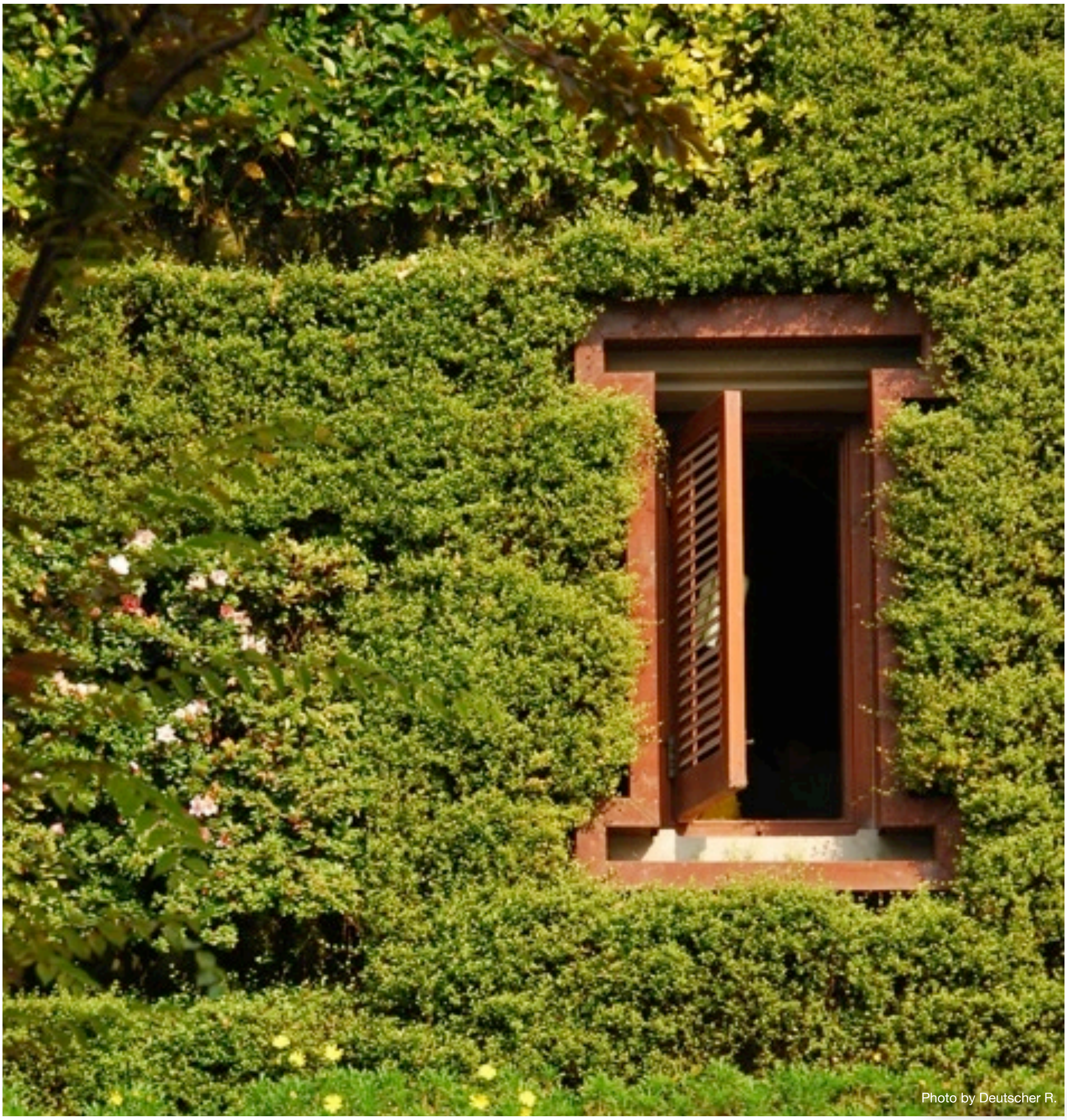

PRACTICAL GUIDE FOR GREEN DEVELOPMENT

October 2014

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Photo by Oakes, H.

Westfield's 21st Century trees

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Leicester New Walk

River Derwent, Derby

1 INTRODUCTION

Climate change is altering traditional weather patterns around the world. In the UK, these changes are resulting in hotter summers with less rainfall and warmer winters with greater rainfall. The East Midlands region for example is estimated to see an increase in daily summer high temperatures of 3.3ºC, warmer average winter temperatures of 2.2°C, a 16% decrease in summer rainfall and a 14% increase in winter rainfall by 2050. These projections raise concerns related to the changing temperatures of city regions, increased flooding, and the need for improved energy efficiency. This guide is designed to provide a series of practical design interventions that can be implemented in new developments to help address these concerns.

When undertaking new development, the guide highlights the need to pay particular attention to the orientation of buildings, the design of the surrounding landscaping, and the types of materials utilised. The guide is divided into two main sections. The first provides a brief overview of the need to consider the urban heat island, flood mitigation, and energy efficiency. This is then followed by a series of design interventions. Many of these interventions are practical, low-cost measures that can be easily incorporated into the design stages of a new development. Each intervention notes:

- Benefits and implementation: notes why a particular intervention is beneficial for a development and how it can best be implemented. This section discusses environmental, health, and economic benefits where appropriate. Further details of the benefits and implementation of measures can be found by referencing the footnotes at the end of this guide.
- Cost: highlighting the relative costs of implementing a measure. A low cost suggests that the measure, if implemented during the design stage of a development, is roughly cheaper or equal to traditional approaches to house building and that in most cases the benefits out-way the costs of implementation. Medium costs are typically slightly more expensive than traditional development approaches, however over the longer term benefits may reduce these costs. High costs are typically the most expensive interventions, however they may have additional social or economic benefits which are not noted here making them feasible and appropriate and often depend on the scale of the development being proposed.
- Category: refers to whether a design intervention benefits the urban heat island, improves flood mitigation, increases energy efficiency, or some combination of the three - as interventions often have multiple benefits.

DISCLAIMER

The information provided here is a guide only. Benefits and drawbacks of particular interventions will always depend on the exact geographic context of development and how the intervention is implemented. Careful consideration should be given to financial, construction, maintenance, and environmental aspects before proceeding with any given intervention. If in doubt, consult your local planning department.

2 CONTEXT

Reducing the Urban Heat Island

Cities and towns tend to be hotter than the surrounding countryside, impacting the climate and liveability of these places. The built form, heat producing structures, darker surfaces, and relative scarcity of tree cover and vegetation present in urban areas results in typical temperature differences of 2.5°C between urban and rural areas on a clear summer day[1]. This effect is known as the urban heat island as solar radiation is either absorbed or reflected by the surrounding environment. This effect is most present at night as absorbed solar radiation is released back into the atmosphere, reducing the typical cooling relief felt at night during extreme heat events.

Global climate change is also increasing temperatures and the cumulative impact of this with the temperature increases stemming from the urban heat island can result in health impacts for people living in urban areas[2]. Long-term exposure to high temperatures can result in heat cramps, heat exhaustion, heat fainting, and death – with those living alone and the elderly at particular risk[3]. In the UK, the urban heat island effect has largely not been a key concern given the moderate temperatures typically seen during summer. However recent research from the Met Office has highlighted rising concerns as heat waves similar to those experienced in 2003 (when temperatures rose to 38.5°C) are now projected to occur every other year by 2040[4]. Individuals living in urban areas will therefore be at particular risk given higher temperatures caused by the urban heat island effect in cities and major towns.

Measures to reduce the urban heat island are well-known. The two main approaches involve altering the urban environment by either increasing vegetation and/or changing the surface materials of cities to reflect more of the solar radiation rather than absorb it. Increasing vegetation reduces temperatures through evaporation processes that cool and humidify the air near the ground. The shading provided by trees also blocks solar radiation from being absorbed into the ground. The types of materials used in developments can also have a dramatic impact on the surface temperature of neighbourhoods. Certain materials, such as cement, reflect solar radiation more than others, such as asphalt. The more solar radiation that is reflected, the less which is absorbed into the material and later released as heat into the urban environment.

How cities are developed is therefore a key concern if the urban heat island is to be mitigated and existing buildings adapted to manage increasing heat events. The choices made during the development stage can either work to reduce or increase the heat island. Small decisions which were typically viewed as aesthetic considerations, such as the colour of roof tiles, the number of trees, or type of pavers used on a driveway, become more important as they can all impact the urban heat island. These changes, if incorporated into the design stage of a development, often add no or little additional cost to development but can help to contribute to improvements in the urban environment.

Improving the Energy Efficiency of Buildings

The Committee on Climate Change reported that, in the UK in 2012, 37% of total greenhouse gas emissions came from buildings. Breaking that figure down to its constituent components – residential, commercial and public sector buildings – reveals that residential buildings accounted for 66% of greenhouse gas emissions from buildings, commercial buildings for 26% and public sector buildings for 8%[5]. These figures represent a 10% rise in greenhouse gas emissions from buildings compared to 2011 figures and were attributed to an increase in carbon intensive power generation in the electricity grid and lower winter temperatures during 2012[6]. Prior to this, greenhouse gas emissions from buildings were reported as falling due to a mixture of improved energy efficiency, fluctuations in seasonal temperatures and economic recession[7]. Crucially, the Committee on Climate Change concluded that emissions from buildings in 2012 were 2% above the progress indicators set in 2009[8]. Clearly, therefore, attention needs to be paid to greenhouse gas emissions arising from buildings and also to the potential mechanisms for implementing the necessary reduction.

There are several legislative and regulatory instruments driving the need for buildings to become more energy efficient, notably in the EU, Council Directive 2010/31/EU of the European Parliament and of the Council on the energy performance of buildings (recast) (Energy Performance of Buildings Directive). The Energy Performance of Buildings Directive includes basic requirements for calculating the energy performance of buildings, minimum requirements for the energy performance of new and existing buildings, national plans for 'nearly zero carbon buildings', and procedures for energy certification for buildings, inspection of heating and cooling systems, as well as inspection reporting requirements[9].

Various UK government policies also promote the consideration of improved energy efficiency of buildings and set requirements for low carbon and zero carbon buildings.

In England the National Planning Policy Framework (NPPF) includes policies on planning development to reduce carbon emissions, improving the energy efficiency of buildings, and taking into account the Government's policies and standards on zero

Wall insulation improves energy efficiency carbon buildings[10]. The current UK Government have maintained a commitment to the target that all new homes should conform to their definition of zero carbon by 2016[11].

The drive to improve the energy efficiency of buildings requires that attention is paid to both passive and active design strategies in order to reduce heating and cooling loads, raising equipment efficiency and increasing the use of renewable energy[12]. A large portion of greenhouse gas emissions from buildings are from heating demands and, as such, can fluctuate considerably depending on seasonal and yearly temperature variation[13].

The energy hierarchy emphasises the order in which interventions should be considered and consists of:

- reducing the need for energy;
- using energy more efficiently;
- using renewable energy sources; and
- using fossil fuels cleanly and efficiently[14].

The first measures when considering the contribution of design to the energy efficiency of a building are those which seek to reduce the demand for energy. Measures to reduce energy demand include:

- passive solar design, insulation and utilising building or structural mass to reduce the need for heating and cooling;
- ventilation and building sealing;
- measures to reduce water demand;
- reducing electricity demand from plant, primarily reducing heating and cooling requirements but also equipment such as computers and refrigerators;
- choosing materials with low embodied energy and minimising waste during construction;
- intelligent, useable and adjustable control systems for building services;
- plant which does not contribute to indoor air pollution; and
- maximising natural daylighting, through glazing and sun tubes for example, reduces the need for lights to be on, and therefore reduces electricity consumption, it also makes the building more pleasant for the occupants[15].

Passive energy efficiency solutions are generally less expensive to implement and include those which can be designed into, or utilised in the fabric of the building, which reduce the energy demand required (primarily related to heating and cooling, ventilation, and lighting of a building) or which use renewable energy sources[16].

When considering energy efficiency performance of the building fabric (including walls, roofs, floors and glazing) its ability to retain heat is an important component and measurement of the thermal performance of materials is expressed as the U-value. The U-value is the amount of energy which is transferred through 1 square metre of the material. The lower the U-value the better the insulating performance of the material[17].

The Importance of Flood Mitigation

Swales in Manor Kingsway Phase 1, Derby work to reduce flood risk

The UK has experienced several severe flood events in recent years, notably the flooding in Yorkshire and Humberside, and Gloucestershire in 2007[18] and in Somerset,

Source	Description
River (fluvial)	Flooding caused by water overflowing from river channels.
Surface water (pluvial)	Flooding caused when engineered drainage systems are overwhelmed by the volume of water.
Groundwater	Flooding caused if water levels underground rise above their natural surface.
Coastal	Flooding cause when sea level rises above the level of coastal land.
Source: [22]	

the Thames Valley and elsewhere in December 2013 and January 2014[19]. These, and other severe flood events, have highlighted and raised awareness of our need to manage flood risk.

Recent experiences with surface water flooding have also emphasised the need to consider multiple forms of flood risk, particularly widening consideration beyond traditional coastal and river flooding[20]. It is therefore necessary to consider flood risk from multiple sources including; river (fluvial) flooding, surface water (pluvial) flooding, groundwater flooding and coastal flooding[21]. The built form, heat producing structures, darker surfaces, and relative scarcity of tree cover and vegetation present in urban areas results in typical temperature differences of 2.5°C between urban and rural areas on a clear summer day

Many design interventions can be used to combat and manage flood risk whilst also providing additional benefits, such as contributing to the management of the urban climate and the urban heat island. This guide introduces some possible interventions which could be employed and which will contribute to reducing flooding risk for various sources, although the focus is on the management of surface water arising from development sites through sustainable drainage systems.

Sustainable Drainage Systems (SuDS) aim to control and manage drainage primarily stemming from surface water, typically through multiple small scale interventions and co-ordinated actions[23]. Major benefits of SUDS are:

- quantity: This relates to reducing flood risk by attenuation and slowing down runoff
- quality: This relates to improved water quality by removal of pollutants
- amenity (/biodiversity): This relates to the increased levels of biodiversity, green infrastructure, better places to live, and adaption to climate change

Surface water run-off in particular can present several problems in terms of water management because its pollutant load can be difficult to model and predict and exact sources are hard to trace[24]. SuDS can enable effective treatment of surface water by moving away from traditional drainage systems to incorporate interventions which mimic natural drainage systems. The key principles of SuDS are:

- storing and slowing the flow of water (attenuation);
- allowing water to soak into the ground (infiltration);
- slowly transporting water (conveying);
- filtering out pollutants; and
- allowing sediments to settle naturally[25].

Many of these components can be brought together on site to form a SuDS and can contribute to the management of different sources of flood risk – the contribution of various SuDS components to different flood sources is dependent on site context,

3 DESIGN INTERVENTIONS

Photo by Darkroom Daze

This section highlights the range of design interventions that can be implemented into developments in order to improve the environmental quality and liveability of urban areas. The benefits of the interventions are noted as well as how they might best be implemented.

DESIGN INTERVENTIONS SUMMARY

The diagram below highlights just some of the practical green design interventions that can be incorporated into a development.

Orientating houses so that the longest facade faces south helps to maximise solar gain

Coniferous trees placed in the south west of a property can help to block winter winds reducing heating costs

Appropriately sited deciduous trees can provide shade in the summer and allow sun through to heat the home in the winter, while also providing flood mitigation and reducing the urban heat island

Solar panels and wind turbines can help to reduce energy costs in the long term

Inexpensive water butts can help to manage stormwater

Depressions in the ground called 'swales' can be built to help collect stormwater and reduce the chance of flooding

Maximising the amount of natural grassed surfaces within a development helps to mitigate flooding and reduce the urban heat island

Retractable awnings can help to manage the amount of heat entering a property at different times of the day and year

Louvers are a cost effective way to manage heat and air flow in a home

Vines are a fast growing and effective means to cool a property, reduce the urban heat island, and mitigate flooding

Townhouse developments help to save energy by limiting the number of exterior walls

Design Interventions Summary

Design interventions noted throughout this section provide a range of benefits. Individual interventions include a table noting which benefit chiefly applies in each case. A summary table of all the interventions and the benefits is provided on the next two pages for reference.

Increases selling price of property: Increases in the value of a property can result from a green development design intervention for a variety of reasons, such as improved energy efficiency, reduction in flood risk, or improved aesthetics. While studies suggest certain interventions can increase the selling price of a property this will be variable and depend on local characteristics, such as the real estate market, the manner in which the intervention is implemented, and buyer preferences.

Reduces future maintenance costs: Many of the interventions noted in this guide do not require considerable up-keep, such as light coloured roof tiles which do not degrade as rapidly as darker tiles as they do not absorb as much heat, reducing longer term maintenance costs.

Reduces chance of flooding: Interventions such as trees, maximising natural surfaces, and swales naturally absorb water, compared to impermeable surfaces such as pavements and asphalt, reducing the chance of flooding.

Reduces air pollution: A range of interventions noted throughout this guide suggest the use of plants and trees that naturally work to filter the surrounding air.

Improves biodiversity: In addition to reducing the chance of flooding and improving air quality, natural interventions can improve biodiversity by providing landscapes for a wide range of living creatures to live and feed on.

Reduces property operating costs: Green design interventions often provide long-term energy savings which can reduce the cost of owning a home through lower heating and cooling bills.

Decreases cost of construction: By using more natural materials and landscaping the costs of construction can be reduced, such as by replacing paving stones or asphalt with grass or through thoughtful building siting to maximise the use of land on a piece of property.

Improves well-being: A range of green interventions, such as trees, have been shown to increase individual sense of well-being, including improved happiness, health, and greater sense of community and place.

Reduces noise pollution: Both natural and manufactured interventions can be used to improve the insulation within a home while also having a strong impact on noise reduction, such as by sealing gaps and providing additional barriers to sound.

Eligible for Government rebates: In order to encourage improved housing sustainability, both local and national governments occasionally offer rebates for the inclusion of more green products in house building and renovations, be sure to consult with your local council to determine which rebates are currently available.

DESIGN INTERVENTION SUMMARY TABLE

Intervention	Increases selling price of property	Reduces future maintenance costs	Reduces chance of flooding	Reduces air pollution	Improves biodiversity	Reduces property operating costs	Decreases cost of construction	Improves well-being	Reduces noise pollution	Eligible for Government rebates	Cost	Category	Impact
Tree Planting	✓		✓	✓	✓	✓		✓	✓		Low	Urban heat island, Flood mitigation, Energy efficiency	Low cost with a range of benefits for both the built and natural environment
Wall Planting			✓	✓	✓	✓		✓			Low	Urban heat island, Flood mitigation, Energy efficiency	Inexpensive and fast growing to provide quick and easy results
Parks	✓		✓	✓	✓			✓	✓		Medium to High	Urban heat island, Flood mitigation, Energy efficiency	Local amenity that can also offer green benefits
Grassed and Other Natural Spaces	✓	✓	✓	✓	✓	✓	✓				Low to Medium	Urban heat island, Flood mitigation	Thoughtful landscaping offers green alternative to impermeable surfaces
Light Coloured Building Materials		✓				✓		✓			Low to Medium	Urban heat island, Energy efficiency	Simply changing colour palettes can offer major benefits
Green Roofs	✓	✓	✓	✓	✓	✓		✓	✓		Medium to High	Urban heat island, Flood mitigation, Energy efficiency	Long-term investment with big range of benefits
Sustainable Drainage Systems		✓	✓	✓	✓	✓	✓	✓			Low to High	Flood mitigation	Provides home and community flood mitigation
Rainwater Harvesting			✓			✓					Low to High	Flood mitigation, Energy efficiency	Simple solution to manage rain water

DESIGN INTERVENTION SUMMARY TABLE

Intervention	Increases selling price of property	Reduces future maintenance costs	Reduces chance of flooding	Reduces air pollution	Improves biodiversity	Reduces property operating costs	Decreases cost of construction	Improves well-being	Reduces noise pollution	Eligible for Government rebates	Cost	Category	Impact
Building Orientation and Natural Daylighting						✓		✓			Low	Energy efficiency	Design stage intervention for energy efficiency
Building Form						✓	✓				Low	Energy efficiency	Design stage intervention for energy efficiency
Building Walls	✓					✓			✓		Low to Medium	Energy efficiency	Range of energy efficiency options for all budgets
Mechanical Ventilation With Heat Recovery						✓					Medium to High	Energy efficiency	Effective but specific energy efficiency option
Louvers, Extended Eves, or Awnings						✓					Low to Medium	Energy efficiency	Very low cost and effective option to improve energy efficiency
Glazing						✓			✓		Low to Medium	Energy efficiency	Range of glazing options for energy efficiency available depending on budget
Draught Proofing						✓			✓		Low	Energy efficiency	Effective and low cost solution to low energy costs
Heating Systems	✓			✓		✓				✓	Low to High	Energy efficiency	Efficient energy solutions for a range of budgets
On-site Renewable Energy Generation	✓	✓				✓				✓	High	Energy efficiency	Range of options available for energy generation and long-term savings

DESIGN INTERVENTIONS

Tree Planting

Benefits and Implementation: When appropriately sited, trees are one of the most effective ways to reduce the urban heat island, improve the energy efficiency of buildings, and increase house prices. The absorption of water through tree roots and out through leaves as well as the evaporation of water from the soil surrounding trees and other vegetation works to reduce peak summer temperatures in surrounding areas. Trees also block sunlight decreasing the temperature on the ground. This reduces the amount of heat transmitted back into the atmosphere and to surrounding buildings resulting in a range of benefits. All greenspace offers restorative experiences that can reduce stress; it can also stimulate both physical activity and social contact. However the quality of the greenspace matters - it should be attractive, feel safe, and be suitable for recreational use.

- Housing developments with mature trees are typically 2 to 3°C cooler than areas without mature trees[26];
- The cooling energy savings of trees for houses can range from 7 to 47% depending on location of planted trees and the geographic context;
- The existence of trees and other vegetation in residential developments has been shown to increase house prices from 3 to 10%[27] depending on a range of factors[28];
- The shading trees provide can reduce maintenance resurfacing costs for driveways and pavements from 15 to 60% depending on the amount of shading, type of trees used and specific location of the housing development[29];
- Larger housing developments should consider the planting of trees along sides of streets at regular intervals of 6 to 12 metres in order to increase the shading benefits for adjacent houses and parked cars[30];

Trees along Strawberry Hill in London provide a range of benefits for residents and the surrounding environment

- Trees have also been shown to provide a range of quality of life benefits, including reduced crime[31], increased habitat for wildlife, reduction of 3 to 5 decibels in noise in urban areas if clustered together[32], lower ultraviolet exposure[33], and a reduction in stress[34];
- Trees can also be sited to improve privacy; and
- Trees increase infiltration of surface water run-off and therefore can reduce flood risk[35].

Trees should be planted at least 1.5 to 3 metres away from a house however not further than 9 to 15 metres. Be sure to review soil surveys of the area to ensure the tree you plant is compatible with the surrounding soil. Trees should be located on the east and west sides of houses. Careful thought should be given to trees planted to the south of houses as these provide benefits in the summer due to shading but can have negative impacts in the winter if they block sunlight into the house. If located to the south, it is best to locate them to the southwest where they can also provide wind protection in the winter. Coniferous trees, that keep their leaves in the winter, should be placed to the west of houses in England to help block cold western winds in the winter months. Consideration should always be given to maintaining existing trees when developing a property and siting a building. Where possible design around existing trees.

Cost: Low

Category: Urban heat island, Flood mitigation, Energy efficiency


Photo by Anguskirk

Care must be taken when planting trees in order to maximise benefits

Next Steps: When planting new trees, it is important to consider the type of tree. The most appropriate type of tree will vary depending on the location of the tree (near a pavement, in a back yard, etc.) and the climate. Consult your local council for recommendations on the best type of tree to be planted or find a registered Arboricultural Association tree consultant at http://www.trees.org.uk/

INCORPORATION OF DESIGN INTERVENTION POTENTIALLY:			
✓	Increases selling price of property	✓	Reduces property operating costs
	Reduces future maintenance costs		Decreases cost of construction
✓	Reduces chance of flooding	✓	Improves well-being
✓	Reduces air pollution	✓	Reduces noise pollution
✓	Improves biodiversity		Eligible for Government rebates

DESIGN INTERVENTIONS

Wall Planting

Benefits and Implementation: Vine plants grown directly onto the sides of buildings or grown on trellises can greatly improve the energy efficiency of homes and reduce the amount of heat absorbed by the house. Vine plants also cool the surrounding air through evapotranspiration[36].

- Vines can decrease wall temperatures on houses by up to 20°C[37];
- Vines grow rapidly, ensuring short-term gains are achieved quickly;
- Vines do not need a large amount of space to grow or significant amounts of soil like trees do; and
- Covered trellises with vines constructed over driveway spaces can help to reduce the heat emitted from parked cars and the pavement underneath.

Cost: Low

Category: Urban heat island, Flood mitigation, Energy efficiency

Vines on trellises provide a quick and easy way to reduce wall temperature

INCORPORATION OF DESIGN INTERVENTION POTENTIALLY:			
	Increases selling price of property	✓	Reduces property operating costs
	Reduces future maintenance costs		Decreases cost of construction
✓	Reduces chance of flooding	✓	Improves well-being
✓	Reduces air pollution		Reduces noise pollution
✓	Improves biodiversity		Eligible for Government rebates

Next Steps: When planting vines it is important to use the correct type of vine to ensure it does not damage aspects of the building in the long-term. Consult the Lanscape Institute for more information - http://www.landscapeinstitute.co.uk/

DESIGN INTERVENTIONS

Parks

Benefits and Implementation: In contrast to the urban heat island, parks can have a 'park cool island' effect on cities whereby - depending on the design of the park - moderate to large sized parks lower temperatures both within and around the park compared to the surrounding urban area[38]. Parks therefore provide an oasis from the built up urban area and provide a range of benefits.

- Parks can have a dramatic impact on the surrounding temperature depending on wind direction and speed, with some studies showing small parks of only tens of metres across can create lower temperature differentials of 2°C or more[39];
- The greatest difference in temperature between parks and surrounding built up areas is around the edges of parks[40];
- Parks enhance local wind patterns in cities through the park breeze (cooler air over parks replaces warmer air in adjacent city neighbourhoods). The cooler air which sits over parks enhances wind patterns in the city as it replaces warmer air in nearby areas;
- Parks can be built to incorporate extended infiltration basins. These basins are large depressions in the ground which provide storage for surface water and allow gradual infiltration; and
- Parks offer opportunities for physical activity which helps reduce obesity, and improves cardiovascular and mental health.

In order to reduce day-time temperatures parks should have a range of vegetation, such as bushes and trees in order to increase evaporation processes, rather than just grass[41]. To maximise day-time and night-time cooling parks are best designed with vegetation and tress around the borders of the park with wider open spaces in the middle. Paved areas in the park should be kept to a minimum in order to maximise flood mitigation.

Cost: Low to High

Category: Urban heat island, Flood mitigation, Energy efficiency

INCORPORATION OF DESIGN INTERVENTION POTENTIALLY:			
✓	Increases selling price of property		Reduces property operating costs
	Reduces future maintenance costs		Decreases cost of construction
✓	Reduces chance of flooding	✓	Improves well-being
✓	Reduces air pollution	✓	Reduces noise pollution
✓	Improves biodiversity		Eligible for Government rebates

Next Steps: The siting of parks should be undertaken in consultation with the local planning department to ensure the design meets wider community development goals.

DESIGN INTERVENTIONS

Grassed and Other Natural Spaces

Benefits and Implementation: Grassed and other natural spaces provide a useful means for reducing the urban heat island and providing flood mitigation as part of a SuDS as they allow water to be absorbed into the ground as well as easily evaporated which allows natural cooling of the surrounding area. If surfaces are paved over or built-up through development these processes become less effective.

- Approximately 90% of rain water flows off built-up surfaces which can lead to flooding or other sewage problems[42];
- For every 10% increase in the amount of built-up area, the long-term average level of the air temperature in the built area rises approximately 0.2°C above the temperature of the non-built surroundings[43];
- A general rule of thumb is to maximise the amount of natural, non-built up area in a development wherever possible; and
- There are potential cost savings as a result, with less money spent on paving stones or asphalt as well as labour costs for installation in a development.

Grassed or other natural surfaces reduce the risk of flooding compared to pavers or asphalt

Increases in the amount of grassed and other natural spaces in a development can be achieved by reducing the size of pavement areas, driveways, and patios as well as including front and/or back gardens in developments. Including grassed and treed boulevards between the pavement and the street rather than paving all the way up to the street line should also be considered.

Cost: Low to Medium

Category: Urban heat island, Flood mitigation

Photo by Romans, P.

Backyards that maximise natural surfaces provide a range of environmental benefits

INCORPORATION OF DESIGN INTERVENTION POTENTIALLY:			
✓	Increases selling price of property	✓	Reduces property operating costs
✓	Reduces future maintenance costs	✓	Decreases cost of construction
✓	Reduces chance of flooding	✓	Improves well-being
✓	Reduces air pollution		Reduces noise pollution
✓	Improves biodiversity		Eligible for Government rebates

Light Coloured Building Materials

Benefits and Implementation: The colour and type of material used in a development influences the amount of heat absorbed and reflected from its surface. Generally, lighter coloured materials reflect more solar radiation than darker coloured materials which absorb the radiation and release it back into the surrounding environment as heat. Black asphalt for example absorbs 80 to 90% of incoming radiation compared to only 20 to 35% for white walls[44]. The difference in the temperatures of materials can vary from as much as 50°C for black painted surfaces to 10°C for white painted surfaces[45].

- Lighter coloured building materials should be used when possible, such as for roof shingles, house siding, or pavements[46];
- A 'Relative Cooling Index' (see page 19) has been developed and provides a useful guide on the types of colour and materials that should be used (100%=best performing colour/material)[47];
- White Paint (titanium oxide pigment) = 100%; Red Paint (hematite pigment) = 53%; Aluminum Roof Coating = 44%; 'White' Asphalt Shingle = 35%; Green Asphalt Shingle = 18%; Black Paint = 0%;
- Lighter coloured materials typically have longer life spans as the amount of contraction and expansion due to heat is lower than for darker coloured materials[48]; and
- While traditional black asphalt absorbs more solar radiation it tends to lighten over time which improves its solar reflectance while light coloured concrete pavers tend to darken over time, despite this concrete pavers continue to perform better than asphalt even after this process[49].

Cost: Low to Medium

Category: Urban heat island, Energy efficiency

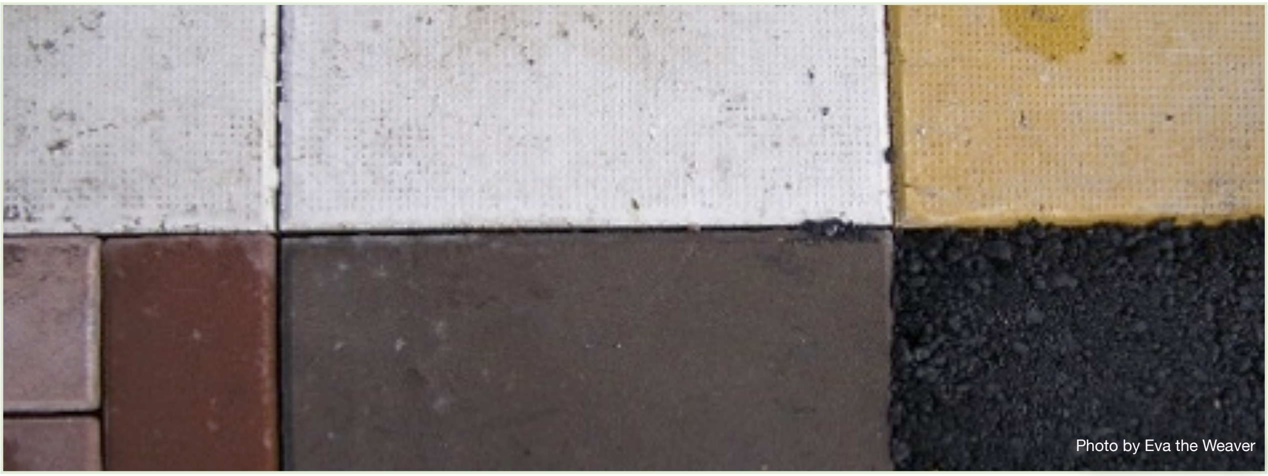


Photo by Eva the Weaver

Lighter coloured materials reduce the urban heat island effect

Solar reflectance values for commonly used and cool paving materials.

Material	Solar Reflectance	
Black conventional asphalt	0.04-0.06	WORST
Red rubber tile	0.07-0.10	
Dark coloured granite	0.08-0.12	
Aged conventional asphalt	0.09-0.18	
Grey concrete slab	0.12-0.20	
Dark coloured marble	0.20-0.40	
Cool coloured thin layer asphalt	0.27-0.55	
White topping on asphalt	0.30-0.45	
Cool coloured pigmented concrete block (red, yellow, grey)	0.45-0.49	
White concrete slab	0.60-0.77	
Cool coloured pigmented concrete tile (grey, green, beige)	0.61-0.68	
White marble	0.65-0.75	
Photocatalytic white concrete tile	0.77	BEST

Homes built using lighter coloured materials can reduce future maintenance and operating costs

INCORPORATION OF DESIGN INTERVENTION POTENTIALLY:			
	Increases selling price of property	✓	Reduces property operating costs
✓	Reduces future maintenance costs		Decreases cost of construction
	Reduces chance of flooding	✓	Improves well-being
	Reduces air pollution		Reduces noise pollution
	Improves biodiversity		Eligible for Government rebates

Green Roofs

Benefits and Implementation: Through shadowing and evapotranspiration, the incorporation of vegetation onto the roofs of new developments (ie. green roofs) can reduce the urban heat island, improve energy efficiency and contribute to flood mitigation.

- During summer the surface of a green roof can be up to 50°C cooler than the surface of a traditional rooftop depending on the climate[50];
- During winter green roofs can reduce heat loss from within a house by approximately 25%[51];
- Green roofing can increase the lifespan of a roof by over 200% due to the waterproof membrane used which protects against roof damage caused by ultra-violent radiation[52];
- Green roofs can improve flood mitigation by absorbing up to 70% of rain water and by reducing peak run-off rates during a storm by 95%[53];
- Storm water runoff is also filtered by green roofs, removing up to 95% of the cadmium, copper, and lead found in water run off[54].
- Green roofs have been shown to improve air quality by reducing particulate matter, carbon dioxide, and other pollutants while also producing oxygen[55];
- External noise reduction can be reduced by 40-50 decibels depending on the type of green roof[56];
- The inclusion of a green roof in a development has been shown to increase sales, leasing, and property values[57].

Care needs to be taken when installing green roofs and should only be done by professional installers. The types of plants utilised must also be carefully considered and will depend on type of roof (slanted versus flat), the climate, sunlight, and amount of irrigation available. Hardy perennials, such as sedums, that are shallow rooting, fire resistant, do not require a wide range of nutrients, spread rapidly and can handle extreme temperature changes are typically utilised. When considering a green roof individuals need to be sure that the structure can support the weight of the green roof.

Cost: Medium to High

Category: Urban heat island, Flood mitigation, Energy efficiency

Green roofs can be built on a range of buildings, such as Village School in Derby

Green roofs provide a wide range of benefits but should be installed by qualified professionals

INCORPORATION OF DESIGN INTERVENTION POTENTIALLY:			
✓	Increases selling price of property	✓	Reduces property operating costs
✓	Reduces future maintenance costs		Decreases cost of construction
✓	Reduces chance of flooding	✓	Improves well-being
✓	Reduces air pollution	✓	Reduces noise pollution
✓	Improves biodiversity		Eligible for Government rebates

Next Steps: For further information on green roofs consult Livingroofs.org - an independent organization that promotes green roofs and living roofs in the UK at http://www.livingroofs.org

DESIGN INTERVENTIONS

Sustainable Drainage Systems (SuDS)

As highlighted throughout this guide, several of the design interventions which can provide flood mitigation can be brought together on a site to form a Sustainable Drainage System (sometimes also referred to as Sustainable Urban Drainage Systems). SuDS seeks to achieve three broad interconnected benefits:

1. Quantity – Relating to a reduction in flood risk by attenuation and slowing down runoff;

2. Quality – Relating to improved water quality by removal of pollutants;

3. Amenity(/biodiversity) – Relating to increased levels of biodiversity, green infrastructure, better places to live and adaption to climate change.

Several of the primary measures used as part of SuDS are described in greater detail in this section of the guide, however, here an extended list is provided of various interventions which might also be considered together with a brief description.

Designing infiltration basins into developments can greatly reduce property damage during flood events

SuDS quick reference table	
SuDS component	**Description**
Swales	Broad, shallow, vegetated channels which convey water slowly allowing water storage, infiltration and filtration.
Filter strips	Wide, sloping stripes of vegetated ground which convey surface water run-off away from impermeable surfaces allowing infiltration and filtration.
Bio-retention areas	Shallow, depressed areas which are heavily vegetated to encourage infiltration and filtration of surface water run-off.
Filter drains and perforated pipes	Trenches filled with permeable material surrounding paved or impermeable areas which provide filtration of surface water run-off and conveyed elsewhere on site. Perforated pipes may be built into the base of the trench to collect and convey water.
Infiltration devices	Provide temporary water storage and allow for slow percolation into the ground.
Pervious surfaces/ permeable pavements	Where hand-standing is required pervious surfaces or permeable pavements allow some surface water to infiltrate into storage layer before slowly percolating into the ground.
Green roofs	Vegetation used as roof covering which reduces surface water run-off through infiltration, provides some water storage and slows down the conveyance of surface water run-off. Green roofs may also provide additional insulation to the building.
Infiltration basins	Depressions in the ground which provide storage for surface water and allow infiltration.
Extended detention basins	Similar to infiltration basins but on a larger scale and may have some permanent pools of water. Extended detention basins provide additional water storage capacity.
Ponds	Permanent areas of open water which have capacity to provide additional water storage for surface water run-off.
Constructed wetlands	Areas of wetland which provide the natural services of natural wetlands, including water storage, filtration and additional wildlife and biodiversity benefits.
Sources: [58, 59]	

Cost: Low to High

Category: Flood mitigation

INCORPORATION OF DESIGN INTERVENTION POTENTIALLY:			
	Increases selling price of property		Reduces property operating costs
✓	Reduces future maintenance costs	✓	Decreases cost of construction
✓	Reduces chance of flooding	✓	Improves well-being
✓	Reduces air pollution		Reduces noise pollution
✓	Improves biodiversity		Eligible for Government rebates

Next Steps: For further information consult SusDrain on the implementation and construction of SuDS at http://www.susdrain.org/

DESIGN INTERVENTIONS

Rainwater Harvesting

Rainwater harvesting is the storage and use of rainwater from roofs and hard surfaces. The simplest installation is the water butt, but more sophisticated applications also exist.

Benefits and Implementation: Rainwater harvesting can provide non-potable water for irrigation and certain other uses and can also contribute to mitigating surface water flood risk. Applications include simple water butts (or rain barrels) and rainwater harvesting systems (direct systems, gravity systems and centralised systems). Rainwater harvesting systems involve a minimal level of filtration though coarse filters before a quantity of rainwater is stored for permanent use, additional storage space can also be provided for surface water run-off.

- Water butts can reduce water demand and provide water for irrigation of gardens.
- Rainwater harvesting systems can reduce water demand by providing water for non-potable uses (e.g. washing machines and flushing toilets).
- Rainwater harvesting systems can provide water storage to mitigate surface water flooding and can be integrated with other interventions as part of a SuDS, e.g. infiltration basins.

Cost: Standard water butt – Low / Rainwater harvesting system – installation can be High

Category: Energy efficiency (reducing water demand), Flood mitigation

Water butts are a cheap and easy way to reduce the risk of flooding and decrease water costs

INCORPORATION OF DESIGN INTERVENTION POTENTIALLY:			
	Increases selling price of property	✓	Reduces property operating costs
	Reduces future maintenance costs		Decreases cost of construction
✓	Reduces chance of flooding		Improves well-being
	Reduces air pollution		Reduces noise pollution
	Improves biodiversity		Eligible for Government rebates

Next Steps: Standard water butts can be purchased at major home hardware stores across the UK

DESIGN INTERVENTIONS

Building Orientation and Natural Daylighting

Benefits and Implementation: Building orientation is one of the most important aspects of passive solar design for buildings and optimising the orientation to capture natural daylight in a building can achieve many benefits. Through careful consideration of building orientation, passive solar design or passive solar gain can be utilised to improve energy efficiency and can contribute to the thermal comfort within a building without the use of powered heating and cooling equipment.

Potential benefits include:

- Low-cost as orientation can be considered early in design processes;
- Reduced energy demand for lighting and heating and reduced need for more sophisticated solutions to improve energy efficiency;
- Increased quantity of daylight, further reducing energy demand for lighting and making the interior of the house more pleasant for occupants; and
- Improved performance of solar collectors[60].

A southern orientation is considered to be generally optimal as it enables the greatest solar gain during winter/heating months and also enables optimal control of solar gain during summer months. The longest façade of the house should be orientated to the south[61] in order to maximise the amount of sun entering the home. Orientating buildings to the South and considering the sun's path should be balanced with other factors, such as existing street patterns, and flexibility employed – orientations from due south to 30° or 40° South can also achieve good solar gain results[62].

Cost: Low

Category: Energy efficiency

INCORPORATION OF DESIGN INTERVENTION POTENTIALLY:			
	Increases selling price of property	✓	Reduces property operating costs
	Reduces future maintenance costs		Decreases cost of construction
	Reduces chance of flooding	✓	Improves well-being
	Reduces air pollution		Reduces noise pollution
	Improves biodiversity		Eligible for Government rebates

Next Steps: Consult your local planning department to ensure building siting and orientation meet additional planning regulations and other local council requirements.

Building Form

Benefits and Implementation: Building form is influential for reducing the energy demand of a building. Building form can relate to the compactness, shape and envelope of a building. Building form is influential on a building's ability to store and lose heat through its outer surface.

- A building with a high compactness (a low volume to surface area ratio) can reduce heat loss, potentially reducing its demand for energy used for heating;
- This needs to be balanced with the potential for a highly compact building to overheat in the summer - overheating can be managed through the use of passive cooling systems[63] as described throughout this guide;
- The shape factor of a building, the ratio between building length and depth, reinforces the conclusions related to building orientation - the longest façade should face south to optimise solar gain[64]; and
- Homes that share adjoining walls, such as townhouses, reduce the demand for heating in the winter as fewer exterior walls are exposed to the elements.


Photo by Stainthorp, P.

The longest facade of a building should face south to optimise solar gain

Compact building envelopes help to reduce heat loss

The building envelope refers to various components of buildings, including walls, fenestration (windows and doors), foundations, insulations materials, and external shading devices. One of the primary measurements of thermal performance of the building envelope is the U-value, or thermal transmittance. Over recent decades U-value requirements for building envelope components in the UK have increased substantially. A well designed building envelope can significantly reduce the energy demand of building for heating, cooling and lighting[65].

Fenestration is the term describing openings in the building façade – typically windows and doors[66]. The façade of the building is an important consideration when designing an energy efficient building given that it is influential over heat loss and solar gain as well as daylight penetration[67]. The glazing ratio, the ratio between the area of glazing and total area of the façade[68], can be influential on the potential for passive solar gain and also on heat loss through windows. Consideration of the glazing ratio together with the glazing type during the design stage can increase the energy efficiency of a building.

Cost: Low if considerated during design stage

Category: Energy efficiency

INCORPORATION OF DESIGN INTERVENTION POTENTIALLY:			
	Increases selling price of property	✓	Reduces property operating costs
	Reduces future maintenance costs	✓	Decreases cost of construction
	Reduces chance of flooding		Improves well-being
	Reduces air pollution		Reduces noise pollution
	Improves biodiversity		Eligible for Government rebates

Next Steps: Consult your local planning department to ensure building siting and form meet additional planning regulations and other local council requirements.

DESIGN INTERVENTIONS

Building Walls

Benefits and Implementation: Walls are typically a significant proportion of the building envelope and several different options exist for wall systems which improve the energy efficiency of a building. When walls are poorly insulated up to 35% of heat lost can be through the walls. Measures to insulate walls are therefore important, but other measures can also be considered to gain further energy efficiency benefits from the walls of a building[69]. Every year in England, mortality is on average 19% higher in the winter months, compared to the rest of the year. The 2011 publication 'The Health Impacts of Cold Homes and Fuel Poverty stated that "countries which have more energy efficient housing have lower excess winter deaths, and that this is due to better preparedness for cold weather and well-insulated, well-heated and energy-efficient homes".

Thermal insulation:

- Thermal insulation slows down the rate at which heat flows through the fabric of a building and is a simple and effective way to improve the energy efficiency of a building.
- Increasing thermal insulation using existing technologies/materials can reduce the demand for energy for heating and cooling.
- Standard thermal insulation options include:
    - mineral fibre blankets; loose fill blown into cavities; mixed with concrete; rigid boards; sprayed in place; boards and blocks; insulated concrete blocks and insulated concrete forms; and reflective coatings[70].
- High performance thermal insulation options, such as Neopor, can overcome space issues associated with increased thicknesses of standard thermal insulation[71].
- Highly insulated buildings with correspondingly low heating demands have been found to reduce the need to consider building orientation[72], potentially providing greater flexibility on site.

Photo by NM Energy$mart Academy

Blown in netted insulation is one method of improving energy efficiency

Walls with latent heat storage:

- The thermal storage capacity of lightweight wall structures can be improved by the use of phase change material (PCM);

- Phase change material is impregnated into wall materials (typically into plasterboard/gypsum or concrete walls)
- The greater weight of PCM which can be impregnated into the wall material the greater the potential to reduce the heating demand[73].

Passive solar walls:

- The passive solar wall or Trombe wall takes advantage of available solar energy to reduce heating demand and are therefore most effective on the southern façade of a building;
- They typically include a glazed outer surface which acts like the glass in a greenhouse and an internal element of structural mass (often a large concrete mass) to absorb solar energy which is then gradually distributed internally;
- For colder climates with long heating periods the traditional Trombe Wall or unventilated passive solar wall is preferable;
- One such suitable design consists of an external steel panel with polystyrene mounted on the internal side[74].

Cost: Low to medium

Category: Energy efficiency


Photo by Joe

Passive solar walls on homes can make the most of southern exposures in order to reduce energy costs

INCORPORATION OF DESIGN INTERVENTION POTENTIALLY:			
✓	Increases selling price of property	✓	Reduces property operating costs
	Reduces future maintenance costs		Decreases cost of construction
	Reduces chance of flooding		Improves well-being
	Reduces air pollution	✓	Reduces noise pollution
	Improves biodiversity		Eligible for Government rebates

Next Steps: Guidance on insulation materials and options is available from the National Insulation Association - http://www.nia-uk.org/

DESIGN INTERVENTIONS

Mechanical Ventilation With Heat Recovery

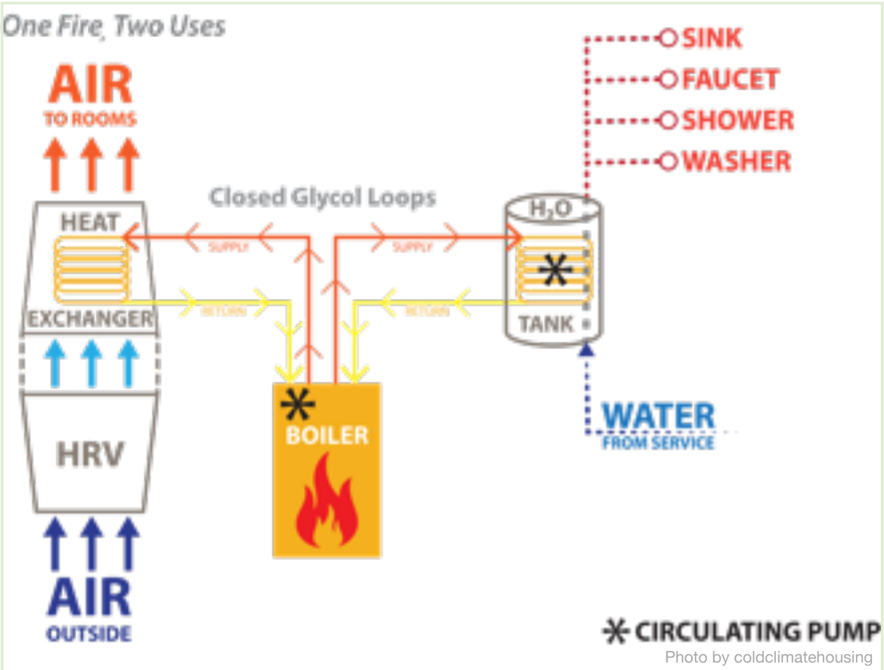
Mechanical ventilation systems with heat recovery aim to recover the heat from internal air whilst providing ventilation. Traditionally ventilation has been achieved by opening windows and doors; however, this may have negative consequences by introducing draughts and resulting in considerable heat loss[75].

Benefits and Implementation:

- Reduce heat loss through ventilation.
- Reduce overall energy demand for heating[76].

Cost: Medium to High; £1,500 to £3,000 – costs vary depending on individual property.

Category: Energy efficiency



Heat loss can be reduced through the use of mechanical ventilation

INCORPORATION OF DESIGN INTERVENTION POTENTIALLY:			
	Increases selling price of property	✓	Reduces property operating costs
	Reduces future maintenance costs		Decreases cost of construction
	Reduces chance of flooding		Improves well-being
	Reduces air pollution		Reduces noise pollution
	Improves biodiversity		Eligible for Government rebates

DESIGN INTERVENTIONS

Louvers, Extended Eves or Awnings

In addition to making use of available solar energy during heating seasons to reduce the demand for heating attention should also be paid to managing solar gain during summer months to avoid overheating[77].

Benefits and Implementation:

- Louvers, extended eves and awnings can be used to provide shading over glazed sections of building façades to control the thermal comfort within buildings.
- In the UK it is important to ensure that passive solar heating through solar incidence is not compromised during the winter.
- The use of mechanical or automatic louvers can ensure optimum use whilst maintaining the building's ability to benefit from solar energy gain[78].
- Retractable awnings over windows allows flexibility in the management of solar energy entering a home.
- Verandas/arcades/colonnades/portico can also be used to manage solar gain in a home.

Cost: Low to Medium

Category: Energy efficiency

Louvers are an inexpensive way to improve thermal comfort

Arcades and colonnades can be used to manage solar gain

	INCORPORATION OF DESIGN INTERVENTION POTENTIALLY:		
	Increases selling price of property	✓	Reduces property operating costs
	Reduces future maintenance costs		Decreases cost of construction
	Reduces chance of flooding		Improves well-being
	Reduces air pollution		Reduces noise pollution
	Improves biodiversity		Eligible for Government rebates

DESIGN INTERVENTIONS

Glazing

Benefits and Implementation: The placement of windows provides several functions, including enhancing aesthetics and ensuring sufficient daylight illumination inside a building. One of the key functions of glazing is also to do with the potential for passive solar gain, or for solar energy to contribute to heating needs in a building[79]. The use of windows and glazing to make use of passive solar gain for heating should be mindful of the need to avoid excessive heat gains or losses[80]. To overcome these issues the placement and materials used should be considered.

General placement considerations:	
Northern façade	• Provide natural light • Double glazed windows can reduce potential heat loss during cold months/heating season • Provide natural ventilation
Eastern and western façades	• Provide natural light • Can be more difficult to control the potential for excessive solar gains (see louvers and extended eves)
Southern façade	• Provide natural light • Provide solar gain opportunities during winter months • May require measures to control potential for excessive solar gains (see louvers and extended eves)
Source: [81]	


Photo by Jones, J.

Placement and materials used when fitting windows is important to maximise benefits

Material considerations:

- Material selection can help to manage the multiple considerations of insulations performance, solar gain control and natural light performance. Vacuum glazing with low emissivity coating (double and triple glazing) – provides low U-values to reduce heat loss. Triple glazing outperforms double glazing.

Aerogel glazing (granular aerogel encapsulated between polycarbonate panels) is lightweight, provides good light diffusion, has low U-values to reduce heat loss and is useful in roof-light applications[82].

Cost: Low to medium (cost varies depending on glazing option)

Category: Energy efficiency

Triple paned windows are useful for capturing passive solar energy

INCORPORATION OF DESIGN INTERVENTION POTENTIALLY:			
	Increases selling price of property	✓	Reduces property operating costs
	Reduces future maintenance costs		Decreases cost of construction
	Reduces chance of flooding		Improves well-being
	Reduces air pollution	✓	Reduces noise pollution
	Improves biodiversity		Eligible for Government rebates

Next Steps: Technical advice and general guidance on glazing products and standards can be found on the Glass and Glazing Federation website - http://www.ggf.org.uk/

DESIGN INTERVENTIONS

Draught Proofing

As well as improvements to the insulation performance and the potential for passive solar gain through building walls and glazing it is important to pay attention to joints between these components.

Benefits and Implementation: The National Insulation Association reported that 20% of heat is potentially lost through a building's windows and doors (based on a three bedroom gas heated semi-detached house). Draught proofing around doors and windows can reduce this and produce associated energy efficiency improvements[83].

Draught proofing doors is an inexpensive and effective way to reduce heat loss in a home

The various options below can be used in a range of situations including new construction and retrofit applications. Care should be taken when considering draught proofing and should not be done around vents for fires and heating appliances. Sealing exterior windows and doors of bathrooms and kitchens should also be avoided to ensure ventilation, instead consider sealing internal doors of these spaces[84].

Location	Solution	Description
Doors	Brush strips	‣ For internal or external doors ‣ Tough plastic bristles maintain seal ‣ Usually fixed to base of door
Doors	Compressed door seal	‣ For circumference of external doors ‣ Profiled aluminium and rubber inserted seal
Doors	Rain deflectors	‣ For base of door on external side ‣ Prevents rain ingress
Doors & windows	Rubber seal	‣ For door or window gaps of 1.5mm to 5mm ‣ Large contact area while staying elastic and reusable
Doors & windows	Rubber blades	‣ For door or window gaps of more than 5mm ‣ Large contact area while staying elastic and reusable
Doors & windows	Polymer foam seal	‣ For door and window gaps of 1.5mm to 5mm ‣ Low strength material for applications where repeated use is minimal
Windows	Window insulating film	‣ Thin transparent film fitted to inside of existing window as temporary secondary glazing
Windows	Silicone mastic sealant (for metal framed windows)	‣ For damaged areas and gaps around windows ‣ Forms water tight and flexible seal
Source: [85]		

Cost: Low

Category: Energy efficiency

INCORPORATION OF DESIGN INTERVENTION POTENTIALLY:			
	Increases selling price of property	✓	Reduces property operating costs
	Reduces future maintenance costs		Decreases cost of construction
	Reduces chance of flooding		Improves well-being
	Reduces air pollution	✓	Reduces noise pollution
	Improves biodiversity		Eligible for Government rebates

Next Steps: Further advice on draught proofing homes can be found on the Energy Saving Trust website - http://www.energysavingtrust.org.uk/

DESIGN INTERVENTIONS

Heating Systems

There are several heating system options available which can improve a building's energy efficiency and which utilise different energy sources, including; renewable energy and gas.

Solar Water Heating systems: Solar water heating systems utilise solar energy through solar panels (not photovoltaic solar panels – see renewable energy generation for information) to provide low carbon hot water.


Photo by Thiesen, S.

These collectors provide heating for a 1500 litre water tank and space heating system

Benefits and Implementation:

- Calculated to reduce household gas bill by approximately 10%.
- Consideration should be given to sighting of solar panels and compatibility with receiving appliances (e.g. boiler and washing machine)[86].

Heat pumps: Can be air source heat pumps or ground source heat pumps. Air source heat pumps extract heat directly from the air while ground source heat pumps extract heat from the ground via buried tubes. Both options can provide heat to radiators, underfloor heating, and warm air heating systems and can be used to provide hot water[87, 88].

Benefits and Implementation:

- Can reduce energy bills.
- Low carbon option.
- Requires little maintenance - 'fit and forget' technology.
- May qualify for government financial support through the Renewable Heat Incentive[89, 90].

Biomass boilers: Biomass heating systems come in the form of biomass stoves and boilers and typically burn wood logs, pellets or chips[91].

Benefits and Implementation:

- Can reduce energy bills as the cost of biomass fuel is often less expensive than other heating options.
- Low carbon option – so long as biomass fuel is available locally.
- May qualify for government financial support through the Renewable Heat Premium Payment and the Renewable Heat Incentive[92].

Gas boilers:

Benefits and Implementation:

- Can be highly fuel efficient, with some modern condensing boilers now reaching 90% efficiency[93].
- Utilising temperature and boiler controls effectively can improve efficiency.
    - Zoning thermostat controls by having multiple thermostats and 'circuits' in your heating system allows you to vary the temperature in low and high use areas of the building.
    - Thermostatic radiator valves can vary the temperature in each room by adjusting the performance of individual radiators[94].
- Installing new systems can be costly.
- Relies on fossil fuels.

Cost: Installation costs vary by technology and each technology incurs different life time or operational costs.

Category: Energy efficiency


Photo by Hayes, S.

Biomass stoves are a low carbon method for heating homes

INCORPORATION OF DESIGN INTERVENTION POTENTIALLY:			
✓	Increases selling price of property	✓	Reduces property operating costs
	Reduces future maintenance costs		Decreases cost of construction
	Reduces chance of flooding		Improves well-being
	Reduces air pollution	✓	Reduces noise pollution
	Improves biodiversity	✓	Eligible for Government rebates

Next Steps: For information about renewable or low carbon heating systems, gas central heating, other considerations (e.g. optimal standards of insulation) and energy/cost savings visit the Energy Saving Trust - http://www.energysavingtrust.org.uk/

On-site Renewable Energy Generation

After considering energy efficiency measures and alternative technologies further environmental and economic benefits can be achieved through the use of renewable energy generation technologies. Use of renewable energy generation technologies does require considerable planning to ensure appropriate use and technology selection[95].

Photovoltaic (PV) Solar Panels: Photovoltaic solar panels utilise solar energy to produce electricity which can either be used on site or exported back to the national grid. PV technologies come in various forms, including: aluminium frame solar panels, plain cladding, solar roof tiles and custom built glazing options[96].


Photo by Hayes, S.

Solar panels on homes can reduce electricity bills by approximately 40%

Benefits and Implementation:

- Should be placed in unshaded south facing location. Consideration at the design stage can ensure optimum performance.
- Can generate electricity during cloudy periods in the UK[97].
- Can reduce household electricity bills by approximately 40%[98].
- Electricity generated is low carbon.

Cost: Medium to High - Typical system installation costs approximate £7,000 (correct in 2014) and can be supported as electricity generated qualifies for the government feed-in tariff [99].

Wind Turbines: Several on-site wind turbine options exist, including building mounted wind turbines and small free standing turbines (less than 1 Megawatt).

Benefits and Implementation:

- Low carbon renewable source of energy.
- Good wind conditions are required – The Energy Saving Trust provides a wind estimator tool[100].
- Greater potential for economically viable generation of electricity from small scale free standing wind turbines in rural locations than building mounted turbines in urban locations[101].

Cost: High - Costs can be supported as electricity generated qualifies for the government feed-in tariff[102].

Category: Energy efficiency

Small, free-standing wind turbines can provide supplementary electricity to homes

INCORPORATION OF DESIGN INTERVENTION POTENTIALLY:			
✓	Increases selling price of property	✓	Reduces property operating costs
✓	Reduces future maintenance costs		Decreases cost of construction
	Reduces chance of flooding		Improves well-being
	Reduces air pollution		Reduces noise pollution
	Improves biodiversity	✓	Eligible for Government rebates

Next Steps: Further information on renewable energy in the UK can be found by consulting RenewableUK, a not for profit renewable energy trade association - http://www.renewableuk.com/

Additional Information

For comprehensive information on the use and construction of SuDS consult *The SUDS manual* (2007) (publication # C697) and *Site handbook for the construction of SUDS* (2007) (publication # C698) produced by CIRIA - http://www.ciria.org/

Detailed guidance and tools on the design and cost of installing SuDS in the UK can also be found at http://www.uksuds.com/ developed by HR Wallingford

The following organisations and websites offer further information and resources on environmentally sensitive design and specifying materials:

- Adaptation and Resilience in the Context of Change (ARCC) Network - http://www.arcc-network.org.uk/
- Building Research Establishment (BRE) Sustainable Design Advice & Guidance - www.bre.co.uk
- Building Research Establishment Environmental Assessment Methodology (BREEAM) - www.breeam.org
- Energy Saving Trust - http://www.energysavingtrust.org.uk/
- The Green Book Live - www.greenbooklive.com
- The Planning Portal: UK Government's online planning and building regulations resource for England and Wales - http://www.planningportal.gov.uk

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