

The energy performance of buildings depends on a number of factors including:

- **Building types:** In general, dense development is more energy efficient. Buildings which are less spaced out and share walls (for example terraced houses and flats) have a lower heat loss area and lower heat demand than for more separated building types such as detached homes. It is also often the case that on dense developments, dwelling sizes are lower which again result in lower energy demand. It is important to note that the energy demand intensity on dense developments is usually higher than for less dense developments – this is due to there being a greater floor area / number of dwellings in the same spatial area as a less dense site.

  On new developments, increasing the density on masterplans can also facilitate more options for delivering decentralised renewable and low carbon heat and power by improving the economic viability of schemes. If density is increased to create greater open space, there may also be more options for larger scale renewable generation such as site-scale wind turbines, but this needs to be balanced against potential problems with reducing the space for building mounted technologies such as photovoltaics or solar thermal systems. This latter issue is particularly relevant on high density urban developments where the building heights mean that very little roof area is available for the installation of solar technologies in relation to floor areas.
- **Age:** Thermal performance of buildings has improved with time, particularly following the introduction of Part L of the Building Regulations and progressive increases in its minimum requirements. Insulation, glazing performance and air-tightness have all improved significantly with these and so generally the opportunities or 'key wins' for improving energy efficiency are greater on the older building stock. The uptake of some energy efficiency measures is relatively independent of age (for example loft insulation is as likely to be installed into a 1900 home as a 1970 home with retrofit). However, other measures are heavily dependent on age, with particular examples being glazing (with sash windows on older properties being expensive and difficult to replace with double glazed equivalents) and solid walls (typically found on pre 1920 dwellings) requiring internal or external insulation.
- **Tenure:** Tenure and the utility billing arrangements affect the energy use of a property. The most recent English House Condition Survey revealed that social sector homes on average have been the most energy efficient and have also shown the highest rate of improvement since 1996[11]. This is due to government funded schemes such as the Decent Homes Programme, large scale retrofit opportunities, and the generally newer nature of the social housing stock.

  In some rented or leased properties, payment of a fixed service charge rather than utility bills linked to metered consumption reduces the incentive for tenants to minimise their own energy use, whereas landlords may be less inclined to make improvements to the building where tenants pay energy bills directly. Government has proposed the introduction of a "green landlord scheme" to incentivise landlords to invest in whole house energy efficiency. In the interim period, LAs could implement a similar, local scheme which will encourage landlords with poorly performing properties to invest in energy efficiency.

Under The Home Energy Conservation Act 1995 (HECA), local authorities with housing responsibilities are required to implement practical and cost-effective measures to improve the energy efficiency of all accommodation in their area and report on progress. The target is to achieve a 30% reduction in energy consumption across the entire housing stock (including private housing) from 1995 levels by 2011. Annual reports publish the progress of each authority against this target. Table 3.1 opposite illustrates the rates for each of the project group authorities in Hertfordshire (figures for Stevenage are included for comparison).

The latest HECA results from 2007 show that on average, Hertfordshire is behind the national average in terms of improvement from 1995, at 1.7% below the average 21.6% reduction and 2.1% behind the targeted 22% reduction. This does not necessarily mean that the efficiency levels in Hertfordshire are lower than the national average, because the data is based on the 1995 starting point, at which point Hertfordshire may have had more efficient stock than the national average. However, it does give some indication of the improvements during the HECA period and the uptake of measures.

Within Hertfordshire, there is a significant range in improvement between the authorities. By 2007, Watford had significantly exceeded the target at 27.1% improvement whilst Broxbourne achieved around half the target at 12.8% (although Stevenage is not included as part of this study, it has the lowest reduction in energy use at 9.8%).

This data indicates that the uptake of efficiency measures across the County and the efficiency of authority led schemes are extremely variable, with some authorities performing significantly better than others. Alongside this, the County is performing worse than average suggesting that there is potentially greater scope for making efficiency savings than in other areas of the country.

It is important to note that there is a degree of uncertainty over the accuracy of HECA data due to a lack of standardised reporting / calculation methodology, and so if different authorities monitor and report using different methods, the results may misrepresent relative performance. This should always be considered when analysing these results.

[11] English House Condition Survey 2007 (Department for Communities and Local Government, September 2009)

Authority	Progress in 2007
Broxbourne	**12.8%**
Dacorum	23.0%
East Hertfordshire	22.8%
Hertsmere	21.1%
North Hertfordshire	**19.5%**
St Albans	22.8%
Stevenage	9.8%
Three Rivers	20.7%
Watford	27.1%
Welwyn Hatfield	**19.3%**
NATIONAL AVERAGE	21.6%
NATIONAL TARGET FOR 2007	22.0%
HERTFORDSHIRE AVERAGE	19.9%
Data in bold indicates no reporting for 2007 and previous years figures used.	
Data in red indicates figures below the County average.	

Table 3.1: 2007 HECA progress for each authority (taken from the 2007 HECA Progress Report).

3.2 Improving Energy Efficiency of Homes

A range of measures which can be used in existing and new homes in order to improve energy efficiency are presented below. It should be noted that improving energy efficiency does not always result in a corresponding reduction in energy consumption. A "rebound effect"[12] has been identified where potential energy and CO_2 savings from energy efficiency improvements are counteracted by changes in occupier behaviour. For example, if a heating system is replaced with a more efficient version, or insulation levels are improved, this doesn't necessarily mean that occupants will turn down room thermostats. Indeed, there can be a tendency for occupiers to make use of these benefits by increasing heating temperatures. A similar effect can be observed when energy costs are reduced. This effect may be particularly prevalent in fuel poverty homes where current levels of heating may be below those required for comfort, and any efficiency improvements lead to adequate levels of comfort being achieved rather than efficiency savings.

[12] Zero Carbon Britain – An Alternative Energy Strategy (Centre for Alternative Technology and the University of East London, 2007)

3.2.1 Insulation

The rate of heat loss through the building fabric will depend upon the thermal properties of the building material and the area through which heat loss can take place; this is measured by a parameter known as a U-value. A lower U-value value means a lower rate of heat loss.

In existing buildings, the main method of improving the U-values of the fabric is through improved insulation in the loft and cavity walls where possible; this is straightforward to apply and relatively cheap. In general, there has nationally been a relatively good uptake of the standard insulation measures following incentive schemes, efficiency commitment schemes on utility providers and education combined with high energy costs. In general, these simple measures have a short payback, and it is expected that they will almost reach saturation in the next decade.

A sector which is difficult to improve significantly is older buildings (typically pre 1930) which consist of solid walls with no cavity to insulate, leading to very high thermal losses through the walls. Insulation can be added to these structures either internally or externally. Internal insulation requires cladding of walls with insulation and a new interior plasterboard surface. This has the effect of reducing floorspace, and can have a significant impact on internal fixtures and fittings, particularly in homes with period features. External insulation consists of a cladding and rendering process which has obvious impacts on external appearance. However, in some areas, the visual impact may be acceptable (for example, in concrete walled dwellings with existing render) but on older historic properties, the effect may not be desirable. Although the cost of installing external insulation on solid walled properties is generally more expensive than fitting internal insulation (costing many £1000s per dwelling), it is generally far less disruptive and allows the works to be undertaken with occupants in-situ. The added costs decanting and potential relocation of occupants must also be considered.

Data from the Home Energy Efficiency Database (HEED) operated by the EST provides the number of homes in Hertfordshire which may be suitable for cavity wall insulation, or which may require solid wall insulation. This data is summarised in Table 3.2 below.

In general the number of homes with the potential for cavity wall insulation is relatively low, with typically 10 – 20% of an authority's dwellings having the potential to be retrofitted. In most authorities, the majority of homes with cavity walls have had them insulated; either at the time of build, or as retrofit. However, as a cost effective measure it is important for all the Local Authorities to maximise the savings available from cavity wall insulation and target the remaining private and public sector homes with potential.

The number of homes with solid walls differs significantly between Hertfordshire's authorities, with Watford having the highest proportion at 45%, and Welwyn Hatfield the lowest at 12%. This is almost certainly due to the age of these towns with Watford having a large proportion of older dwellings built pre 1930. It is important for each LA to identify the housing stock with solid walls and assess the potential for solid wall insulation. In the early years, it is likely that the greatest potential is in the social housing sector where large scale retrofit combined with similar dwelling designs can help reduce the installation costs of solid wall insulation combined with helping to alleviate fuel poverty. It is likely that a great many homes, particularly in the private sector and in historic areas, will not be able to install solid wall insulation in the near future.

	% solid	% cavity	No. dwellings with solid walls	No. dwellings with unfilled cavity walls
Broxbourne	20%	7%	7,015	2,680
Dacorum	33%	15%	18,586	8,676
E. Herts	23%	20%	12,399	10,641
Hertsmere	31%	14%	11,865	5,581
N. Herts	36%	5%	17,813	2,672
St Albans	21%	10%	11,141	5,343
Three Rivers	43%	13%	14,580	4,546
Watford	45%	13%	15,054	4,189
Welwyn Hatfield	12%	5%	4,855	1,957

Table 3.2: Summary of the potential for cavity wall insulation and solid wall insulation in Hertfordshire (Source: Homes Energy Efficiency Database [HEED], 2010)

The discussion has so far covered existing buildings. Energy efficiency levels in the new building sector is covered in Part L of the Building Regulations and recent revision combined with the trajectories set by government mean that standards should be high. As part of the current Building Regulations consultations, a back-stops position is being developed which means that all buildings must meet strict criteria for efficiency, irrespective of other CO_2 reducing measures. It should be recognised that there are diminishing returns in installing ever greater levels of insulation and there is a point where the cost and practical benefits if increasing insulation thickness will outweigh the small energy and CO_2 benefits.

3.2.2 Air Tightness and Thermal Bridging

Alongside thermal losses through fabric (the conduction of heat), buildings lose heat through air transfer – this could be desired air transfer for ventilation or undesirable air leaks.

Existing buildings can be very leaky (a poor air tightness) due to gaps around openings and penetrations, and general leaks in the fabric and between structural elements. A common place is between floors and walls. Basic draft proofing measures can have a large effect at improving the air tightness, for example ensuring that windows and doors seal when closed, sealing openings around window and door frames, service pipes, and minimising infiltration around floor perimeters. It is unlikely that in existing dwellings, these basic measures will affect in-door air quality although suitable ventilation should be provided for wet areas such as kitchens and bathrooms.

In new construction, air tightness is covered by Part L of the Building Regulations with a minimum value of 10 m^3/m^2hr @ 50 Pa required, verified by pressure testing. These air tightness rates will improve with further revisions of the building regulations to improve standards further. With traditional masonry construction, it is important that attention is paid to construction detail to ensure that all penetrations and joints between elements are adequately sealed. Rates less than 3 m^3/m^2hr @ 50 Pa have been recorded. However, with modern methods of construction including pre-fabricated timber and steel frame structures and panelised systems, there is potential for more reliably improving air tightness making use of precision factory fabrication and reduced joints between components.

It is often recommended that homes with very low air permeability levels install mechanical ventilation in order to ensure adequate ventilation for healthy living conditions and the prevention of condensation. Heat recovery systems which extract heat from exhaust air and pre-heat incoming air can mean that overall thermal losses from ventilation are minimised. However, it is important that the systems are well specified and have high efficiency fans and heat exchangers, to prevent the increase electricity consumption outweighing the thermal savings in terms of CO_2.

Thermal bridges occur where there is a break in the insulation resulting in a route which has a good thermal conductivity. Typical areas are around openings, and joints between floors, walls, and roofs. In existing buildings, there is relatively little which can be done to reduce thermal bridging in structural elements. However simple design details in new buildings can greatly reduce the losses, and standardised Accredited and Enhanced Construction Details allow designers to reduce the losses at bridges.

3.2.3 Lighting

The penetration of natural daylight should be maximised where possible in new buildings to reduce the use of artificial lighting within buildings. This requires correct orientation of the building, optimisation of internal layout, and maximising window dimensions and heights. However it is important to also prevent overheating in summer and thermal losses in winter, and so south facing orientations should be accompanied by suitable shading mechanisms, and glazing should be high efficiency.

All buildings could make use of dedicated low energy lighting in conjunction with appropriate controls to reduce energy consumption. For example, smart controls can be specified which enable all lights to be switched off from a single switch, thus avoiding lights being left on during the night or periods of non-occupancy. External lighting can be controlled using daylight sensors or timers to avoid lights being switched on during daylight hours. Similarly, PIR sensors should be used for security lighting.

3.2.4 Heating and Hot Water

In addition to improving insulation and air-tightness, heating fuel demand can also be reduced by replacing an old boiler with a high efficiency condensing boiler. These recover heat from the flue of the boiler, which would otherwise be wasted, and can convert over 86% of the energy in the fuel into heat, compared to as low as 65% for an old, inefficient boiler.[13] Under current Building Regulations, it is now only possible to install high efficiency condensing boilers, and it is expected that over the next decade, most remaining inefficient boilers will have been replaced.

[13] Source: Energy Saving Trust (www.energysavingtrust.org.uk/Home-improvements-and-products/Heating-and-hot-water)

CO_2 emissions can also be reduced by switching heating fuel for a less carbon-intensive alternative. Where a connection to the gas grid is available, natural gas produces lower CO_2 emissions per unit of heat supplied than grid-supplied electricity, oil or coal.

In older dwellings, hot water is a relatively small component of heat demand, whereas in modern thermally efficient dwellings, the hot water fraction is significantly higher. In all cases, improving boiler efficiency will reduce energy consumption for hot water, and where a cylinder based system is present, further reductions can be made through insulating of internal pipework and by using a foam-insulated cylinder. An additional measure is to reduce the demand for hot water, and efficient fittings such as aerated taps and shower heads can make significant improvements.

3.2.5 Passive Design and Reducing Overheating

There is a real risk of overheating in many of our buildings as higher temperatures are becoming more commonplace due to the effects of climate change. Overheating is often caused by excessive solar gains, particularly during summer. Mechanical cooling is also sometimes used to help avoid overheating which can increase CO_2 emissions through electricity consumption. Passive approaches include building orientation, shading (e.g. external louvres, shutters, or overshading from balconies), natural ventilation design, and the specification of green roofs and walls. Effective design can reduce overheating and provide beneficial solar gains during the winter months.

Thermal mass can also help control temperatures by acting as a buffer to the temperature variations through the day, by absorbing heat as temperatures rise and release heat as temperatures fall. For traditional masonry or stone construction, external walls will have large areas of external thermal mass. For timber or steel construction, thermal mass can be incorporated into the floors and internal walls. The addition of phase change materials to walls and floors in both existing and new buildings can add thermal mass[14].

3.2.6 PassivHaus

PassivHaus is a German standard for ultra-energy-efficient homes where demand for space heating is dramatically reduced, often to the point where a separate heating system (such as a gas boiler) is no longer necessary. A system will still be needed to supply hot water. The standard is met by using passive design, specifying very low U-Values, air tightness, thermal bridging, and the use of mechanical ventilation with heat recovery. There is currently considerable interest in this building technique in the UK, as evidenced by its mention in the recent zero carbon consultation[8]. It remains to be seen whether it will take off as a viable option for new development.

[14] Phase change materials can increase the thermal mass of a building by storing latent heat through the phase change of a material rather than relying on large amounts of material. For example, the change of wax from a solid to a liquid stores latent heat which would require many more times the mass of an alternative material, such as concrete, with no phase change.

Figure 3.1. Example of a Passivhaus development in Austria

3.3 Energy Efficiency in Non-domestic Buildings

Many of the options for reducing CO_2 emissions from housing are also applicable to non-domestic buildings. However, non-domestic buildings tend to be more complex due to the variety of building types, the range of activities that they accommodate and the use of more sophisticated building services. Analysis of monitored data suggests that the energy performance of a non-domestic building is generally determined by its fabric, the mechanical services and the occupants. These operate as a system and each controls a range of performance. A poorly performing building may require much input from services, which if badly managed can lead to high energy consumption. The reverse may also be true. The variation in the fabric, mechanical services or occupant behaviour can result in a 20 fold variation in energy performance.

Principles that could be adopted when improving energy efficiency in non-domestic buildings are described below.

Excessive areas of glazing should be avoided.

CIBSE TM23[15] sets out best practice air permeability rates for different building types which should be adopted for all buildings.

The most appropriate and efficient form of heating for a non domestic building will vary depending on the use. For buildings which are used intermittently (such as churches) or which have large air volumes (such as industrial units) radiant heating may be an effective form of heating. For buildings which are used more regularly and those with smaller air volumes, central hot water systems will be more effective.

[15] TM23 Testing buildings for air leakage (CIBSE, 2000)

The use of air conditioning has become widespread and is likely to become more so as summertime temperatures increase due to climate change. Air conditioned offices can consume about twice as much energy as naturally ventilated buildings[16]. However, studies have shown that in spite of the extra capital and running costs, occupant satisfaction is no greater (and often lower) than in naturally ventilated buildings. There is, therefore, a case for implementing strategies in non-domestic buildings that reduce the need for air conditioning. These can include:

- Controlling solar gains through glazing - making maximum use of daylight while avoiding excessive solar gain
- Selecting equipment with reduced power requirements (e.g. flat screen monitors)
- Separating high heat demand processes (including industrial processes, mainframe computers, large photocopiers etc) from office accommodation
- Making use of thermal mass (and enhancing thermal mass with phase change materials) in combination with night ventilation to reduce peak temperatures. The building effectively acts as a heat store / buffer, preventing overheating in summer.
- Providing effective natural ventilation
- Shading devices for the windows
- Using task lighting to reduce background luminance levels
- Reducing energy demand for lighting by installing energy efficient lighting with a high light output ratio and selecting lamps with a high luminous efficacy
- The use of pale colours on walls and ceilings to reduce the need for artificial lighting
- Providing effective controls which prevent lights being left on unnecessarily.

Effective window design is essential in naturally ventilated buildings. Windows should allow ease of control by occupants regardless of desk arrangements. The benefits of daylighting and good window design are not only related to energy savings. There is growing evidence that the view from windows and the perception of the presence of daylight, even without direct views, is valued by occupants. This can lead to increased well-being and productivity, and also increased tolerance of non-neutral environmental conditions. In office environments the window design must ensure that glare is avoided to prevent blinds from being left closed minimising the benefits of effective day lighting.

[16] Energy consumption guide 19: Energy use in office (CIBSE)

Figure 3.2: Strategies to improve energy efficiency in non-domestic buildings. Shading devices fitted to Lycée Chevrollier, a high school in France (above), and solar shading and natural lighting, Jubilie Campus (below)

3.4 Key Considerations Emerging from this Chapter

This chapter has considered the opportunities for reducing CO_2 emissions through increased energy efficiency in the existing stock and in new developments. Key considerations emerging from this chapter are:

- Energy use and CO_2 emissions from the existing building sector are likely to be significantly higher than for post 2010 construction for many decades to come.
- HECA statistics suggest that Hertfordshire in general is improving the efficiency of the domestic stock at lower rates than other parts of the country.
- There may be significant potential in some authorities to reduce energy demand through solid wall insulation, and efforts should be made to identify potential dwellings and assess the viability of installing insulation.
- Improved thermal performance of homes can lead to a rebound effect, where CO_2 savings are partially offset by improvements in comfort. Assessing potential energy and CO_2 savings should take account of this effect when monitoring.
- Appropriate specification of new buildings or renovations can reduce energy demand and improve thermal comfort, including overheating.